APPENDIX 1: Tacoma Power Resource Portfolio

Tacoma Power serves retail load through utility owned generating resources and power contracts with outside suppliers. The utility's largest source of electricity is a power supply contract with BPA. The BPA contract supplies more than half of Tacoma Power's retail load. Tacoma Power also owns and operates four major and one minor hydroelectric generation projects – Nisqually, Cowlitz, Cushman, Wynoochee and Hood Street (minor). Finally, Tacoma Power also has long-term power supply contracts for the output from two additional projects – Priest Rapids and the Grand Coulee Project Hydroelectric Authority.

The electricity that Tacoma Power supplies to retail customers is virtually all generated by hydro-electric resources minimizing most GHG emission risk. These resources are expected to be sufficient to meet retail load under critical water conditions until the 2020's. This minimizes fuel price risks from increases in natural gas or coal prices as well as carbon dioxide price risks (e.g., should the state or federal government establish limits on emissions of greenhouse gasses).

While Tacoma Power purchases power on the wholesale market, these purchases are mostly to take advantage of a peak/off-peak price differential, or to satisfy some short-term balancing needs. The sales and purchases are different each year depending upon inflows into the hydro-electric projects but the purchased quantity is substantially less than the quantity sold because of the quantity of additional generation capacity Tacoma Power has available in years with greater than critical water inflow. The revenues earned through these sales help Tacoma Power maintain low retail rates. The following sections provide a more comprehensive description of Tacoma Power's power supply portfolio.

The BPA Contract

The BPA currently supplies electricity to Tacoma Power under a Priority Firm Slice/Block Power Sales Agreement. This contract guarantees Tacoma Power approximately 408 aMW of power each year under Critical water; however the monthly amount varies relative to Tacoma Power's load and the two components of the contract. The first element of the contract is the Block portion. This portion is a flat monthly amount of energy guaranteed to be delivered regardless of the water conditions and any excess power BPA has from this portion of their generation portfolio (resulting from sales to Tacoma Power and other utilities) is sold as surplus electricity in the wholesale power market. The revenues BPA receives are credited back proportionately to all of the Block Contract customers of BPA.

The second component of the BPA Power Purchase Agreement is the Slice portion of the contract. The Slice portion represents approximately 51% of the power received from BPA in a Critical water year and the quantity available to be delivered is dependent on the actual water year. This portion of the contract functions similar to Tacoma Power's other hydroelectric resources and has its own constraints and limitations that must be monitored and managed on an hourly basis. Tacoma Power can determine, within an upper and lower limit, the quantity of power that it would like to receive from BPA based on the capabilities and constraints of the projects included in the Slice portion of the Power Sales Agreement. In this way, Tacoma Power is able to try and shape the power received from BPA to better match with our customer needs. The Power Sales Agreement with BPA began on October 1, 2011 and runs through September 30, 2027 however, the rates associated with the contract are updated every two years in a public rate case.

Overview of BPA Resources

The Bonneville Power Administration

BPA was established by Congress pursuant to the Bonneville Project Act of 1937. BPA's central mission is 1) to operate and maintain a reliable regional transmission grid and 2) to market electricity at cost from federally owned and contracted facilities to Northwest utilities. This federal system represents approximately 20,000 MW of capacity and a firm energy capability of 9,590 aMW; sources include 31 federally owned hydroelectric facilities, one nuclear plant and several nonfederal power plants, such as wind plants (See BPA figure below). BPA sells electric power at wholesale rates to 127 utility, industrial and governmental customers in the Northwest. The federal system produces approximately 35 percent of the region's energy requirements. BPA's transmission system has over 15,000 miles of transmission lines, provides about 75 percent of the Northwest's high-voltage bulk transmission capacity, and serves as the main power grid for the Pacific Northwest. BPA's service area covers over 300,000 square miles and has a population of about 11 million people.

Owned Resources

Tacoma Power's own resources are geographically diverse from BPA's. Majority of BPA's power plants are located on the Columbia River whose watershed is east of the Cascade mountain range and west of the Rocky Mountains. Conversely, Tacoma Power's resources and their attendant watersheds are on the west side of the Cascades (see the figure below). This geographic diversity provides a benefit in that weather patterns have different effects east and west of the Cascade mountain range. Dry conditions on one side of the mountains can be balanced out by wet conditions on the other. A historical example of this was in 2010, mid-June forecasts for the Columbia River flow past the Dalles (east side) from April through August, was 78 percent of normal, while flows in the Cowlitz River at Mayfield (west side) were forecast at 102 percent of normal.

Overview of Tacoma Power Resources

The Cowlitz Project

Tacoma Power's largest hydroelectric project is on the Cowlitz River. It consists of two coordinated hydroelectric dams, Mossyrock and Mayfield, located on the Cowlitz River in Lewis County. The Mossyrock dam was placed into service in 1968. Rising 606 feet, the Mossyrock dam is the tallest dam in Washington. In April, 2008, Tacoma Power began a complete rebuild of Mossyrock's two Francis generating units. At the conclusion of the overhaul, units 51 and 52 have ratings of 157 MW and 147 MW, respectively, for a total nameplate capacity of 304 MW. However, at peak flow and head, the total output of these two turbines is anticipated as 379 MW.

Mayfield dam, located approximately 13.5 miles downstream of the Mossyrock dam, was initially placed into operation with three generating units in 1963. A fourth unit was added in 1983. The Mayfield dam is a 200 feet high and 850 feet long concrete arch and gravity dam. It has a controlled spillway with five tainter gates. The Mayfield powerhouse contains four Francis generating units, each rated at 40.5 MW, resulting in a total nameplate rating of 162 MW. Both

FERC Licensing of Hydroelectric Plants

Federal law subjects the hydroelectric projects that Tacoma Power has interest in (4 owned and 2 by contract) to FERC licensure. To issue a license, FERC must find that a project is in the broad public interest. This requires balancing cultural, recreation, land-use, and fish and wildlife, interests with energy production. Numerous stakeholders participate in the process, including federal agencies, Indian tribes, non-governmental organizations, local communities and governmental entities. Some state and federal stakeholders can place mandatory conditions on a license. For example, the National Marine Fisheries Service and the Fish and Wildlife Service can require the installation of fish passage facilities. The FERC license must also be consistent with certain state and federal laws, such as the Endangered Species Act and the Clean Water Act. The hydroelectric relicensing process can be complex, political and controversial.

Cowlitz Hydroelectric Project dams are operated by Tacoma Power under the terms of a single 35-year license issued by the FERC in 2002.

Mossyrock Dam

Mayfield Dam

The Nisqually Project

The Nisqually project includes two coordinated hydroelectric plants on the Nisqually River, Alder and LaGrande, located approximately 30 miles southeast of Tacoma. The Alder plant, constructed in 1945, includes a 1600-foot concrete arch dam and a powerhouse containing two Francis generating units having a total installed nameplate rating of 50 MW.

Alder Dam

The LaGrande Dam is a concrete gravity dam. The plant was originally placed in service in 1912 with four 6 MW horizontal Francis turbine/generators. It was upgraded in 1944 with the construction of a new dam and the addition of a 40 MW Francis turbine/generator unit for a total nameplate rating of 64 MW.

LaGrande Dam

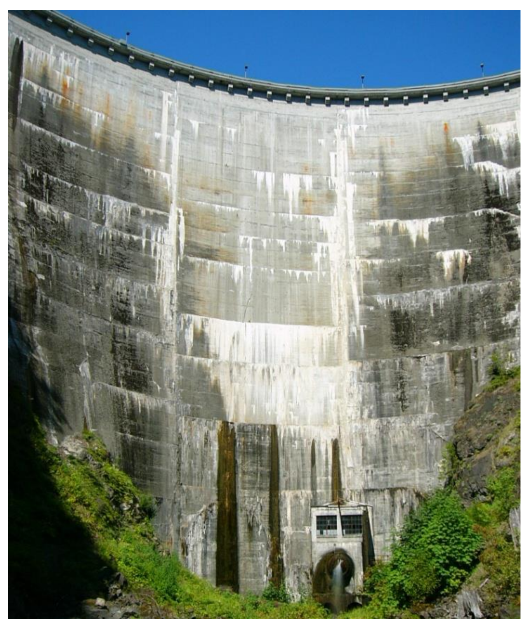
LaGrande 6MW Turbine Generator

The National Hydropower Association has three times given its annual Outstanding Stewardship of America's Rivers award to the Nisqually River Project. The Nisqually River Project also received a five-year, low impact hydroelectric certification from the Low Impact Hydropower Institute and was recertified in 2008 for another five years. In 1997, FERC issued a 40-year license for the Nisqually Project.

The Cushman Project

The Cushman Project consists of two hydroelectric plants located on the North Fork of the Skokomish River. Cushman Number 1, a 275-foot tall concrete arch dam, was completed in 1926 with two 25 MW Francis generating units. The dam's construction created the Lake Cushman reservoir.

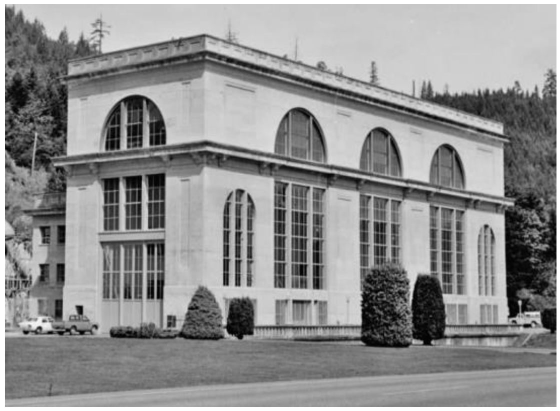
Cushman Number 2 was constructed in 1930 with two 27 MW Francis generating units. A third 27 MW Francis unit was added in 1952 bringing the total installed nameplate rating of Cushman Number 2 to 81 MW. Cushman Number 2 is a somewhat unusual in design in that the powerhouse is 2.5 miles from the dam and is fed by a 17-foot diameter power tunnel.



Cushman No. 1 Dam

A 40-year license was issued for the Cushman project in 1998; however, Tacoma Power appealed the license because the conditions were prohibitively expensive. In January 2009, a comprehensive settlement agreement, signed by the Skokomish Tribe, Tacoma and all of the affected State and Federal Agencies, was sent to FERC. On July 15, 2010, FERC issued an order accepting the license amendment and established a new license running through 2048.

Cushman No. 2 Dam



Cushman No. 2 Powerhouse

The Wynoochee Project

The Wynoochee Dam is a 175 foot tall concrete gravity dam, with earthen embankments. It supports a variety of purposes in addition to generation, including water supply, flood control, recreation, enhancement of fisheries and irrigation. The powerhouse was constructed in 1993 and contains a single Kaplan turbine, which has a nameplate capacity of 12.8 MW. The project's generation is transmitted to the BPA transmission grid over Grays Harbor County Public Utility District's transmission system under a contractual arrangement. From there the power travels over BPA's transmission grid to Tacoma Power.

Wynoochee Dam

Currently the cities of Tacoma and Aberdeen share ownership of the facilities. Tacoma owns the powerhouse, substation, and all improvements made by Tacoma. Aberdeen owns the dam, reservoir and all original facilities constructed by the Corps of Engineers. While Tacoma and Aberdeen are co-licensees, Tacoma handles all FERC correspondence and operates the dam and other facilities as well as the powerhouse. In 2000, Congress passed legislation permitting transfer of title from Aberdeen to Tacoma. A Memorandum of Agreement outlining the terms of this title transfer is under review by the Corps of Engineers and the Wynoochee Project has a 50-year FERC license that runs through 2037.

Other Resources

The Hood Street Generator is a small project installed at Tacoma Water's Hood Street Reservoir. The project generates an average of 2,499 MWh annually and began operating in 1990.

The Priest Rapids Contract provides electricity to Tacoma Power through several long-term agreements with Grant County PUD. The agreements provide Tacoma Power the right to purchase a share of the output of the Priest Rapids Hydroelectric Project that exceeds the actual and prospective needs of Grant County PUD. The amount of electricity that Tacoma Power receives through this contract has significantly declined in the last few years as Grant County's load has increased. The total MW's purchased in 2012 were less than 4.3 aMW. In April 2008, FERC issued a new 44-year operating license for the Priest Rapids Project and Tacoma Power's contract with Grant County PUD coincides with the term of the license.

The Grand Coulee Project Hydroelectric Authority operates and maintains five low-head hydroelectric projects along irrigation canals in eastern Washington. The Grand Coulee Project Hydroelectric Authority (GCPHA) is owned by the South Columbia Basin, East Columbia Basin and Quincy Irrigation Districts. The irrigation projects produce power during the summertime irrigation season and the total installed capacity of all five projects is approximately 130 aMW. The cities of Tacoma and Seattle have entered into five power purchase agreements for the acquisition of the output from these projects and each city receives 50% of the actual output of each project. These five agreements terminate between 2022 and 2026.

APPENDIX 2: Price Forecast

One of the most important components of the IRP is the projection of future wholesale electricity prices. Tacoma Power uses the forecast of wholesale electricity prices at the Mid-Columbia[1] hub (Price Forecast) in the evaluation of alternative resource options, determination of cost effective conservation measures, budgeting, and long-term planning of Tacoma Power's resource portfolio. The base Price Forecast is derived by Wood Mackenzie and Tacoma Power analysts review the significant drivers behind the base forecast. After adding variability to the base forecast with our own econometric models a high and low Price Forecast is produced to accompany the base forecast. As a final step in the development of the Price Forecast, Tacoma Power has created an Avoided Cost Risk Adder as a means of accounting for potential additional risk during the years when a potential new resource would be added to Tacoma Power's portfolio.

The Base Forecast

WoodMac generates the Price Forecast using the Aurora^{XMP} model (Aurora model). The base Price Forecast is primarily influenced by the following factors; WoodMac's 50th percentile natural gas price assumptions ,the 50th percentile water year forecast, a $17 carbon price adder that begins in 2023, and modest load growth assumptions. As new elements of influence in the region emerge they are included in the model. WoodMac's Aurora model simulates regional development of new resources to meet demand growth and produce a spot market price correlated to a set of future scenarios driven by these assumptions. A number of sensitivity analyses are run before determining the final base forecast.

> **WoodMackenzie**
>
> Tacoma Power began purchasing the Natural Gas forecast from Wood Mackenzie (WoodMac) in 2011 to increase our knowledge base and awareness of significant fundamentals affecting power markets and in 2012 we began purchasing WoodMac's Power Price forecast as well. WoodMac's North American Power Service provides biannual updates of a 22-year supply, demand and power forecast for our region. The forecast is based on analysis of key regulatory trends and fundamental issues

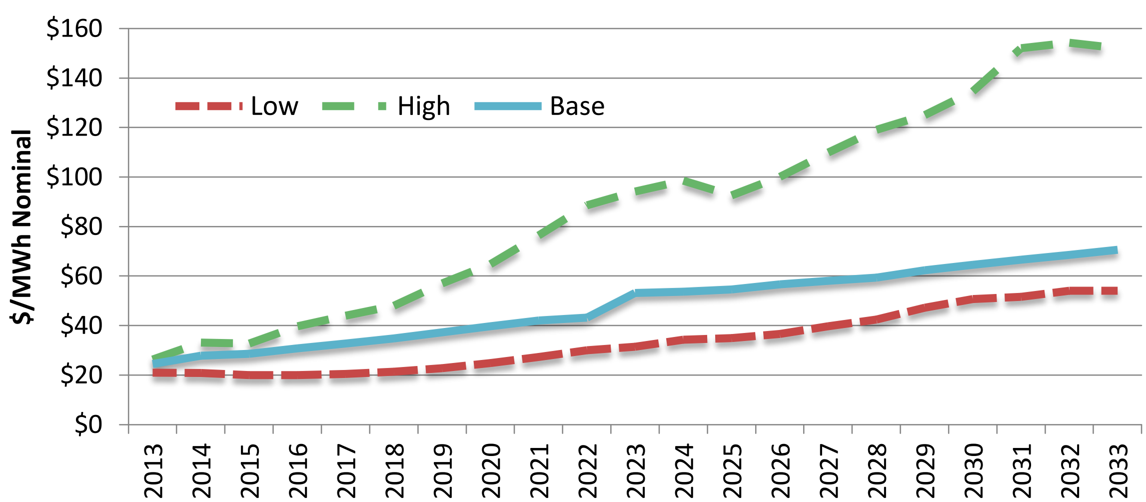


Figure 1 - 2013 Wholesale Price Forecast

[1] The Mid-Columbia (Mid-C) is the common hub for commercial trading of energy in the northwest.

Natural Gas price assumptions are the largest single influence in the final Price Forecast. Natural Gas prices at Henry Hub, as well as price differentials for all other major natural gas trading hubs, are an input to the Aurora model. In the stack of resources in the model has natural gas prices are on the margin approximately 40% to 60% of the time.

As seen in Gas Figure (below), historically Natural Gas prices have been very difficult to forecast. The current forecast is similar to last year's forecast, and represents a significant shift in the fundamentals driving Natural Gas prices. The emergence of new gas harvesting technologies, namely *fracking*, has resulted in analysts predicting sufficient natural gas supplies to offset demand increases for at least the next seven to ten years. This expectation has continued to drive down natural gas prices for the last few years and resulted in sustained near record low prices. The low natural gas prices represent a significant risk as well because there is little expectation they will be much lower than the current forecast but significant potential they will be higher to much higher in the distant years of the forecast. Natural Gas has been a volatile commodity and it is not expected that Natural Gas prices will actually trend with the smooth regularity exhibited by the forecast. This is a contributing factor in the need for applying a risk adder, explained in the Risk Adder section below.

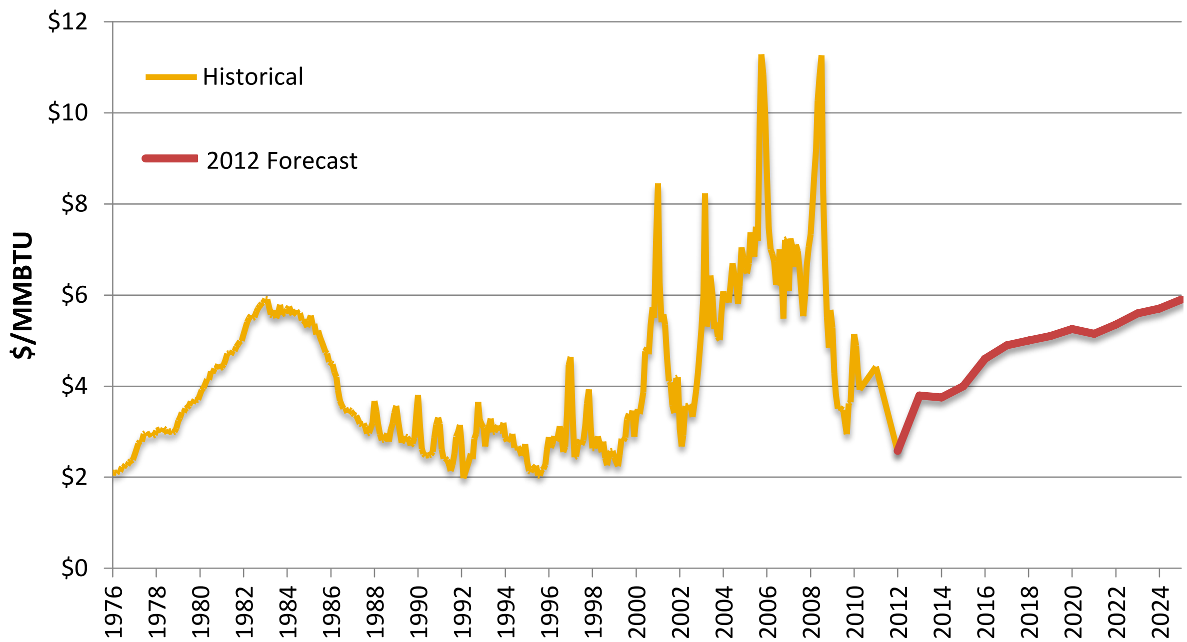


Figure 2 - 2013 Natural Gas Forecast with Actual Historicals

Other fuel inputs and resource types have the potential to significantly influence the output of the Aurora model as well. In the northwest region the largest volume of generation is produced by hydroelectric dams and the amount of generation is dependent upon rainfall conditions and runoff timing throughout the year. The Price Forecast uses average water for all areas in the region and, because of the large amount of water in the spring time, the Aurora reflects hydroelectric generation setting the marginal price of wholesale electricity during this time.

Coal is also an important fuel input for the Aurora model. However, Natural Gas resources are quickly replacing coal resources because of the low price of Natural Gas prices and increasing emission standards. Specific coal facilities that have announced retirement dates are included in the model and in future years it is expected that coal will be on the margin less and less. One other important resource in the northwest is wind generation. The northwest has been adding significant new wind resources in the last several years and while there is no fuel price for wind, the generation is highly variable. In the spring, when hydro generation is high, significant amounts of wind generation shift the supply curve and create periods where there are negative prices.

In the last several years there has been increasing speculation and discussion about regulating the output of CO_2 with state and/or federal legislation. Carbon is the only pollutant in Aurora model that has an emission charge associated with it but it is difficult to forecast when a charge will be implemented and how much it will be. California's cap and trade program and British Columbia's carbon charges are currently the best available comparisons for forecasting the amount and timing of a future charge. The current Price Forecast assumes a federally established charge of $17 per tonne of CO_2 would begin in the northwest in 2023. It would be expected that California's cap and trade program would transition to this amount when it is instituted as well. See Carbon Figure (below) for illustration of carbon assumptions used in the Price Forecast.

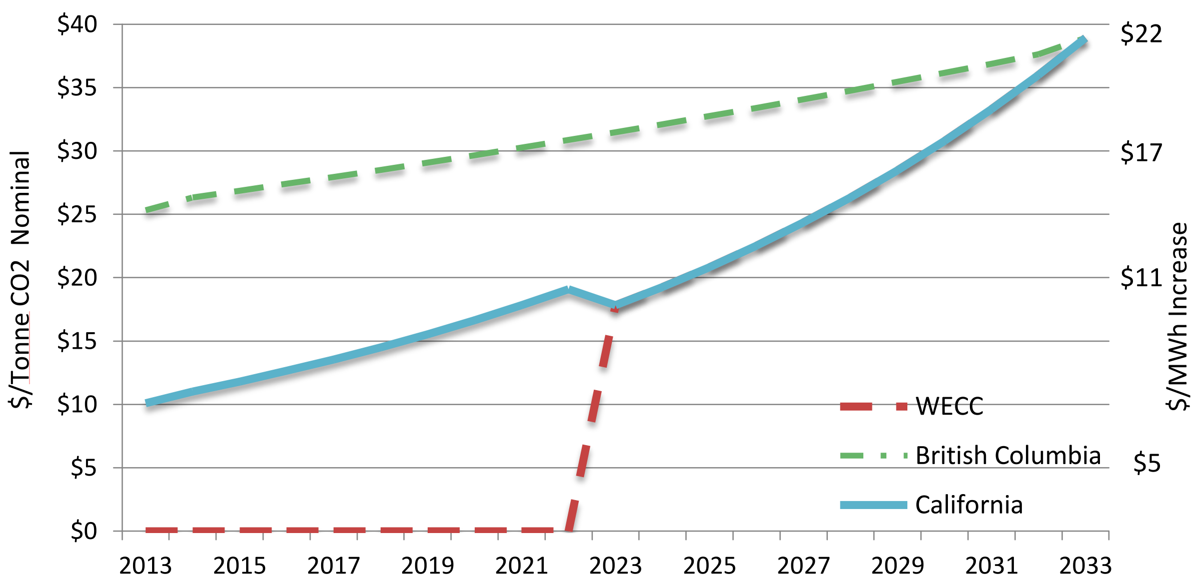


Figure 3 - Carbon Charges: California, BC, and WECC

One other key input in developing the Price Forecast is the forecast for load growth in the region. The amount of additional demand in the region determines how much additional generation supply needs to be constructed to meet the growth. See Demand Figure (below) for illustration of demand trajectories of major regions in WECC included in this Price Forecast.

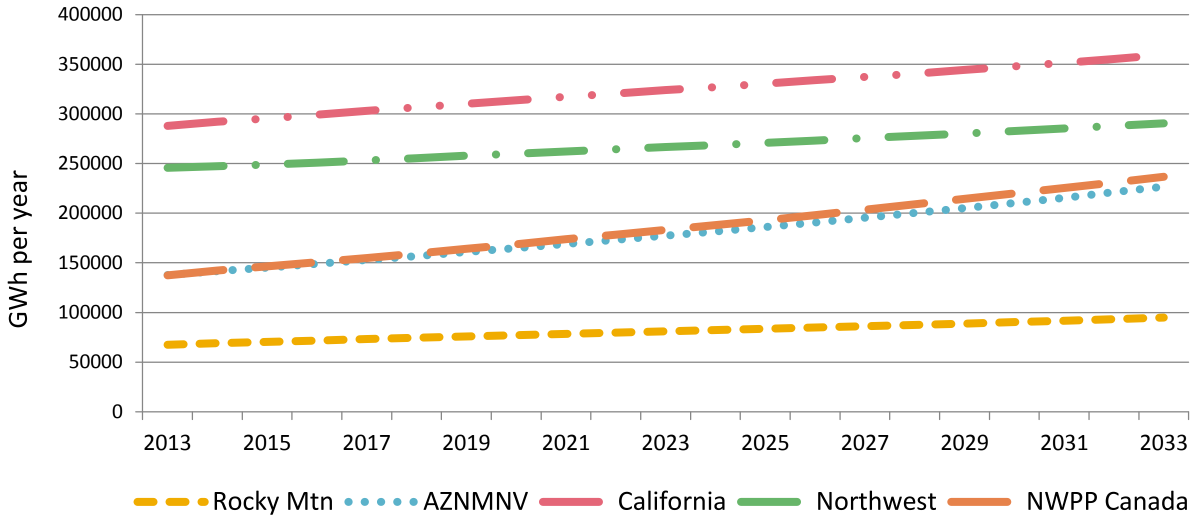


Figure 4 - Demand Increases by Major Region in WECC

Adding Variability and Defining the Highs and Lows

Electricity prices vary significantly on an hourly, monthly, or seasonal basis. There can be rapid changes in water supply conditions, weather, resources serving the region, or other contributing elements of wholesale electricity prices in the region. Because of the potential for these rapid changes, it makes sense to derive a high and low forecast as a likely range in which prices are expected to move around within that range. Tacoma Power did sensitivity analysis based on historic natural gas price prices and potential carbon prices scenarios. The sensitivity produces a range of results based on various factors influencing the Price Forecast. The 10th percentile estimate was selected for the low forecast primarily based on downside risk of lower Natural Gas prices. The 75th percentile estimate was selected for the high forecast primarily based on the potential volatility of higher than expected Natural Gas prices and the likelihood of a statutory or federal carbon tax. This Price Forecast is lower in comparison with previous Price Forecasts and there is more upside risk that actual prices will be higher than the base forecast. See Figure 1 of 2013 Price Forecast (above) for an illustration of the resulting low, base and high Price Forecasts.

Concerns with the Price Forecast

Forecasting wholesale electricity prices is difficult and there are many uncertain variables that have potential to alter the resulting forecast output by the Aurora model. The Price Forecast represents several analysts best estimation of what those variables should be but there are a couple of areas where there is greater uncertainty than others. The most significant area of concern is in the amount and type of additional generation resources that will be built to meet demand projections. Large additions to the natural gas and renewable generation fleet are already planned or being constructed. It is expected that most of the additional generation constructed will be renewable in order to meet the Renewable Portfolio Standard (RPS) requirements of each state.

In California it is expected that much of the additional capacity needed to meet the states RPS requirements will be through the construction of solar infrastructure. The additional generation capacity is anticipated to displace a significant portion of thermal generation currently being imported from neighboring states and alter the existing generation shapes. As these installations increase in number and capacity they are expected to reduce mid-day power prices and generate near peak capacity during heavy run-off periods in the spring. There is significant potential to further exacerbate negative prices in the spring time and/or produce negative prices during peak load periods. There is also concern this could result in a shift in the peak market hours, toward 8:00 p.m. to 10:00 p.m., as solar and wind generation capacities fade for the day. This concern is being further explored and analyzed for inclusion in future Price Forecasts.

Risk Adder

With concerns over how low this Price Forecast is and historical volatility of actual prices in the market, Tacoma Power has developed a Risk Adder of $9.55/MWh. The Risk Adder provides a mechanism to account for price variance over the last 35 years and helps buffer the vulnerability of upside risk in the 2020's. The predominant downside risk is from the California Renewable Portfolio Standard and the build out of significant additional solar infrastructure (further discussed above in Concerns with the Price Forecast). Concerns with downside risk are overshadowed by potential changes to the Natural Gas supply, larger than forecast demand increases, and variance in water supply to the region. Tacoma Power has structured the Risk Adder based on the upside risk of these concerns (see Table 1 below).

Natural Gas price volatility has the potential to alter the stack of resources constructed in the Aurora Model used to meet future loads. Tacoma Power has constructed a series of historic percentage year over year price change scenarios for natural gas prices from 1978 to present. From the 35 different 20-year price change scenarios, there are seven scenarios that have potential to negatively impact Tacoma Power. There is a 15% chance that one of these seven scenarios will be combined with an adverse water year or greater and an estimated loss to Tacoma Power from the scenarios of $12.97/MWh. This derives an expected present value of the Natural Gas risk adder for natural gas alone of $1.95/MWh. There is only a five percent chance that adverse water years or worse will overlap with the seven negative Natural Gas scenarios. When combined with the 25th percentile water years or worse, the estimated loss to Tacoma Power is $17.97/MWh and the additive portion of the risk adder is $0.87/MWh.

Variance in the water supply has significant potential to affect the wholesale market prices of electricity. Tacoma Power has used 70 years of historical hydro data to estimate the effects of water year risk. In low water years prices spike much higher than the Price Forecast and in high water years, prices plummet to near zero or below. The potential for adverse or worse water conditions produce a cost impact to Tacoma Power of $10.46/MWh but there is only a 20% chance that this will occur when Natural Gas has not moved higher. Water conditions have the potential to reduce the impact of high Natural Gas prices in the region. This derives an additive portion of the risk adder for adverse water alone of $2.10/MWh.

Additional demand in the region drives the acquisition of new resources however, the addition of new resources drives prices down. Economic booms drive the variance associated with the quantity and timing of new resource acquisition. Tacoma Power has constructed demand scenarios based on each state's demand growth since 1960. Faster rates of demand growth combined with low natural gas prices and average water conditions have little effect on prices. However, there is a 54% chance that prices will be impacted by faster rates of demand growth combined with lower than average water conditions and the cost impact to Tacoma Power is $7.71/MWh. This derives the final component based on demand and water variance of $4.63/MWh. Each risk set is mutually exclusive and the combination of each of the components results in a total Avoided Cost Risk Adder of $9.55/MWh. The risk adder is affected by high seasonal demand and by water year variance. The seasonal value of the risk adder is $10.40 in Q1, Q2, and Q4 while the seasonal value of the risk adder in Q3 is $7.03. This is a beginning nominal risk adder and would increase at 5.5% per year (illustrated in Figure below on Price Forecast with Risk Adder).

Additive Calculation of Risk Adder	**Basis**	**Odds**	**2013 $/MWh**
Natural Gas Historic Trend Risk (7) with Historic Water Year Series (5)	$12.97	15%	**$1.95**
NG Historic Trend (9) + 25th Percentile Water Year Risk	$17.27	5%	**$0.87**
25th Percentile Water Year Risk (1941)	$10.46	20%	**$2.10**
Demand with Water Variance	$7.71	54%	**$4.63**
			$9.55

Table 1 - Avoided Cost Risk Adder

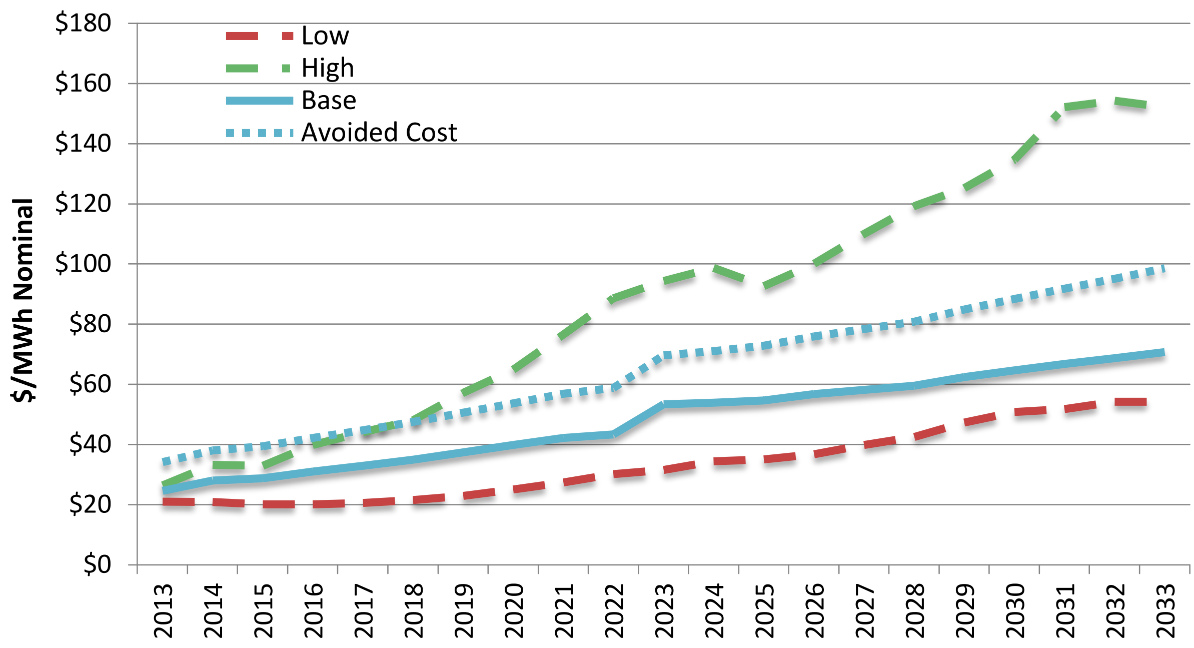


Figure 5 - 2013 Price Forecast with Average Avoided Cost Risk Adder

APPENDIX 3: 2012 Load Forecast

The Load Forecast is one of the primary inputs used in the development of the IRP. Tacoma Power's loads determine the quantity and timing of generation needed to serve customers as well as a forecast of regulatory mandates, such as the amount of generation required to come from a renewable source in meeting Washington's Renewable Portfolio Standard. This appendix discusses the development of the Load Forecast and the results used in analysis throughout the IRP.

Development and Lifecycle of the Load Forecast

Tacoma Power's Rates, Planning, & Analysis Section develops the Load Forecast and updates it annually. A new update is typically completed in June of each year. The Load Forecast gets used for many different purposes throughout the utility and receives careful consideration and review throughout the development process. In addition to using the Load Forecast in the IRP process, it is also used for cost-of-service and rate setting, meeting regulatory requirements, and budget and financial modeling. The final Load Forecast is a combination of relatively complex econometric modeling, trending analysis, and direct estimates from discussion and inquiry with Tacoma Power's diverse customer base.

Tacoma Power has a diverse set of customers and uses different forecasting techniques for the different customer classes. The Contract Industrial (CP) and High Voltage General Service (HVG) customer classes are directly estimated using a combination of analyzing historical trends and direct conversations with the customers in each class. Tacoma Power currently has two CP customers and six HVG customers. The Lighting Services classes are directly estimated using historical trends for utilization and include all street lighting, traffic signals, and private off-street lighting. The 2012 Load Forecast includes the addition of two new HVG customers in the next eight years. The timing and size of those customers are based on direct conversations with customers.

Tacoma Power has been using econometric models to forecast loads for the remaining customer classes for several years. Each year the model and inputs are reviewed and enhanced with the best available information at that time. Any major methodological changes are thoroughly discussed and reviewed prior to incorporation into the modeling environment. The methods used to develop the 2012 Load Forecast are similar to what has been used in previous years.

The residential, small general, and general service customer classes are forecast through econometric modeling. The econometric models are designed to represent the consumption patterns of each customer class. In Tacoma Power's system, most of the variation in monthly energy sales can be attributed to the number of customers and the seasonality of weather, represented through heating degree-days. The models use statistical methods to correlate periods of historical energy sales to demographics, economic trends and weather data. Using regression analysis, correlation coefficients are calculated and then used in an algebraic equation to represent each customer class and forecast future electricity sales to customers.

Heating Degree Days (HDD)

The weather component of Tacoma Power's econometric modeling is based on heating degree-day (HDD) data. A HDD is calculated by subtracting the average temperature for each day from 65° F. Each degree of temperature below 65° F is considered as one HDD and represents when people are expected to turn on their heat.

The econometric models are based on historical information and the 2012 Load Forecast uses the most recent data available through March 2012. The latest estimates for unemployment, number of households, gross metropolitan product, electricity prices, and conservation acquisition targets are incorporated into the forecast. The inputs for these economic and demographic indicators come from multiple sources:

- The number of households in the region, unemployment estimates, and gross metropolitan product are based on IHS Global Insight's regional long-term economic outlook released in March of 2012.
- Electricity prices are based on Tacoma Power's Long Term Financial Model Base Case dated May 23, 2012 and the Energy Information Administration's 2012 Annual Energy Outlook.
- Forecasts of conservation acquisition targets are provided by a separate analysis performed by Cadmus and managed through Tacoma Power's Energy Resource Planning and Analysis workgroup (see Appendix 4 for more information about the Conservation Potential Assessment).

2012 Load Forecast

The average annual rate of system load growth is approximately 1.1 percent for the 20-year forecast. The following tables and charts represent the resulting 2012 Load Forecast. In Section 3 on Preparing the Vista model an explanation is provided on how the 2012 Load Forecast is combined with hourly load and environmental data (such as wind speed, cloud cover, weather normal temperatures, etc.) from Tacoma Power's Metrix ND model to generate a variable hourly forecast.

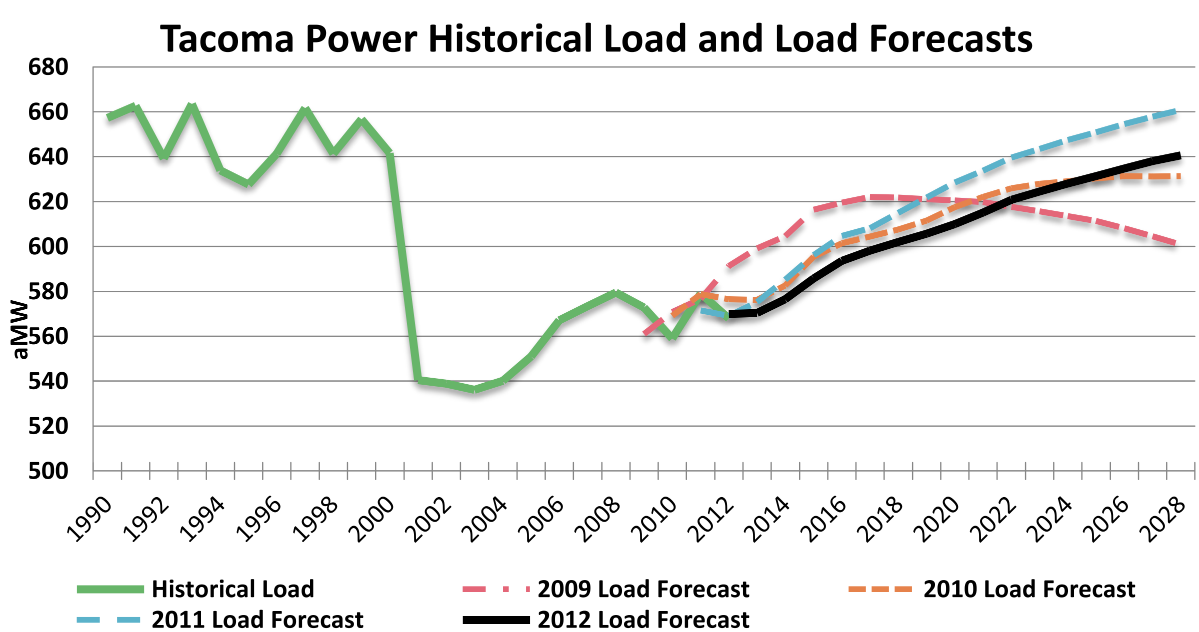
	Residential		Small General		General Service		High Voltage General	
Year	aMW	Growth (%)	aMW	Growth (%)	aMW	Growth (%)	aMW	Growth (%)
2012	216.33	36.25	172.35	54.62				
2013	211.95	-2.03%	35.97	-0.79%	181.84	5.50%	55.29	1.23%
2014	213.53	0.74%	35.85	-0.34%	185.33	1.92%	55.87	1.06%
2015	216.1	1.20%	35.85	0.02%	189.79	2.41%	56.45	1.04%
2016	217.73	0.76%	35.73	-0.35%	192.07	1.20%	59.23	4.92%
2017	220.62	1.33%	35.79	0.19%	194.43	1.23%	59.79	0.94%
2018	223.11	1.13%	35.76	-0.09%	195.65	0.63%	60.19	0.67%
2019	225.35	1.00%	35.65	-0.30%	196.62	0.49%	60.6	0.69%
2020	225.3	-0.02%	35.55	-0.30%	197.13	0.26%	62.98	3.93%
2021	226.97	0.74%	35.72	0.50%	198.67	0.78%	65.65	4.24%
2022	228.85	0.83%	35.81	0.23%	200.11	0.73%	68.09	3.71%
2023	230.53	0.73%	35.89	0.23%	201.64	0.76%	68.74	0.96%
2024	231.91	0.60%	35.88	-0.04%	202.36	0.36%	69.22	0.69%
2025	233.81	0.82%	36.04	0.46%	204.16	0.89%	70.09	1.25%
2026	235.36	0.66%	36.11	0.19%	205.51	0.66%	70.78	0.98%
2027	236.72	0.58%	36.18	0.19%	206.94	0.69%	71.48	0.99%
2028	237.49	0.32%	36.15	-0.08%	207.79	0.41%	71.41	-0.10%

Annual growth rates and load forecast by sector

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	703.9	660.2	650.2	551.6	509.8	488.9	485.4	496.3	491.3	542.3	641.7	686.5	575.6
2013	695.6	682.3	623.2	557.8	515.6	494.6	498.6	502	497	548.4	648.7	693.7	579.3
2014	708.1	694.5	634.3	567.7	524.7	503.3	507.4	510.8	505.7	558.1	660.2	707.2	589.6
2015	729.5	715.5	653.5	584.7	540.4	518.4	522.6	526.1	520.9	574.9	680.1	727.5	607.3
2016	739.8	723.8	662.8	592.8	547.8	525.3	529.7	533.2	527.9	582.9	690	739.3	616
2017	750.3	735.3	671.7	601.4	554.4	531.7	535.4	540.4	534.5	589.4	698.9	748.5	623.8
2018	758.9	743.7	679.3	608.2	560.5	537.5	541.3	546.4	540.4	595.9	706.8	757.2	630.8
2019	766.9	751.6	686.5	614.5	566.4	543.1	546.9	552.1	546	602.2	714.3	765.4	637.4
2020	775.6	758.2	694.4	621.3	572.5	548.8	552.7	558	551.7	608.8	722.6	774.4	644.7
2021	785.6	769.9	703.1	629.3	579.9	556.1	560	565.3	559	616.7	731.7	783.7	652.8
2022	795.9	779.9	712.2	637.4	587.3	563.1	567	572.4	566.1	624.5	741.2	793.9	661.2
2023	804	787.9	719.4	643.7	593.1	568.6	572.6	578	571.7	630.7	748.7	802	667.8
2024	811.6	793.5	726.3	649.6	598.3	573.5	577.6	583.1	576.5	636.5	756	810.1	674.1
2025	819.3	802.8	732.9	655.7	604	579.1	583.1	588.7	582.1	642.5	762.8	817.2	680.2
2026	826.9	810.3	739.7	661.7	609.5	584.3	588.4	594	587.4	648.3	769.9	824.8	686.5
2027	834.4	817.6	746.3	667.6	614.8	589.4	593.5	599.2	592.5	654	776.8	832.3	692.6
2028	840.9	822.1	752.3	672.6	619.3	593.5	597.7	603.4	596.6	658.9	783.1	839.3	698

2012 Load Forecast of Tacoma Power's total system before acquiring any conservation (reported in aMW)

The graph below represents the Tacoma Power historical total system load and the 2009, 2010, 2011, and 2012 Load Forecasts. Historically, Tacoma Power has been very successful in predicting near-term loads. The longer term forecast is far from certain. While the forecasts are smooth, the economy and new or lost customers can cause the actual load to move up or down fairly rapidly. This can easily cause jumps or drops of 20 to 40 aMW, illustrated in the contraction from 2008 to 2010. Large drops like the one in 2000 to 2001 are caused by the loss of very large customers. So while the timing of economic shocks is unknown, we can still plan for them. Tacoma uses stochastic shifts in load to model these effects and to "stress test" the load resource balance effects of conservation and new resources.



FINAL REPORT

Tacoma Power
15-Year Conservation Potential Assessment for the 2013 Integrated Resource Plan

November 2013

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Executive Summary

Overview

This 15-year Conservation Potential Assessment (CPA) summarizes results from an independent study of potentials for electric demand-side management (DSM) resources in Tacoma Power's service area from 2014 to 2028. Tacoma Power commissioned the analysis as part of its biennial integrated resource planning (IRP) process.

The study, building on previous efforts, has incorporated improvements over the 2010 assessment, regarding scope and methodology. As in the previous study, the assessment included savings from electric energy-efficiency measures. This study benefited from updated baseline and DSM data, informed by primary and secondary data collection as well as from efforts of other entities in the region, such as the Northwest Power and Conservation Council (the Council), and including the Regional Technical Forum (RTF). In addition, this study has incorporated savings from conservation acquired by Tacoma Power since the previous study. Methods used to evaluate technical potentials and cost-effectiveness drew upon utility industry best practices, consistent with the Council's methodology in assessing regional conservation potentials in the Northwest.[1] This study estimated potential for the residential, commercial, and industrial sectors. Independently, Tacoma Power's Transmission and Distribution department developed a potentials assessment for savings for its sector.

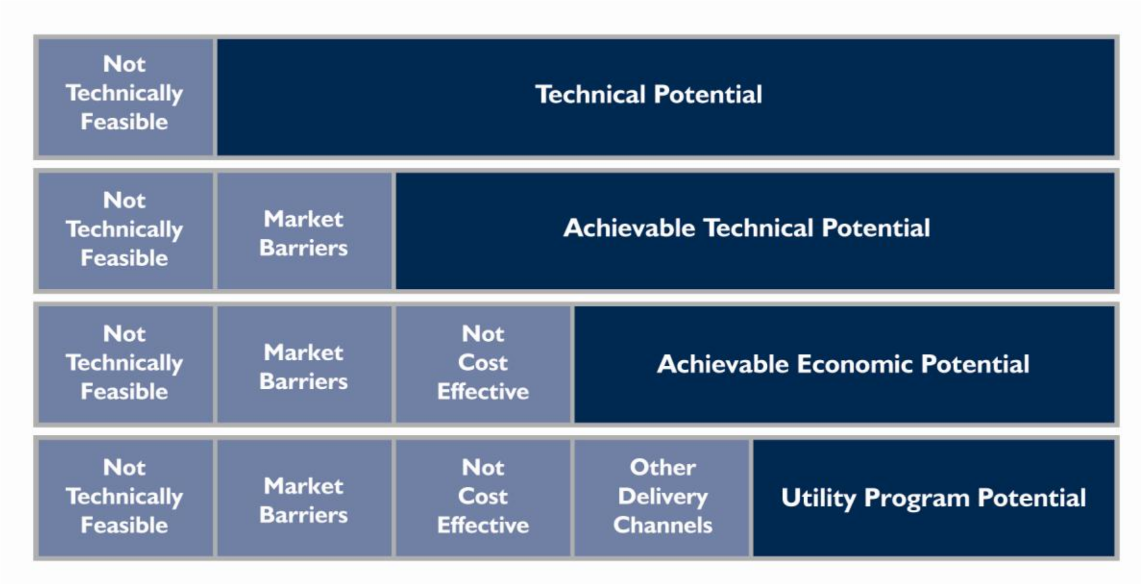
Figure ES-1, below, shows types of potential available in a utility's territory. The largest portion derives from "technical potential." This represents savings from the universe of all technically feasible measures potentially installed. A portion of technical potential will never be installed due to market barriers—with the resulting potential being the achievable technical potential.

The next level down—achievable economic potential—is determined by applying a cost-effectiveness screen, based on the utility's avoided cost. Only measures with a benefit-to-cost ratio greater than one, based on the Total Resource Cost Test, constitute achievable economic potential.

Finally, a portion of this achievable economic potential will actually be best delivered through channels other than utility programs, such as market transformation efforts, codes and standards, and other non-programmatic opportunities. This CPA presents technical, achievable technical, and achievable economic potential. Program potential has not been assessed.

[1] The methodology can be found at:
http://www.nwcouncil.org/energy/powerplan/6/supplycurves/I937/CouncilMethodology_outline%20_2_.pdf

Figure ES-1. Energy-Efficiency Potentials



Summary of the Results

Table ES-1 shows 2028's forecasted potential by sector for the 15-year horizon. With market constraints accounted for, the achievable technical potential is just under 67 aMW. Applying the forecast market price of electricity to each of these measures, the achievable economic conservation potential amounts to 59.5 aMW. Results shown are at the meter.

Table ES-1. Energy Conservation Potential by Sector (aMW in 2028)

Sector	Achievable Technical Potential	Achievable Economic Potential
Residential	35.9	32.1
Commercial	15.8	10.5
Industrial	13.4	12.7
Federal Facilities*	NA	2.7
Distribution Efficiency	1.5	1.5
Total	**66.7**	**59.5**

* Only achievable economic potential was assessed for the federal facilities (JBLM).

Comparison with 2010 Assessment

As noted, this assessment updates to the one completed in 2010. Compared to the previous assessment, achievable economic potential has decreased from 56 to 40 aMW. This change is attributed to the following factors:

- **Decrease in the baseline sales forecast.** The 15-year sales forecast decreased by 6%, largely in the nonresidential sector (reduced potential).
- **Accounting for program accomplishments.** From 2011–2013, Tacoma Power acquired approximately 18 aMW in system-wide savings (reduced potential).

- **Wholesale price forecast.** Modeling the value of conservation on an hourly basis instead of the heavy load, light load monthly basis resulted in finer resolution of cost effectiveness. The most significant change was addition of the ductless heat pump in a standard electric heat single family home (increased potential).
- **Adjustments to technical assumptions.** Updates primarily affected measure savings and costs, based on more recent data (largely from the RTF). The most significant changes were; determination that heat pump water heaters are mostly not cost effective (reduced potential), phasing out of compact fluorescent lamps (CFLs) from the potential (reduced potential), applied ductless heat pump to central forced air electric heated homes (increased potential).
- **Accounting for pending codes and standards in the baseline.** Any new codes and standards not enacted at the time of the 6th Power Plan have been included in the baseline and measure definitions (reduced potential).

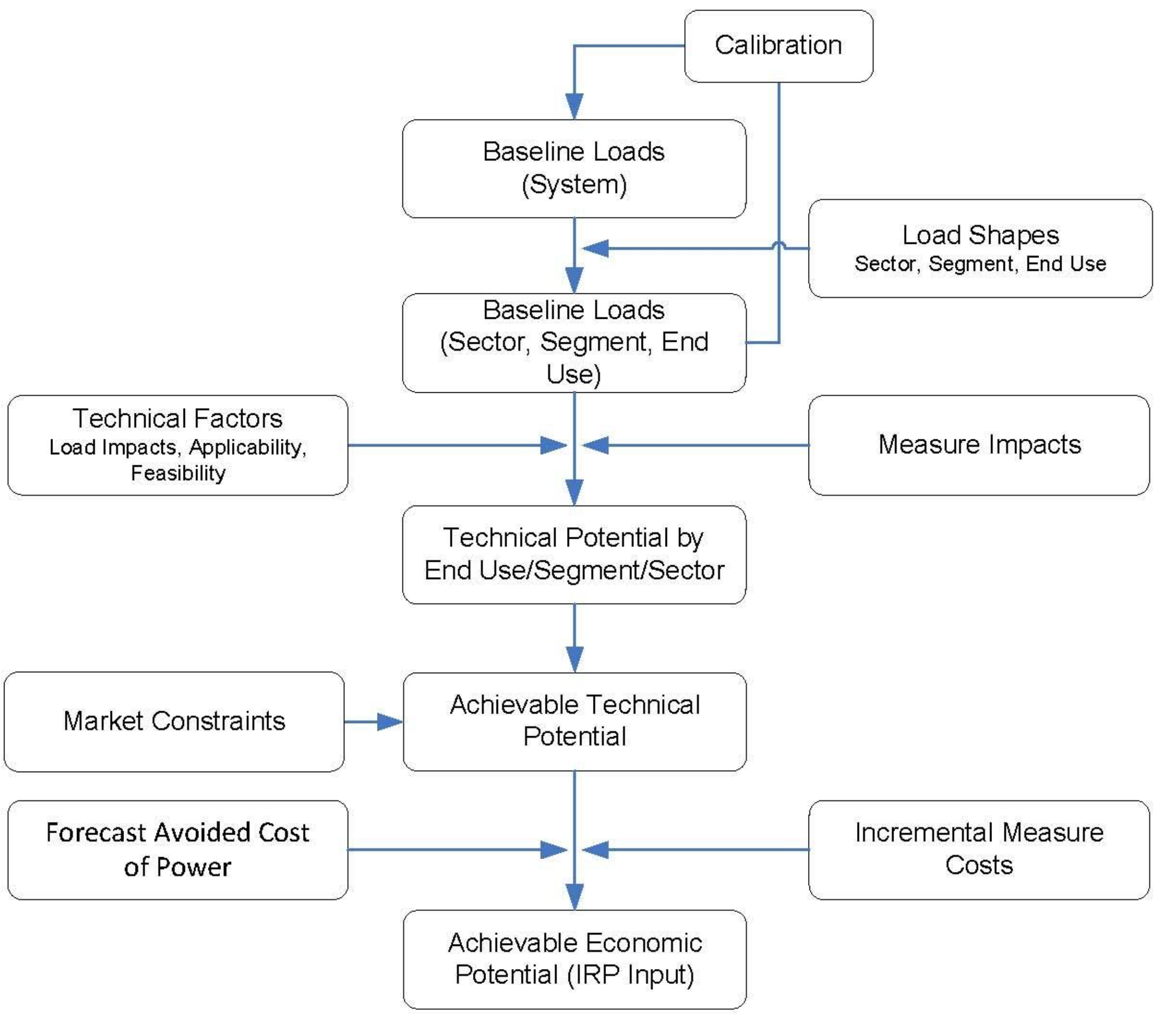
Most of these factors have driven the potential down, with the net result decreasing about 28% for the 15-year potential. Although this CPA uses a more current price forecast, the average avoided cost (approximately $37 per MWh) including Power Act 10% for conservation and risk adders is comparable to that used in the previous study.

1. General Approach and Methodology

Demand-side management (DSM) resources analyzed through this study differ regarding technology, availability, type of load impact, and target consumer markets. Analysis of their potentials required customized methods, addressing the unique characteristics of each resource. Still, these methods derived from the same conceptual framework and general analytic approach.

The general methodology can best be described as a hybrid "top-down/bottom-up" approach. As shown in Figure 1, this began with the current load forecast, decomposed into its constituent customer-class and end-use components, and examining effects of a range of DSM resources and practices on each end use, accounting for fuel shares, current market saturations, technical feasibility, and costs. These unique impacts were aggregated to produce estimates of resource potentials at the end-use, customer-class, and system levels.

Figure 1. General Methodology for Assessment of Demand-Side Resource Potentials



The basic methodology for estimating energy-efficiency potential remained consistent for all three sectors:

- **Develop a baseline forecast:** A baseline forecast was created, based on end-use consumption estimates, and calibrated to Tacoma Power's base year sales and official forecast. This provided accurate estimates of consumption by fuel, sector, customer segment, end use, and year.
- **Compile measure lists:** All measures applicable to Tacoma Power's climate and customers were analyzed to accurately depict energy-efficiency potential over a 15-year planning horizon. This list was based on measures used by the Northwest Power and Conservation Council (the Council) for the Sixth Northwest Conservation and Electric Power Plan (6th Power Plan). When expanded by customer segment and end use, this list totaled over 3,186 measures (as discussed in further detail below).
- **Estimate Potentials:**
  - Naturally occurring conservation refers to energy-efficiency gains occurring due to normal market forces, such as technological changes, energy prices, market transformation efforts, and improved energy codes and standards. In this analysis, market effect components of naturally occurring conservation were accounted for by explicitly incorporating changes to codes and standards, and to marginal efficiency shares in development of the base-case forecasts.
  - Technical potential assumes all resource opportunities may be captured, regardless of costs or market barriers. For demand-side resources, such as energy efficiency, technical potentials further fall into two classes: "instantaneous" (discretionary); and "phased-in" (lost-opportunity) resources.
  - Achievable technical potential is defined as the portion of technical potential that might be assumed achievable in the course of the planning horizon, given market barriers, which may impede customer participation in DSM programs. Assumed achievable potentials levels principally are meant to serve as planning guidelines. Ultimately, actual achievable opportunity levels will depend on: customers' willingness and ability to participate in demand-side programs; administrative constraints; and availability of an effective delivery infrastructure. Customers' willingness to participate in demand-side programs also depends on incentive amounts offered.
  - Achievable economic potential is defined as the portion of achievable technical potential proving cost-effective, using the utility's avoided cost and discount rate as the basis for the economic screen. Measures with a benefit-cost ratio greater than one are included in achievable economic potential.

Measures used to assess potential have been classified into the following four categories:

- ***Discretionary*** represents retrofit opportunities in existing construction. Examples of such measures include: shell improvements (insulation, weather-stripping, etc.); and early equipment replacement. This potential can be considered a "retrofit" as it occurs in existing building stock, and, theoretically, is available for acquisition any time during the study.

- ***Existing lost opportunity*** refers to efficiency upgrades conducted during normal replacement of equipment in existing buildings. This includes efficient end-use equipment, such as central air conditioners and ENERGY STAR® appliances. The availability of these resources is driven by equipment burnout rates; if an opportunity to upgrade is missed, it must wait until new equipment burns out (a lost opportunity).
- ***New construction improvements*** represent potentials specific to measures in new construction. For some retrofit measures, costs and savings will be different from existing construction due to differing baseline conditions (building codes vs. existing conditions). Availability of this potential will be driven by Tacoma's new construction forecast, and missed efficiency upgrades will typically need to wait until installed technologies must be replaced (a lost opportunity).

The methodology used for estimating technical energy-efficiency potential has been based on standard industry practices, consistent with the methodology the Council used in its assessments of conservation potentials for the 6th Power Plan, and electric energy-efficiency technologies and measures considered in this study include those used in the 6th Power Plan. For example, as described in Section 2, ramp rates used to determine achievable potential for retrofit opportunities were consistent with rates the Council used for calculating achievable potentials in the 6th Power Plan. Appendix A provides a detailed discussion of the methodology for estimating energy-efficiency potential.

This study used energy codes and appliance standards in effect by 2013, including impacts of the 2009 Washington Energy Code.

In compliance with rules established in Chapter 194-37-070 (6) of the Washington Administrative Code (WAC), this report fully describes technologies, data inputs, data sources, data collection processes, and assumptions used in calculating technical and achievable long-term potentials.

Organization

Four sections of this report each present results per sector:

- Combined;
- Residential;
- Commercial; and
- Industrial.

The final section presents potentials from alternative economic forecasts. Additional technical information, and descriptions of data, and their sources, are included in the document's appendices.

2. Energy-Efficiency Potentials

Scope of Analysis

This assessment's primary objective has been to develop accurate estimates of available energy-efficiency potential, essential for Tacoma Power's Conservation Potential Assessment (CPA) and program planning efforts. To support these efforts, Cadmus performed an in-depth assessment of technical, achievable technical, and achievable economic potential for electric resources in the residential, commercial, and industrial sectors.

Data on measure costs, savings, and market size were collected at the most granular level possible. Within each sector, the study distinguished between customer segments or facility types, and their respective applicable end uses. Analysis included:

- Six residential segments (existing and new construction for single-family, multifamily, and manufactured homes);
- 20 commercial segments (10 building types within existing and new construction vintages); and
- 17 industrial segments.

The study includes a comprehensive set of energy-efficiency electric measures, applicable to the climate and customer characteristics of Tacoma Power's service territory. This list has been based on measures used in the Council's 6th Power Plan, and includes measures analyzed for the previous CPA, and new measures commercially available since the last study. The analysis began by assessing technical potential for 302 *unique* electric energy-efficiency measures (shown in Table 1). Considering all permutations of these measures across all customer sectors and segments, customized data had to be compiled and analyzed for 3,186 measures.

Table 1. Energy-Efficiency Measure Counts by Sector

Sector	Measure Counts	
	Unique	Permutations
Residential	75	396
Commercial	173	1814
Industrial	54	976

This study used the 2009 Washington State energy code for new construction as a baseline. In addition, Federal standards, as of July 1, 2011, were incorporated.[2]

Part of Tacoma Power's load (32,000 MWh annually) is attributable to facilities for which potential has not been calculated, including:

- Port cranes;
- Refrigerated containers temporarily stored at port (excluding lighting improvements);

[2] Many of these were also incorporated in the 6th Power Plan (see Table 4-1 of the 6th Power Plan).

- Certain accounts closed during the period; and
- Wholesale power to the City of Ruston.

This report includes the results of two separate studies at two large federal facilities: McChord Air Force Base; and Fort Lewis (now known as Joint Base Lewis-McChord [JBLM]). The Bonneville Power Administration (BPA) completed a comprehensive energy audit of these federal facilities. Audit summary results, provided in Appendix B, determined achievable economic potential of 2.8 aMW for these facilities. For this report, accomplishments of 0.1 aMW following the audit were removed from assessed potential.

In addition, this report includes the results of a separate study of the Tacoma Power distribution system efficiency. Tacoma contracted with RW Beck (an SAIC company) to conduct a detailed distribution efficiency study of three representative substations. The results were applied the other similar substations to estimate potential. Audit summary results, provided in Appendix C, determined an economic potential of 1.5 aMW for these systems.

The remainder of this section divides into three parts:

- A brief description of the methodology used for estimating technical and achievable technical potential;
- A summary of resource potentials by sector and jurisdiction; and
- Detailed sector-level results.

Summary of Resource Potential

Table 2 shows 15-year (2014–2028) forecasted potentials by sector. Study results indicate just under 67 aMW of achievable technically feasible, electric energy-efficiency potential will be available by 2028, the end of the 15-year planning horizon (not including federal facilities). Achievable economic potential is just over 59 aMW. All results shown are at the meter. The 59 aMW of achievable economic potential in 2028 would reduce 189,000 tonnes of generated CO_2 per year, over the course of the nearly 16-year weighted average measure lifetime.[3]

[3] Estimated CO_2 reduction would not result directly from Tacoma Power. The utility has an oversupply of electricity, generated predominantly through dams, which emit no CO_2. Rather, the savings estimate assumes Tacoma Power would sell excess power, and the purchasing utility would use this electricity to displace energy it would otherwise produce through a natural gas combustion turbine.

Table 2. Summary Conservation Potential by Sector (aMW in 2028)

Sector	Achievable Technical Potential	Achievable Economic Potential
Residential	35.9	32.1
Commercial	15.8	10.5
Industrial	13.4	12.7
Federal Facilities*	NA	2.7
Distribution Efficiency	1.5	1.5
Total	**66.7**	**59.5**

* Only achievable economic potential was assessed for the federal facilities (JBLM).

The conservation potential assessment maintains neutrality regarding acquisition approaches required. Some technologies require "upstream" encouragement, which most utilities, on their own, cannot fulfill. However, groups within the region may be able to acquire these savings on the utility's behalf. Consequently, these actionable potentials have been included.

Further, these savings have been based on forecasts of future consumption, absent utility program activities. While consumption forecasts account for past savings Tacoma Power has acquired, estimated potential includes—rather than adds to—current or forecasted program savings.

Effective conservation programs will be critical for capturing lost opportunity potentials of replacements on burn-outs, new construction, and major remodels, which account for about 43% of the total achievable economic potential. The potentials, by acquisition type and sector, are shown in Table 3.

Table 3. Achievable Economic Potential by Acquisition Type (aMW in 2028)

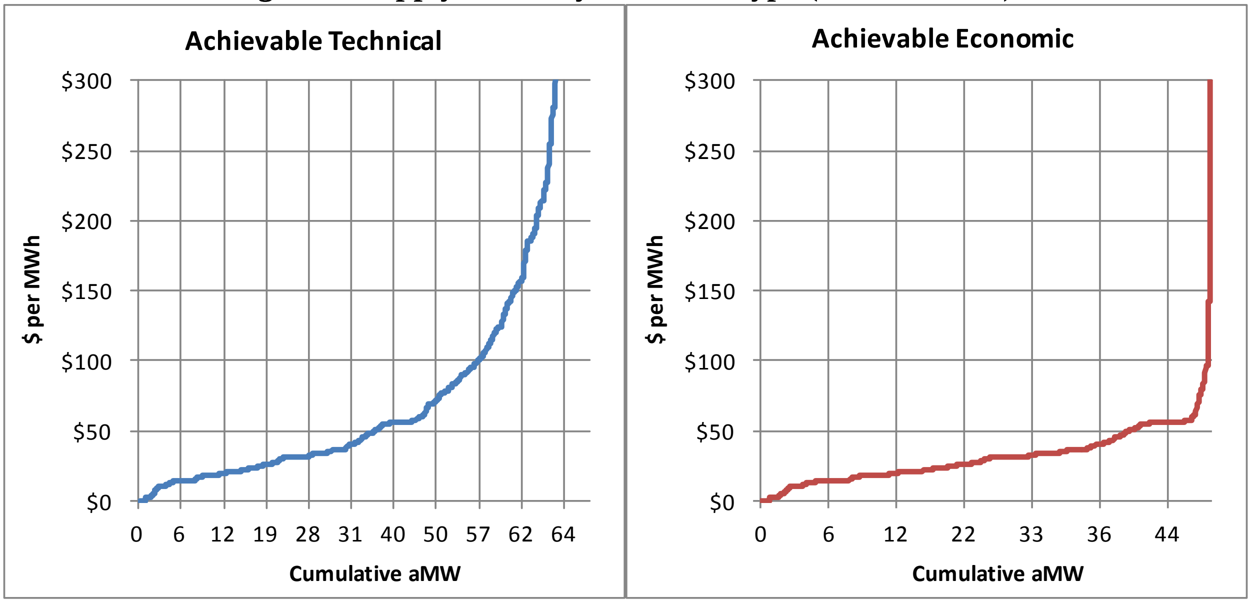
	Discretionary	Lost Opportunity Existing Construction	Lost Opportunity New Construction	Total
Residential	13.8	14.1	4.3	32.1
Commercial	3.1	6.1	1.3	10.5
Industrial	12.7	0	0	12.7
Federal Facilities	2.7	NA	NA	2.7
Distribution Efficiency	1.5	NA	NA	1.5
Total	**33.7**	**20.2**	**5.6**	**59.5**

Figure 2 shows a supply curve of commercial, industrial, and residential resources totaling 55 aMW, based on levelized costs. This curve represents the universe of measures evaluated for this study, and their relative contribution to potential. Measure costs used in this analysis includes Tacoma specific direct administration costs for the programs. Because the measures are economically screened using the Total Resource Cost (TRC) approach,[4] which incorporates NEBs, this allows measures with a cost well above the levelized avoided cost (around $37 per MWh) to pass the economic screen. Note that the shape of energy savings for each measure tends to weight higher cost avoided cost hours, which are generally higher than a simple 20 year

4 As required by the Washington Energy Independence Act.

levelized cost. Note that while a measure with a high levelized cost could pass the TRC, the utility is ultimately limited to offer incentives no higher than the forecast avoided whole cost of power for that measure, which can be considerably lower.

Figure 2. Supply Curve by Potential Type (aMW in 2028)



Alternative Scenarios

In addition to reference case results shown above (and throughout most of the report), the assessment studied two alternate scenarios:

- A high avoided-cost scenario:
  - A levelized avoided cost of $51 per MWh which includes a Power Act 10% for conservation adder.
  - The most significant measures introduced under this scenario included: conversion of electric forced air heating to a heat pump. This measures accounted for approximately 51% of additional potential in this avoided-cost scenario.
- A low avoided-cost scenario:
  - A levelized avoided cost of $30 per MWh which includes a Power Act 10% for conservation and risk adders.
  - The most significant measures no longer remaining cost-effective under this scenario included: residential weatherization measures (windows and insulation); large home and standard home ductless heat pumps also no longer proved cost-effective in some specific facility types. These measures accounted for approximately 87% of the lost potential under this avoided-cost scenario.

Table 4 shows results of the high and low avoided-cost scenarios. Note the potential estimate for federal facilities was not included in the scenario analysis.

Table 4. Achievable Economic Potential under Alternate Scenarios (aMW in 2028)

Sector	Low Avoided Cost	Medium Avoided Cost	High Avoided Cost
Residential	22.7	32.1	32.3
Commercial	9.5	10.5	10.7
Industrial	11.7	12.7	12.8
Federal Facilities	2.7	2.7	2.7
Distribution Efficiency	1.5	1.5	1.5
Total	**48.1**	**59.5**	**60.0**

3. Residential Sector

Single-family, manufactured, and multifamily dwellings composing this sector present a variety of potential savings sources, including:

- Equipment efficiency upgrades (e.g., heat pumps, refrigerators);
- Improvements to building shells (e.g., insulation, windows, air sealing); and
- Increases in lighting efficiency (e.g., compact fluorescent light [CFL] bulbs; light emitting diode [LED] interior lighting).

Table 5 shows potentials by segment, with results given at the meter. The 32.1 aMW of achievable economic potential in 2028 would reduce approximately 102,000 tonnes of generated CO_2 per year over the course of a nearly 18-year weighted average measure lifetime.

Table 5. Residential Sector Potential by Segment (aMW in 2028)

Segment	Achievable Technical	Achievable Economic	Achievable Economic as % of Total
Single-Family	27.8	23.7	74%
Multifamily	5.9	6.2	19%
Manufactured	2.2	2.2	7%
Total	**35.9**	**32.1**	**100%**

The achievable economic potential estimate presented in this study represents the total potential to be realized in Tacoma Power's service area. These savings may be partly realized by Tacoma Power through its programs, but savings will derive from other channels. For example, potential for certain conservation measures, such as refrigerators and many residential plug loads, will be realized through other regional entities, such as the Northwest Energy Efficiency Alliance (NEEA) or through new codes or standards.

As shown in Table 5, single-family homes represent 74% of the total achievable economic electric potential for the residential sector, followed by multifamily and manufactured homes (19% and 7%, respectively). Each home type's proportion of baseline sales primarily drives these results, but other factors, such as heating fuel sources, play important roles in determining potential. For example, manufactured homes typically have more electric heating than other home types, increasing their relative share of the potential. Conversely, lower average use per customer for manufactured units decreases this potential, as the same measures may save less in a manufactured home than in a single-family home. Appendix A provides further detail regarding these factors.

Figure 3 shows a supply curve of resource potentials, based on levelized costs for the residential sector. The achievable technical curve differs from achievable economic curve due to interactions between energy-efficiency measures that do not pass the economic screen.

Figure 3. Residential Supply Curve by Potential Type (aMW in 2028)

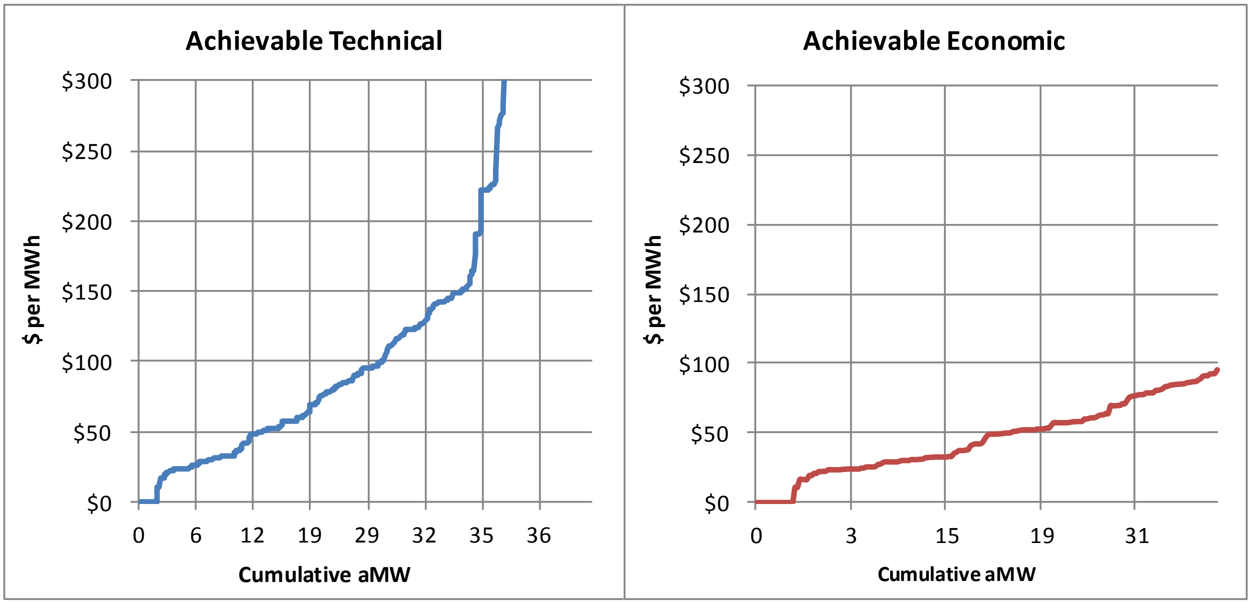


Figure 4 shows total achievable economic potential by end-use category. As indicated:

- Space heating represents the largest portion (47%) of achievable economic potential. This end use includes heating savings from weatherization measures as well as from space heating equipment measures (e.g., converting a forced-air furnace to a heat pump in new homes, and converting baseboard heating to a ductless heat pump in existing home).[5]
- Plug loads represent approximately 35% of achievable economic potential, and include non-refrigeration appliances, such as set-top boxes (representing more than half of the plug load potential), televisions, computers, and clothes washers.
- While this study has accounted for expected impacts of new lighting standards outlined in the 2007 Energy Independence and Security Act, lighting still represents the third-largest portion (5%) of achievable economic potential.
- Water heating accounts for 13% of achievable economic potential, after incorporating new federal water heating standards, effective in 2014. This potential is primarily Showerheads.
- Other potential includes the refrigerator end use (accounting for less than 1% of the potential) only encompasses savings from replacing refrigerators with ENERGY STAR

[5] The heat pump end use only includes upgrading a less-efficient heat pump to a more-efficient unit, while the conversion to a heat pump is categorized under the space heating end use. These have been treated separately due to complications arising from heating and cooling savings associated with heat pumps

or better units. Savings for this end use are lower than previous assessments due to efficiency standards scheduled for 2014.

Figure 4. Residential Sector Achievable Economic Potential in 2028 by End Use

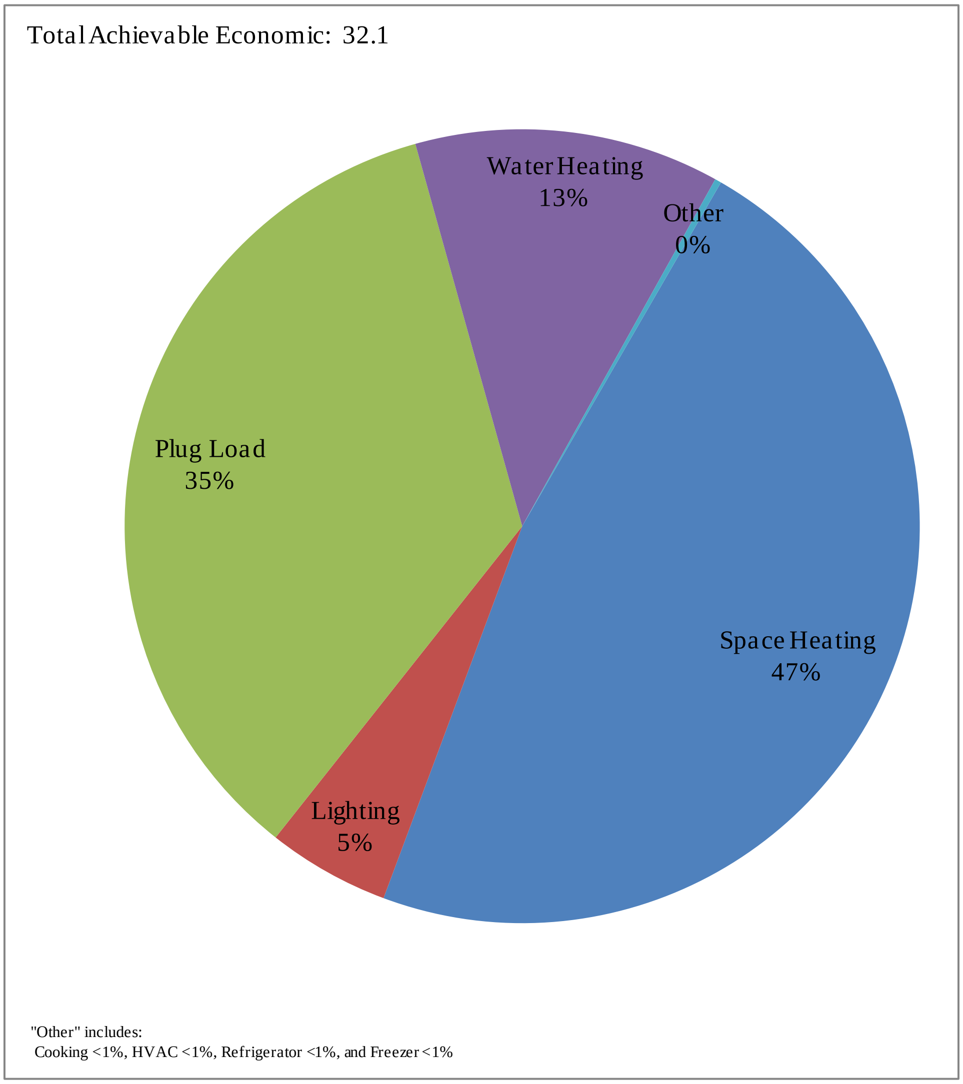


Table 6 provides detailed sales and potentials by end use. Baseline sales total across Tacoma's territory. Although baseline sales for plug loads nearly equal space heat, this does not imply, in a given home, space heating usage equals all plug loads. Rather, only about half the homes in Tacoma's territory have electric space heating, but all homes have plug loads; thus, total sales account for these fuel share and saturation distributions. Appendix A provides further information on data sources used to calculate these potentials.

Economic potential in this assessment includes measures such as specialty lighting which is difficult to implement even though it is widely commercialized. Specialty lighting accounts for approximately 5% of Tacoma Power residential achievable economic potential. Acquiring these savings will require aggressive program activity since the right specialty bulb can be highly specific to the application.

Table 6. Residential Sector Potential by End Use (aMW in 2028)

End Use	Achievable Technical	Achievable Economic
Space Heating	**15.8**	**15.2**
Ductless Heat Pump	6.6	5.8
Weatherization	5.8	6.6
Heat Pump Conversion	3.4	2.8
Lighting	**1.9**	**1.6**
General Service	.4	0.4
Specialty	1.4	1.2
Plug Load	**8.7**	**11.3**
ENERGY STAR Computer	1.8	0.0
ENERGY STAR Set Top Box	3.3	5.4
ENERGY STAR Television	3.3	5.4
Other	.4	0.4
Water Heating	**8.7**	**4.0**
Heat Pump Water Heater	4	<0.1
Showerhead	3.1	3.1
Clothes Washer	.9	0.9
Other	.7	-
HVAC Efficiency Upgrade	**0.1**	**0.1**
Heat Pump Upgrade	< 0.1	-
Room AC Upgrade	0.1	0.1
Cooking	**0.5**	**-**
Refrigerator	**< 0.1**	**< 0.1**
Freezer	**< 0.1**	**< 0.1**
Other	**0.2**	**-**
Total	**35.9**	**32.1**

Figure 5 and Table 7 show achievable economic potential by vintage and measure type, grouped as follows:

- Discretionary;
- Lost opportunity existing construction; and
- Lost opportunity new construction.

These distinctions prove important in terms of timing resource availability and acquisition, as only certain portions of potential can be accelerated. Though program planning falls outside this study's scope, these considerations remain vital for setting accurate annual program and portfolio goals.

Discretionary resources in existing construction account for 43% achievable economic potential, with lost opportunity measures in existing construction representing 57% of achievable economic potential. Given this study's time frame, with low expected housing starts, new construction potential composes just 13% of total achievable economic potential.

Effective and flexible conservation programs will prove critical to capturing lost opportunity potentials constituted by equipment replacement categories (14.1 aMW). In addition, for new construction potential (4.3 aMW), analysis has been based on the recently adopted 2009 energy code.

Figure 5. Residential Sector Achievable Economic Potential in 2028 by Acquisition Type

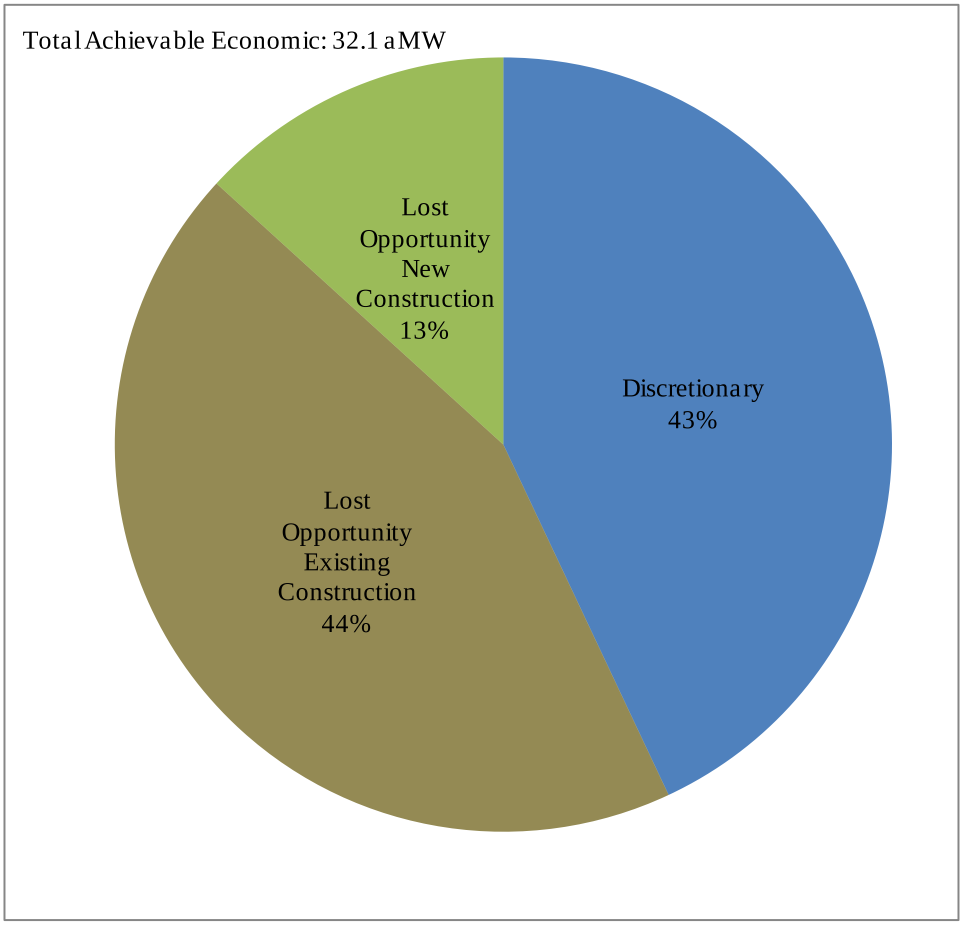


Table 7. Residential Sector Achievable Economic Potential by End-Use and Acquisition Type (aMW in 2028)

End Use	Discretionary	Lost Opportunity Existing Construction	Lost Opportunity New Construction	Total
Space Heating	**11.2**	**2.8**	**1.2**	**15.2**
Ductless Heat Pump	5.8	0.0	0.0	5.8
Weatherization	5.4	0.0	1.2	6.6
Heat Pump Conversion	0.0	2.8	0.0	2.8
Lighting	**0.0**	**1.5**	**0.1**	**1.6**
General Service	0.0	0.4	< 0.1	0.4
Specialty	0.0	1.1	< 0.1	1.2
Plug Load	**0.0**	**8.9**	**2.3**	**11.3**
Energy Star Computer	0.0	0.0	0.0	0.0
Energy Star Set Top Box	0.0	4.5	1.0	5.4
Energy Star Television	0.0	4.2	1.2	5.4
Other	0.0	0.3	0.1	0.4
Water Heating	**2.6**	**0.7**	**0.7**	**4.0**
Heat Pump Water Heater	0.0	< 0.1	< 0.1	< 0.1
Showerhead	2.6	0.0	0.5	3.1
Clothes Washer	0.0	0.7	0.2	0.9
Other	0.0	0.0	0.0	0.0
HVAC Efficiency Upgrade	**0.0**	**0.1**	**< 0.1**	**0.1**
Heat Pump Upgrade	0.0	0.0	0.0	0.0
Room AC Upgrade	0.0	0.1	< 0.1	0.1
Cooking	**0.0**	**0.0**	**0.0**	**0.0**
Refrigerator	**0.0**	**< 0.1**	**< 0.1**	**< 0.1**
Freezer	**0.0**	**< 0.1**	**< 0.1**	**< 0.1**
Other	**0.0**	**0.0**	**0.0**	**0.0**
Total	**13.8**	**14.1**	**4.3**	**32.1**
Percent of Total	**43%**	**44%**	**13%**	**100%**

4. Commercial Sector

A wide range of building types in this sector present a variety of potential savings sources, including:

- Increases in lighting efficiency (e.g., T-8 lighting; light emitting diode [LED] lighting in exterior and interior locations
- Equipment efficiency upgrades (e.g., heat pumps, refrigeration, motors, and process improvements

Data sources used to determine commercial sector potential include:

- Tacoma building classification (approximately 94% of the power sales);
- Commercial Building Stock Assessment;[6] and
- The Council's 6th Power Plan.

Based on resources included in this assessment, in 2028, approximately 15.8 aMW of achievable technical potential will be available. The achievable economic scenario results in 10.5 aMW of potential. Table 8 shows potential, broken out by segment.

[6] The 2007 CBSA data were parsed to include buildings in and near Tacoma power territory.

Table 8. Commercial Sector Potential by Segment (aMW in 2028)*

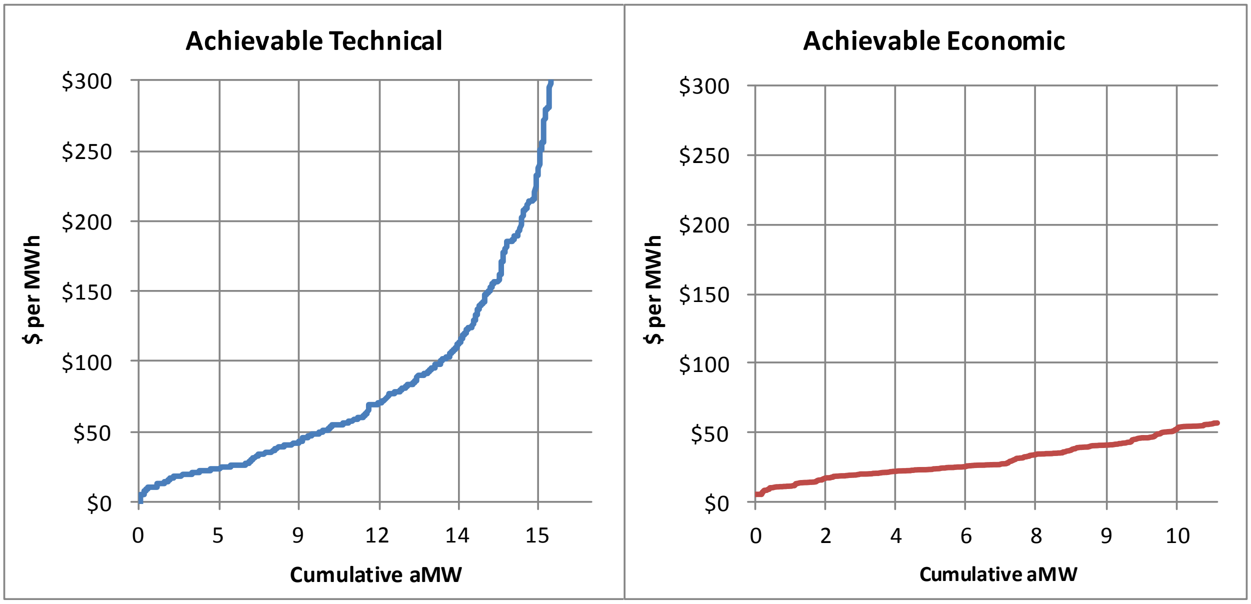
Segment	Achievable Technical	Achievable Economic	Achievable Economic as % of Total
Assembly	0.3	0.2	2%
Grocery	1.4	0.9	9%
Hospital	0.5	0.4	4%
K12	0.9	0.6	6%
Lodging	0.3	0.2	2%
Minimart	1.0	0.7	6%
Office	3.0	1.6	15%
Other Classified	2.2	1.3	12%
Other Health	0.6	0.4	3%
Other Unclassified	0.9	0.5	5%
Restaurant	0.9	0.7	6%
Retail	1.4	0.8	8%
Street Lighting	0.7	0.7	7%
University	0.6	0.4	4%
Warehouse	1.3	1.1	10%
Total	**15.8**	**10.5**	

*Numbers may not sum to total due to rounding.

The 10.5 aMW of achievable economic potential in 2028 would reduce approximately 33,000 tonnes of generated CO_2 per year over the course of the 15-year weighted average measure lifetime.

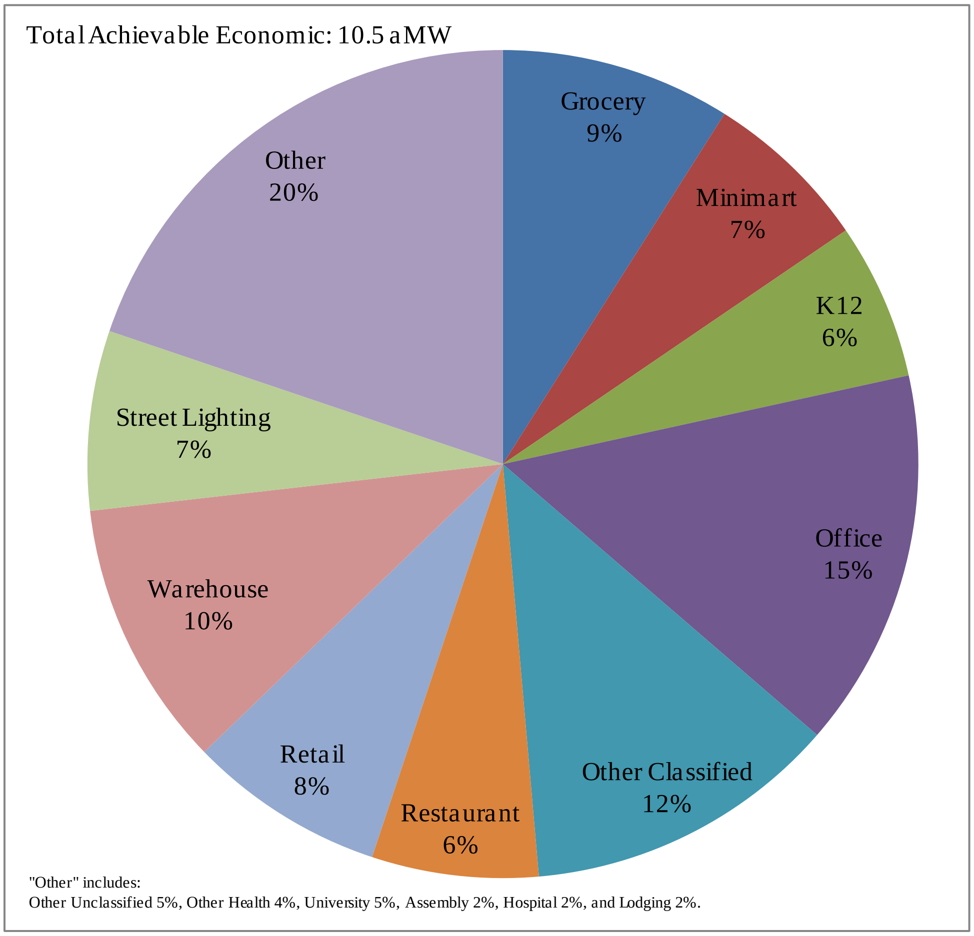
Figure 6 shows the supply curve of resource potentials, based on levelized costs for the commercial sector. The achievable technical curve differs from the achievable economic curve due to interactions between energy-efficiency measures not passing the economic screening.

Figure 6. Commercial Supply Curve by Potential Type (aMW in 2028)



As shown in Figure 7, offices, warehouse, and retail represent one-third of the available economic potential (15%, 10%, and 8%, respectively). Acquiring the savings potential of 2.6 aMW in the other classified and other unclassified segments will require nimble program design, as this sector represents great variety and unique requirements. Hospitals, accounting for 4% of the potential (part of the "Other" segment), represent approximately 30 known accounts, thus requiring active engagement with decision makers to acquire savings.

Figure 7. Commercial Sector Achievable Economic Potential in 2028 by Segment



Lighting efficiency represents, by far, the largest portion of achievable economic potential in the commercial sector (58%), followed by refrigeration (17%) and HVAC (17%), as shown in Figure 8. The large lighting potential includes meeting or exceeding code in existing buildings, and exceeding code in new and renovated existing structures. An estimate of Tacoma's street lighting segment has been included in the lighting potential. Measures considered in this analysis consisted of replacement of high-intensity discharge (HID) fixtures with LED fixtures of various wattages.

Figure 8. Commercial Sector Achievable Economic Potential in 2028 by End Use

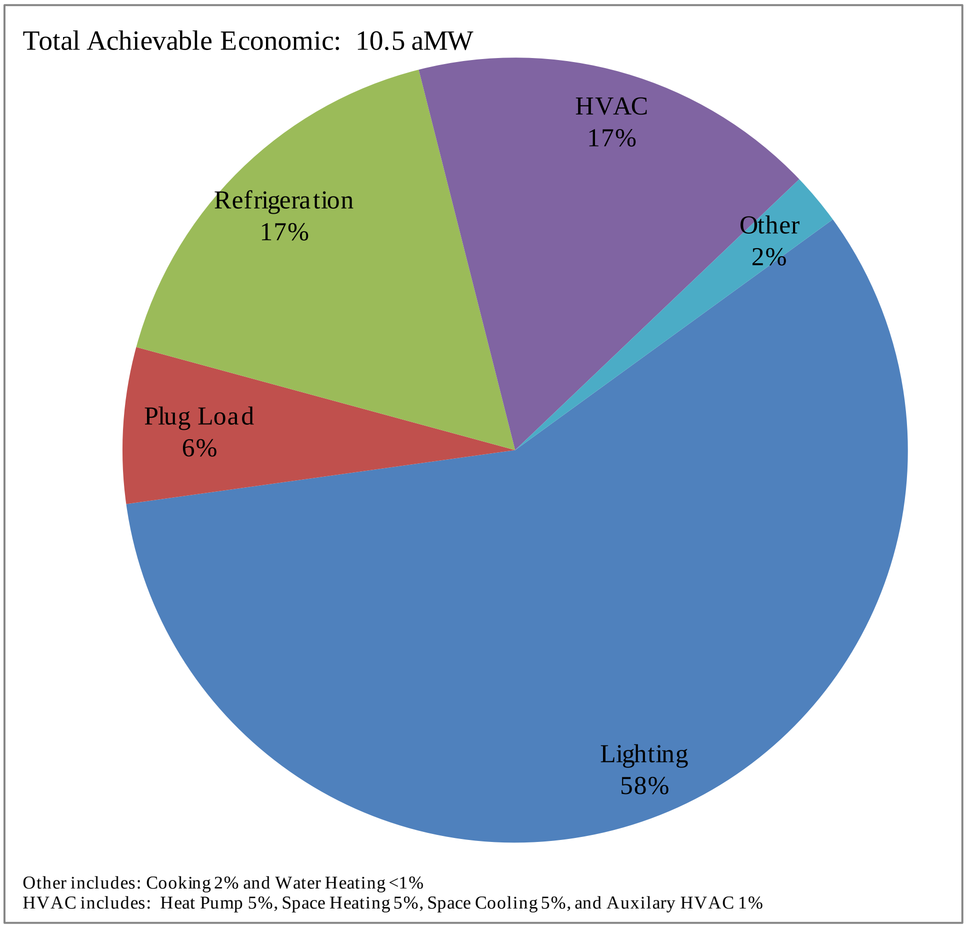


Table 9 shows the distribution of savings across end uses.

Table 9. Commercial Sector Energy-Efficiency Potential by End Use (aMW in 2028)

End Use	Achievable Technical	Achievable Economic
Space Heating	**1.5**	**0.6**
Controls	0.9	<0.1
Equipment Optimization	0.5	0.5
Other	0.1	0.1
Space Cooling	**0.9**	**0.6**
Equipment Optimization	0.4	0.4
Equipment Upgrade	0.4	0.1
Other	0.1	<0.1
Heat Pump	**0.9**	**0.5**
Controls	0.1	<0.1
Equipment Optimization	0.1	0.1
Equipment Upgrade	0.6	0.4
Other	<0.1	<0.1
Auxilary HVAC	**1.0**	**0.1**
Lighting	**7.2**	**6.1**
Interior	3.9	3.8
Exterior	1.2	1.2
Controls	1.0	0.3
Parking	0.3	0.0
Street Lighting	0.7	0.7
Plug Load	**1.5**	**0.7**
Energy Star Computer	0.2	0.0
Server Virtualization	0.4	0.1
PC Power Management	0.4	0.4
Other	0.4	0.1
Refrigeration	**2.7**	**1.8**
Case Lighting	1.1	0.4
Energy Star Refrigerator	0.6	0.6
Other	0.9	0.8
Cooking	**0.2**	**0.2**
Water Heating	**<0.1**	**<0.1**
Total	**15.8**	**10.5**

Figure 9 summarizes:

- Existing (lost opportunity existing construction);
- Major remodel (discretionary); and
- New construction commercial buildings' potential (lost opportunity new construction).

Many economic measures can be achieved through new construction and major remodels, primarily in building envelopes and systems. However, achievable economic potential associated with new construction depends on the load forecast over the period. The current load forecast indicates low load growth in the commercial sector, and, as a result, relatively low new construction potential.

Figure 9. Commercial Sector Achievable Economic Potential in 2028 by Acquisition Type

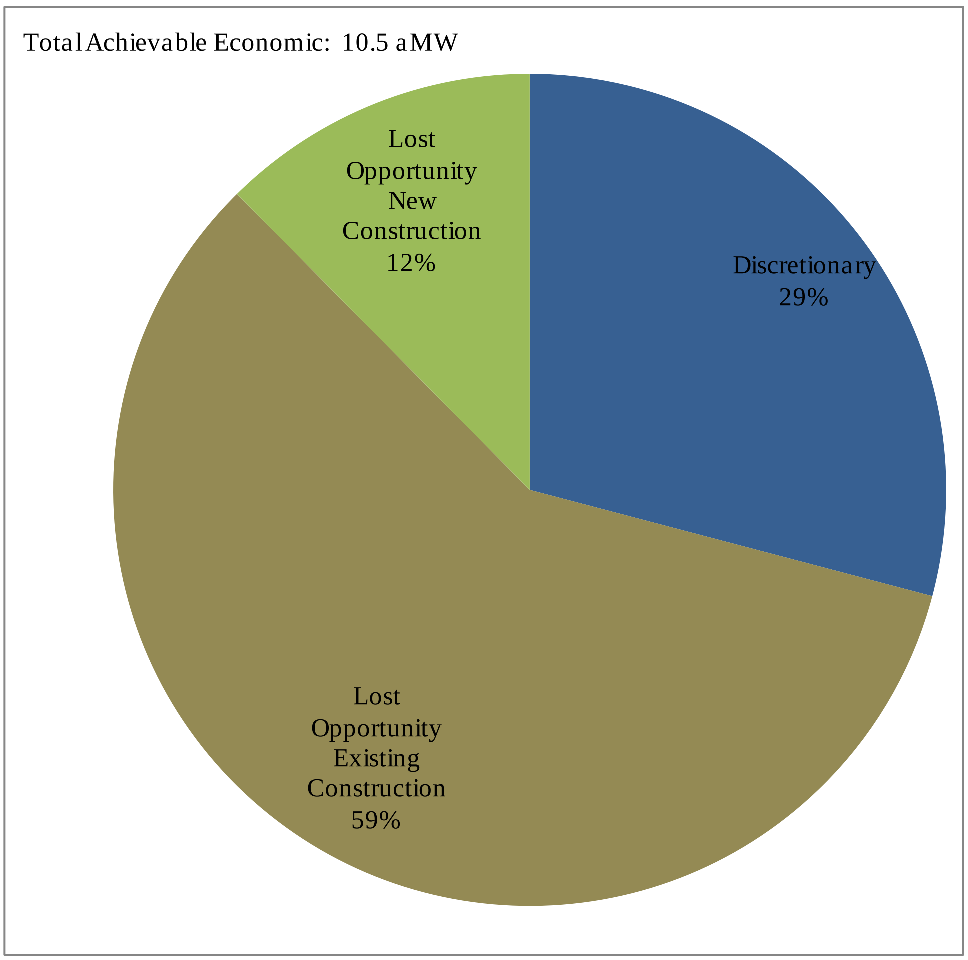


Table 10 breaks down commercial potential by acquisition type and end use. As shown, lighting accounts for 4.6 of the 6.1 aMW of available lost opportunity potential in existing facilities. Acquiring savings from these lost opportunity measures will require deep levels of engagement with lighting contractors and building managers at the time of building purchase or planned upgrades.

Table 10. Commercial Sector Achievable Economic Potential by End-Use and Acquisition Type (aMW in 2028)

End Use	Discretionary	Lost Opportunity Existing Construction	Lost Opportunity New Construction	Total
Space Heating	**0.5**	**0.1**	**<0.1**	**0.6**
Controls	<0.1	0.0	<0.1	<0.1
Equipment Optimization	0.4	0.0	<0.1	0.5
Other	<0.1	0.1	<0.1	0.1
Space Cooling	**0.3**	**0.2**	**0.1**	**0.6**
Equipment Optimization	0.3	0.1	0.1	0.4
Equipment Upgrade	0.0	0.1	<0.1	0.1
Other	0.0	<0.1	<0.1	<0.1
Heat Pump	**0.1**	**0.4**	**0.1**	**0.5**
Controls	<0.1	0.0	<0.1	<0.1
Equipment Optimization	0.1	<0.1	<0.1	0.1
Equipment Upgrade	0.0	0.4	<0.1	0.4
Other	<0.1	<0.1	<0.1	<0.1
Auxilary HVAC	**<0.1**	**0.1**	**<0.1**	**0.1**
Lighting	**0.7**	**4.6**	**0.8**	**6.1**
Interior	0.6	2.9	0.3	3.8
Exterior	0.0	0.9	0.3	1.2
Controls	0.1	0.2	<0.1	0.3
Parking	0.0	0.0	0.0	0.0
Street Lighting	0.0	0.6	0.2	0.7
Plug Load	**0.4**	**0.2**	**<0.1**	**0.7**
Energy Star Computer	0.0	0.0	0.0	0.0
Server Virtualization	0.0	0.1	0.0	0.1
PC Power Management	0.4	0.0	0.0	0.4
Other	0.0	0.1	<0.1	0.1
Refrigeration	**1.1**	**0.5**	**0.2**	**1.8**
Case Lighting	0.3	0.0	0.1	0.4
Energy Star Refrigerator	0.0	0.5	0.1	0.6
Other	0.8	0.0	0.0	0.8
Cooking	**0.0**	**0.2**	**<0.1**	**0.2**
Water Heating	**0.0**	**<0.1**	**0.0**	**<0.1**
Total	**3.1**	**6.1**	**1.3**	**10.5**

5. Industrial Sector

Energy-efficiency potentials were estimated for major end-uses within 13 industrial segments, plus water supply and wastewater. Across all industries, achievable economic potential totals approximately 12.7 aMW over the 15-year planning horizon. The 12.7 aMW of achievable economic potential in 2028 would reduce approximately 40,000 tonnes of generated CO_2 per year over the course of the 11-year weighted average measure lifetime

Figure 10 shows a supply curve of resource potentials, based on levelized costs for the industrial sector. In general, potentials in this sector tend to be less costly than those in the residential and commercial sectors.

Figure 10. Industrial Supply Curve by Potential Type (aMW in 2028)

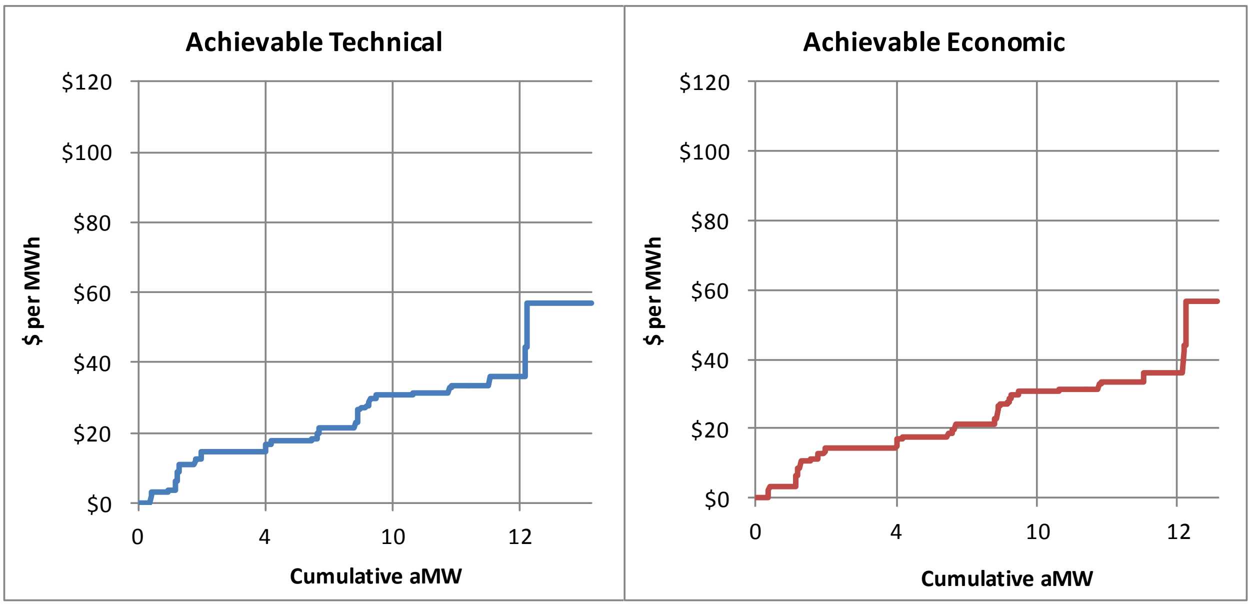
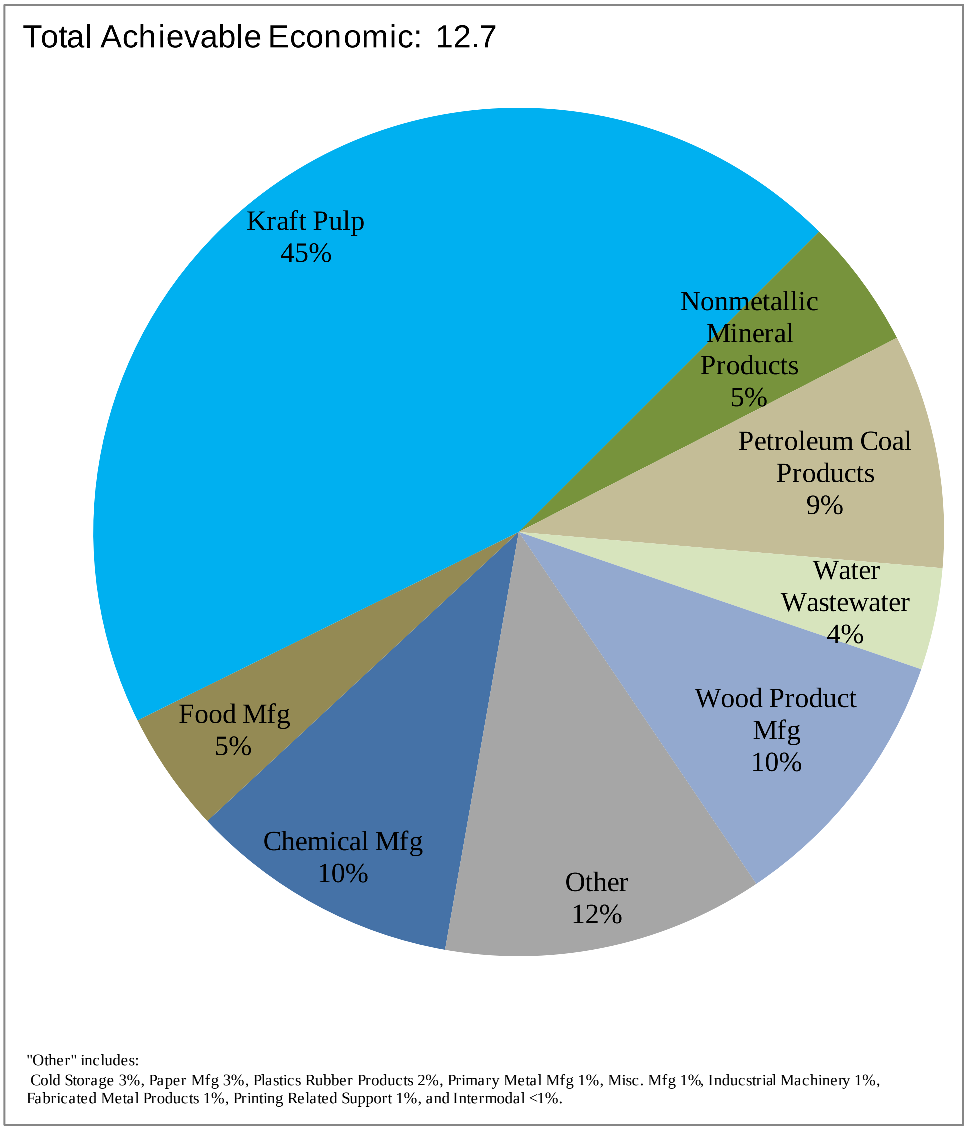


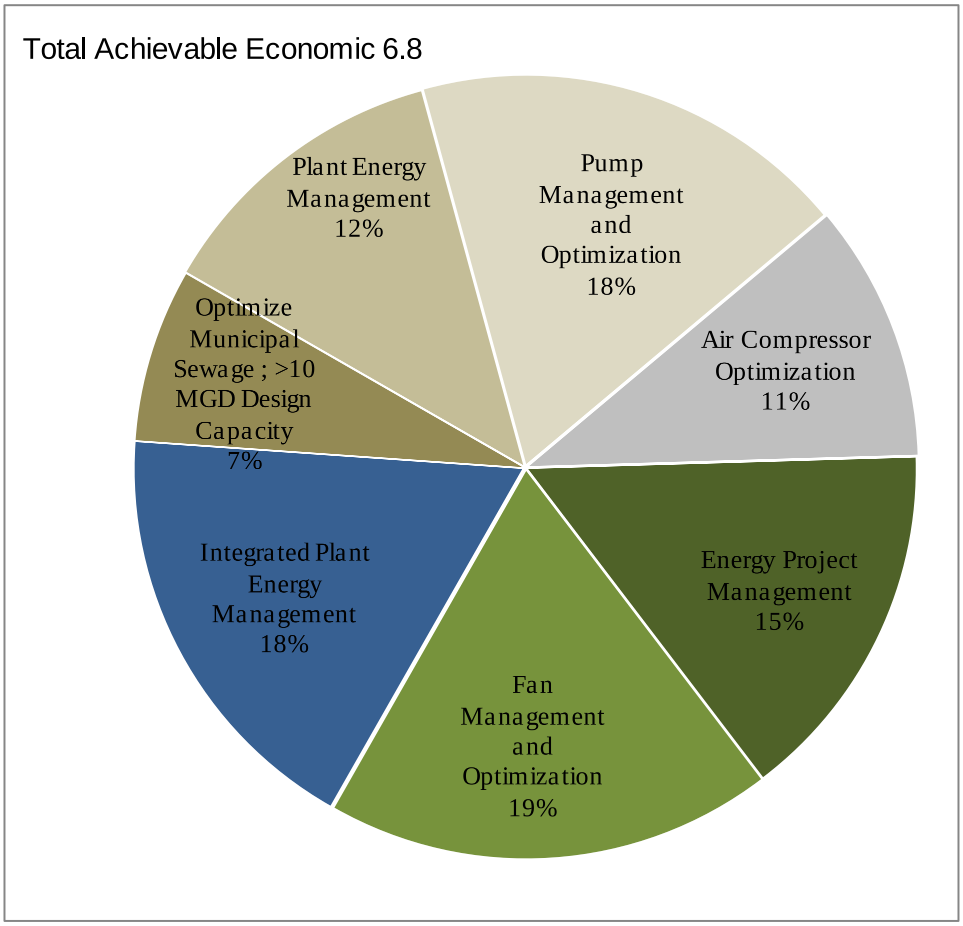
Figure 11 shows the distribution of achievable economic potential by subsector. Kraft pulp accounts for nearly half of the available potential.

Figure 11. Industrial Sector Achievable Economic Potential in 2028 by Segment



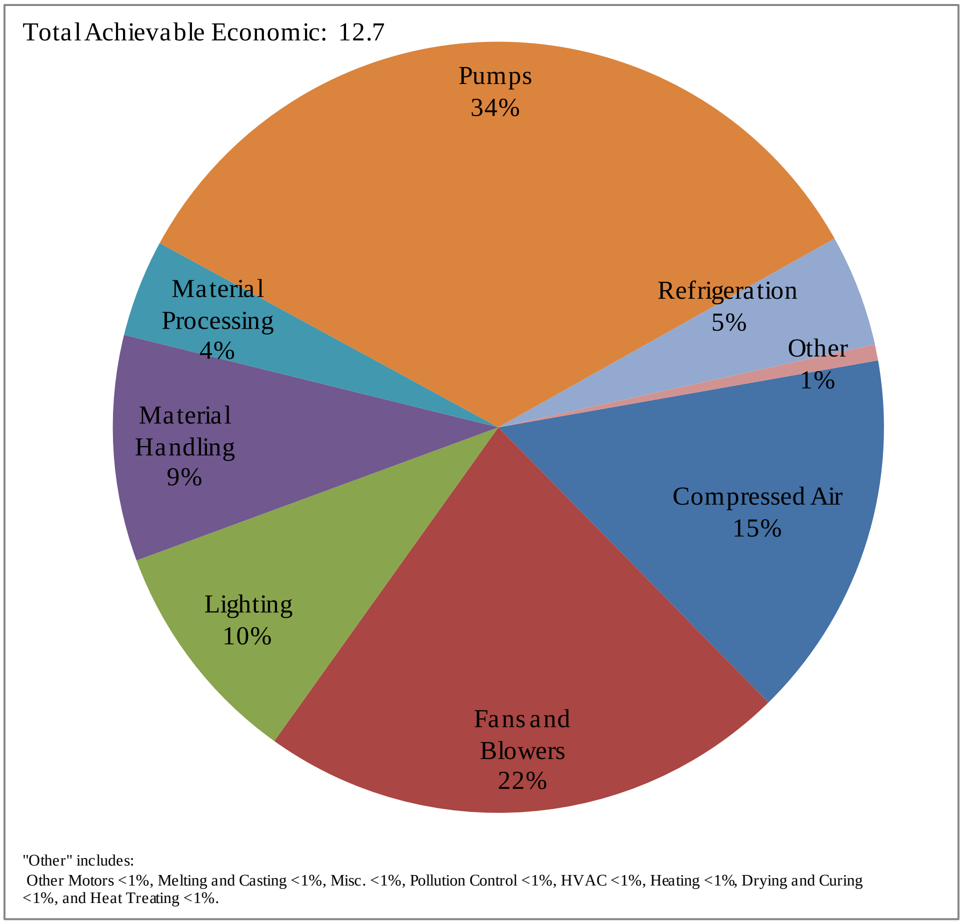
Most industrial sector achievable economic potential results from relatively low-cost measures. Energy management measures account for approximately half (6.8 aMW) of potential across all end uses. These measures, primarily operation and management strategies differing from the hardware components typically promoted in programs, may require a unique approach to capturing savings. Figure 12 shows the distribution of savings from individual energy management measures by end use.

Figure 12. Industrial Sector Achievable Economic Potential in 2028 by Energy Management Measures



By end use, the majority of electric achievable economic potentials in the industrial sector (72%) can be attributed to efficiency gains in motor system improvements (mainly air compressors, fans, and pumps). Lighting represents the next most significant savings source (10%). Together, material processing and handling constitute 14% of the potential. A small amount of additional potential exists for other motors, process improvements, and facility improvements (as shown in Figure 13 and Table 11). All industrial conservation potential can be considered existing construction retrofits. In other words, all load growth in the industrial sector is anticipated from an increase of energy use within existing facilities.[7]

Figure 13. Industrial Sector Achievable Economic Potential in 2028 by End Use



[7] Due to the site-specific nature of the industrial sector, it is very difficult to accurately capture the differences between energy consumption characteristics of existing and new facilities. We acknowledge that, in reality, industrial sector load growth may come from an increase in consumption by existing facilities or due to construction of a new facility.

Table 11. Industrial Sector Energy-Efficiency Potential by End Use (aMW in 2028)

End Use	Achievable Technical	Achievable Economic
Compressed Air	2.0	2.0
Drying and Curing	< 0.1	< 0.1
Fans and Blowers	2.8	2.8
Heat Treating	< 0.1	< 0.1
Heating	< 0.1	< 0.1
HVAC	< 0.1	< 0.1
Lighting	1.4	1.2
Material Handling	1.7	1.2
Material Processing	0.5	0.5
Melting and Casting	< 0.1	< 0.1
Miscellaneous	< 0.1	< 0.1
Other Motors	< 0.1	< 0.1
Pollution Control	< 0.1	< 0.1
Pumps	4.4	4.3
Refrigeration	0.6	0.6
Medium Temperature	0.2	0.2
Low Temperature	0.4	0.4
Total	13.4	12.7

Appendix A. Detailed Methodology

Determination of energy-efficiency potential is based on sequential analysis of various energy-efficiency measures in terms of technical feasibility (technical potential), market adoption rates (achievable technical potential), and economic viability, based on standard cost-effectiveness criteria (achievable economic potential).

The assessment follows three, primary steps:

1. ***Baseline forecasts***: Determining 10-year future energy consumption by segment and end-use, calibrated to each utility's load forecasts. The baseline forecast reflects efficiency characteristics of current codes and standards, assumed fixed (frozen efficiency) over the forecast horizon.

2. ***Estimation of technical potentials***: Estimating technical potential, based on load forecasts reflecting technical impacts of specific energy-efficiency measures and market constraints, respectively. Differences between the baseline and alternative forecast represent the energy-efficiency potential associated with a particular type of potential.

3. ***Estimation of achievable technical potentials***: Estimating achievable technical potential, based on technical potential, but applying ramp rates and acquisition percentages. The total acquisition percentage is, at most, 85% at the end of the planning horizon.

4. ***Estimation of achievable economic potentials***: Estimating achievable economic potential, based on the avoided-cost forecast. This potential is a subset of the achievable technical potential, representing only cost-effective potential.

Figure A-1 presents these steps conceptually, showing a hypothetical baseline forecast, along with alternative forecasts associated with technical, technical achievable, and technical economic potentials.[8] These alternative forecasts represent consumption under different sets of assumptions, and the difference between the baseline and each alternative forecasts represents their respective potential savings. For example, the technical potential forecast represents total consumption after incorporation of all measures, consistent with the above definition. Results are intuitive, with total consumption in the technical potential forecast much lower than in the baseline, which also indicates the greatest amount of potential.

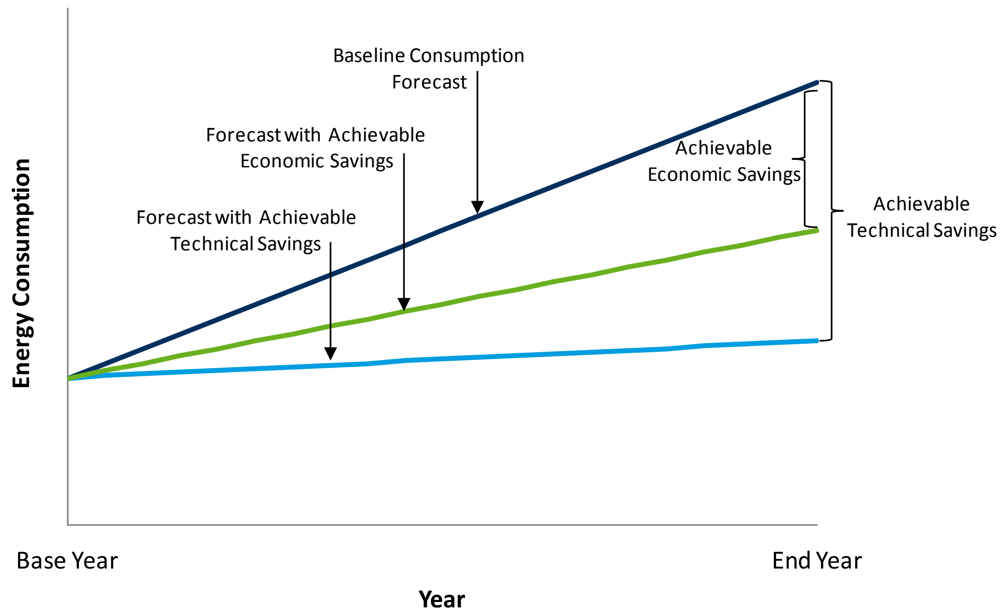
This approach provides two advantages:

- First, savings estimates are driven by a baseline calibrated to the utility's sales forecasts, and thus consistent with filings. The sales forecast serves as a reality check, helping control for possible errors. Other approaches may simply generate the total potential by summing estimated impacts of individual measures, which can result in total savings estimates representing an unrealistically high percentage of baseline sales.

[8] The baseline and alternative forecasts shown in Figure A-1 are purely for example, and do not represent the actual data underlying this assessment.

- Second, the approach maintains consistency among all assumptions underlying the baseline and alternative forecasts (technical, achievable technical, and achievable economic). In the alternative forecasts, relevant inputs at the end-use level are changed to reflect impacts of energy-efficiency measures. As estimated savings represent differences between baseline and alternative forecasts, they can be directly attributed to specific changes made to analysis inputs. A transparent framework results, allowing linkages to be traced between various assumptions and calculated measure impacts.

Figure A-1. Representation of Alternative Forecast Approach to Estimation of Energy-Efficiency Potential



Data Sources

Full assessment of energy-efficiency resource potential required compilation of a large set of measure-specific technical, economic, and market data from secondary sources and through primary research. The study's main data sources included:

- ***Tacoma***. 2010 sales, customers, and forecasts, historical energy-efficiency activities, customer databases, residential audits, residential surveys. Table A-1 provides a complete list of data elements Tacoma provided.

Table A-1. Energy Efficiency Utility Data Sources

Data Element	Key Variables	Use in This Study
2010 sales and customer counts	Number of customers and total sales by customer segment.	Base year customers and sales for calibration in end-use model.
2011 load forecasts by rate class	Sales and customer forecasts by customer segment, excluding all DSM activity.	End-use model calibration, new customers as drivers in end-use model development.
Historical program activity/ achievements	Program participation and historical program achievements.	Measure saturations, validation of measure characterization (savings, costs).
Economic assumptions	Discount rate, inflation, line loss, etc.	Measure analysis and estimates of potential at customer meter and generation

- ***Northwest Power and Conservation Council***. The Council's 6th Power Plan measure database, incorporating Power Council RTF measure updates up through August 2011, was used extensively in this study, ensuring consistency in terms of measures analyzed and expected measure costs and savings. Further, the RTF database was used to update costs and savings for key measures, including weatherization, standard and specialty lighting, heat pump water heaters, and refrigerated case lights.
- ***Commercial Building Stock Assessment***. NEEA sponsored a region-wide assessment of the commercial building stock (CBSA). Results from this 2007 assessment were used to determine measure saturations, fuel shares, and other technical factors.
- ***California Energy Commission***. This study used information available through the 2005 Database of Energy Efficiency Resources (DEER) to validate many assumptions and data collected regarding energy-efficiency measure costs and savings.
- ***Ancillary Sources***. Other data sources primarily consisted of available information from past energy-efficiency market studies, energy-efficiency potential studies, and evaluations of energy-efficiency programs around the country. Primary information sources on the industrial section included:
  - The U.S. Department of Energy (DOE);
  - The Energy Information Administration Office of Industrial Technologies (including the Industrial Assessment Centers database); and
  - NEEA's Industrial Efficiency Alliance initiative.

Baseline Forecasts

Tacoma's sales forecasts formed the basis for assessing energy-efficiency potential. Prior to estimating potential, these forecasts were disaggregated by:

- Customer sector (residential, commercial, and industrial);
- Customer segment (business, dwelling, and facility types);
- Building vintage (existing structures and new construction); and
- End uses (all applicable end-uses in each customer sector and segment).

The first step in developing the baseline forecasts was to determine appropriate customer segments within each sector, with these designations based on categories available in some key

data sources used in this study as well as on discussions with Tacoma and other parties.
Table A-2, Table A-3, and Table A-4 show full sets of customer segments and end uses for each sector analyzed in this study.

Table A-2. Residential Sector Dwelling Types and End Uses

Residential Customer Segments	End Uses
Manufactured	Cooking
Multifamily	Cooling
Single-Family	Dryer
	Freezer
	Heat Pump
	HVAC Auxiliary
	Lighting
	Plug Load
	Refrigerator
	Space Heating
	Water Heating

Table A-3. Commercial Sector Customer Segments and End Uses

Commercial Customer Segments	End Uses
Assembly	Cooking
Grocery	Cooling
Hospital	Heat Pump
K12	Heating
Lodging	HVAC Auxiliary
MiniMart	Lighting
Misc Classified	Plug Loads
Misc Unclassified	Refrigeration
Office	Water Heating
Other Health	
Restaurant	
Retail	
University	
Warehouse	

Table A-4. Industrial Sector and End Uses

Industrial Customer Segments	End Uses
Chemicals	Compressed Air
Cold Storage	Drying and Curing
Fabricated Metal	Fans and Blowers
Food	Heat Treating
Machinery	Heating
Minerals	HVAC
Other Industrial	Lighting
Paper	Low Temp Refer
Petroleum	Material Handling
Plastic/Rubber	Material Processing
Primary Metal	Med Temp Refer
Printing	Melting and Casting
Wood	Miscellaneous
	Other Motors
	Pollution Control
	Pumps

Once appropriate customer segments and end uses were determined for each sector, integration of current and forecasted customer counts with key market and equipment usage data produced baseline end-use forecasts. For commercial and residential sectors, total baseline annual consumption for each end use in each customer segment was calculated, as shown below:

$$EUSE_{ij} = \Sigma_e\, ACCTS_i * UPA_i * SAT_{ij} * FSH_{ij} * ESH_{ije} * EUI_{ije}$$

where:

$EUSE_{ij}$ = total energy consumption for end use *j* in customer segment *i*

$ACCTS_i$ = the number of accounts/customers in customer segment *i*

UPA_i = the units per account in customer segment *i* (UPA_i generally as the average square feet per customer in commercial segments and 1.0 in residential dwellings, assessed at the whole-home level)[9]

SAT_{ij} = the share of customers in customer segment *i* with end use *j*

FSH_{ij} = the share associated with electricity in end use *j* in customer segment *i*

ESH_{ije} = the market share of efficiency level *e* in the equipment for customer segment *ij*

EUI_{ije} = end-use intensity, energy consumption per unit (per square foot for commercial) for the equipment configuration *ije*

[9] It is important to note average square footage by home type differed from those used in the 6th Power Plan, resulting in differences in savings and costs.

Total annual consumption in each sector was then determined as the sum of $EUSE_{ij}$ across end uses and customer segments. The key to ensuring accuracy of the baseline forecasts was calibrating the end-use model estimates of total consumption to actual sales. This calibration to base year sales included making appropriate adjustments to data where necessary to conform to known information about customer counts, appliance and equipment saturations, and fuel shares from a variety of sources.

Consistent with other potential studies, and commensurate with industrial end-use consumption data varying widely in quality, the industrial sector's allocation of loads to end uses in various segments (NAICS) was based on data available from the U.S. DOE's Energy Information Administration.[10]

Derivation of End-Use Consumption Estimates

Estimates of end-use energy consumption (EUI_{ije}) provided one of the most important components in developing the baseline forecast. In the residential sector, these estimates were based on the unit energy consumption (UEC), representing annual energy consumption associated with the end use (and, in some cases, the end use representing the specific type of equipment, such as a central air conditioner or heat pump) at the building level.

For the commercial sector, consumption estimates were treated as end-use intensities (EUIs), representing annual energy consumption per square foot of structure. Accuracy of these estimates proved critical; so they accounted for weather and other factors (described below) driving differences among various segments. For the industrial sector, end-use energy consumption represented total annual facility consumption by end use, as allocated by the secondary data, described above.

Estimating Technical Potential

After developing the baseline forecasts, estimating technical potential came next. As technical potential was based on creating an alternative forecast,[11] reflecting installation of all possible measures, selection of appropriate energy-efficiency resources for inclusion in this study proved to be a central concern.

For the residential and commercial sectors, the study began with a broad range of energy-efficiency measures for possible inclusion. These measures were screened to include only measures commonly available, based on well-understood technologies, and applicable to Washington buildings and end uses. The Council's 6th Power Plan[12] provides examples of these measures.

[10] U.S. DOE, Energy Information Administration, Manufacturing Energy Consumption Survey (2002).

[11] The alternative forecast consisted of four separate forecasts, allowing delineation between existing and new construction, and equipment and non-equipment measures, with distinctions are explained later in this section.

[12] http://www.nwcouncil.org/energy/powerplan/6/default.htm

Table A-5, Table A-6, and Table A-7 outline types of energy-efficiency measures assessed in the residential, commercial, and industrial sectors, respectively.

Table A-5. Residential Electric Energy-Efficiency Measures

End Use	Measure Types
Cooking	High-efficiency oven
Cooling	ENERGY STAR window air conditioner, high-efficiency heat pumps
Dryer	High-efficiency dryer
Freezer	ENERGY STAR freezer
Heat Pump	High-efficiency heat pump, with performance tested comfort system (PTCS) duct sealing and commissioning; high-efficiency heat pump heat pump, with interior HVAC and commissioning
Lighting	Standard compact fluorescent lamp (CFL); specialty CFL ENERGY STAR lighting
Plug Load	High-efficiency microwave oven; ENERGY STAR television; ENERGY STAR set top box; ENERGY STAR desktop computer; ENERGY STAR computer monitor
Refrigerator	ENERGY STAR refrigerator
	Refrigerator recycling
Space Heating	High-efficiency heat pumps; attic insulation; wall insulation; floor insulation; window replacement; vaulted ceiling insulation; slab depth; infiltration improvements; HVAC conversion to high-efficiency heat pump; high-efficiency ductless heat pump
Water Heating	High-efficiency domestic water heater; domestic heat pump water heater; low-flow showerhead replacement; domestic heat pump water heater; ENERGY STAR dishwasher; gravity film heat exchanger; ENERGY STAR clothes washer

Table A-6. Commercial Electric Energy-Efficiency Measures

End Uses	Measure Types
Cooking	High-efficiency hot food holding cabinet, high-efficiency steamers, high-efficiency combination ovens, high-efficiency convection ovens
Cooling	High-efficiency chiller; high-efficiency direct expansion unitary system; windows and glazing improvements; package rooftop optimization and repair; roof insulation; variable speed chiller; integrated building design
Heat Pump	High-efficiency heat pump; HVAC system commissioning; windows and glazing improvements; package roof top optimization and repair; roof insulation; integrated building design; high-efficiency water source heat pump
Heating	Commissioning on HVAC systems; windows and glazing improvements; package rooftop optimization and repair; roof insulation; integrated building design
HVAC Auxiliary	Demand control ventilation; electronically commutated motors (ECMs) on variable air volume (VAV) boxes; dedicated outside air low pressure distribution system (DOAS); underfloor low pressure air distribution system (UFAD); DCV hood; DCV hood with make-up air
Lighting	Lighting power density (LPD) package, composed of: light emitting diode (LED) lamps and fixtures; CFL lamps and fixtures; ceramic metal halide (CMH) lamps and fixtures; halogen infrared reflecting (HIR) lamps and fixtures; T5 high output lamps, ballasts and fixtures; T8 high performance lamps and ballasts; compact fluorescent reflector lamps and fixtures); integrated building design; electroluminescent exit sign; interior lighting controls; covered and surface parking lighting LED conversion; advanced perimeter daylighting controls; exterior building lighting improvements
Plug Loads	ENERGY STAR commercial desktop computer; ENERGY STAR commercial computer monitor; network personal computer (PC) power management-desktop; network PC power management-laptop; server virtualization; smart power strip
Refrigeration	Refrigerated case ECM; high-efficiency ice maker; high-efficiency vertical or semi-vertical open refrigerated case; horizontal commercial refrigerator for glass or solid doors; vertical commercial refrigerator for glass or solid doors; efficient beverage vending machine; open refrigerated case LED lighting; delamping open refrigerated case linear fluorescents; enclosed refrigerated case LED lighting; enclosed refrigerated case motion sensor; low or medium temperature anti-sweat heater control; night covers; overhead lighting; recommissioning; multiplex compressor; high-efficiency visicoolers; walk-in ECM
Water Heating	Pre-rinse spray valve

Table A-7. Industrial Electric Energy-Efficiency Measures

Electric Measure Types
Air Compressor Improvements
Air Compressor O&M
Boiler Improvements
Building Improvements
Clean Room Improvements
Energy Project Management
Fan Energy Management
Fan Equipment Improvements
HVAC Improvements
HVAC O&M
Lighting Improvements
Material Handling Improvements
Motor Improvements
Motor O&M
Other Improvements
Other O&M
Plant Energy Management
Process Cooling Improvements
Process Heating Improvements
Pump Equipment Improvements
Refrigeration Improvements
Synchronous Belts

Once various measures were properly characterized in terms of savings and costs, technical potential could be calculated by subtracting the alternative forecast from the baseline, yielding savings by all dimensions included in the segmentation design (vintage, segment, etc.). The procedure involved three analytic steps, described as follows.

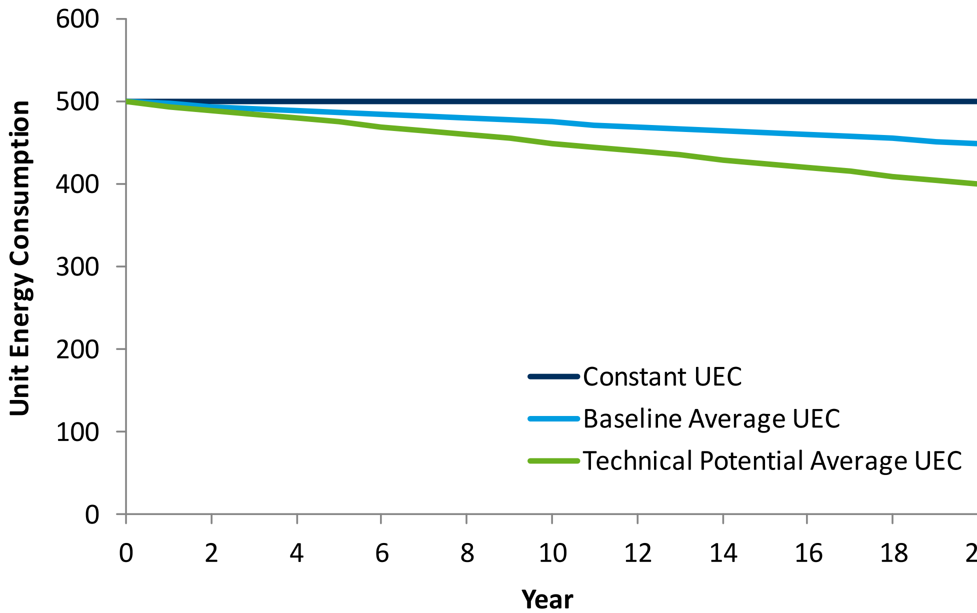
Determine Measure Impacts

Assessing technical potential requires estimating measure-level impacts, which begins by compiling and analyzing data on the following measure characteristics:

- ***Measure savings***: Energy savings associated with a measure as a percentage of total end-use consumption. Sources include the Council's 6th Power Plan, engineering calculations, secondary data sources (case studies), and the California DEER database.
- ***Measure costs***: Per-unit costs (full or incremental, depending on the application) associated with measure installation. Sources include the 6th Power Plan, RTF, and other secondary sources.
- ***Measure life***: The measure's expected lifetime. Sources include the 6th Power Plan.
- ***Measure applicability***: A general term encompassing a number of factors, including installation's technical feasibility, and the measure's current or naturally occurring saturation as well as factors to allocate savings associated with competing.

In estimating potential savings of equipment measures, it is assumed the measure's baseline efficiency would shift from its current level to prevailing codes upon burnout. Thus, average baseline efficiencies for this class of measures would improve over time as existing, sub-code equipment becomes replaced at the end of its normal, useful life. Figure A-2[13] illustrates this methodology, showing average UEC associated with end-use equipment in the baseline forecast, the technical potential scenario, and a constant UEC scenario, in which effects of natural decay and current codes and standards are eliminated. The difference between the baseline UEC and the technical potential UEC represents savings.

Figure A-2. Example of Equipment Potential: Average UEC Over Planning Horizon



The demonstration highlights two important aspects of the approach. First, the figure shows how average baseline usage gradually declines as equipment turns over, and is replaced by units complying with current code. In this case, expected baseline efficiency improves by 10% over 20 years.

Second, by contrasting average usage in the baseline with the constant efficiency scenario, the figure shows how estimates account for effects of naturally occurring conservation. Technical potential savings are represented by the difference between the technical potential and the baseline, which would not be the case with a constant UEC. This demonstrates how this approach accurately estimates total potential, and accurately accounts for naturally occurring potential. The approach, however, does not include any increased efficiency requirements embodied in future changes to codes and standards (that is, the baseline assumes a "frozen efficiency").

Approaching non-equipment (or "retrofit") measures becomes more complicated as it requires assessing collective impacts of a variety of measures with interactive effects. For each segment

13 This purely illustrative example does not contain Tacoma-specific data.

and end-use combination, the analysis seeks to estimate cumulative effects of the bundled eligible measures, incorporating those impacts into the end-use model as a percentage adjustment to the baseline end-use consumption. In other words, the approach seeks to estimate the percentage reduction in end-use consumption that could be saved in a "typical"[14] structure (e.g., multifamily dwelling, small office) by installing all available measures. This approach begins by characterizing individual measure savings in terms of the end-use consumption percentage rather than absolute energy savings. For each individual, non-equipment measure, savings are estimated using the following basic relationship:

$$SAVE_{ijm} = UEC_{ije} * PCTSAV_{ijem} * APP_{ijem}$$

where:

> $SAVE_{ijm}$ = annual energy savings for measure *m* for end use *j* in customer segment *i*
>
> UEC_{ije} = calibrated annual end-use energy consumption for the equipment *e* for end use *j* and customer segment *i*
>
> $PCTSAV_{ijem}$ = the percentage savings of measure *m*, relative to base usage for the equipment configuration *ije*, taking into account interactions among measures such as lighting and HVAC, calibrated to annual end-use energy consumption
>
> APP_{ijem} = measure applicability, a fraction representing a combination of technical feasibility, existing measure saturation, end-use interaction, and any adjustments to account for competing measures

As described later in this section, a measure's savings can be appropriately viewed in terms of what it saves as a percentage of baseline end-use consumption, given its overall applicability. In the case of wall insulation saving 10% of space heating consumption, if the overall applicability is only 50%, the final percentage of the end use saved would be 5%. This value represents the percentage of baseline consumption the measure saves in an average home.

However, as stated previously, the study deals almost exclusively with cases where multiple measures affect a single end use. To avoid overestimation of total savings, assessment of cumulative impacts accounts for interactions among the various measures—a treatment called "measure stacking." Stacking effects primarily are accounted for by establishing a rolling,

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14 This approach aspect requires careful determination of what a "typical" structure represents. For example, the average structure might have only a fraction of a measure installed; so it becomes necessary to think of the average single-family home (for instance) as having only 20% of a high-efficiency window already installed. Many structural attributes—size, measures installed, number of stories—have been based on data collected in surveys. These values were determined using averages from survey results. When necessary, an R-value was converted to a U-value to correctly calculate the average insulation level, and then was adjusted back to the typical R-value unit.

reduced baseline, applied iteratively while assessing measures in the stack. The equations below show this, with measures 1, 2, and 3 applied to the same end use:[15]

$$SAVE_{ij1} = UEC_{ij\,e} * PCTSAV_{ije1} * APP_{ije1}$$

$$SAVE_{ij2} = (UEC_{ije} - SAVE_{ij1}) * PCTSAV_{ije2} * APP_{ije2}$$

$$SAVE_{ij3} = (UEC_{ije} - SAVE_{ij1} - SAVE_{ij2}) * PCTSAV_{ije3} * APP_{ije3}$$

After iterating through all of measures in a bundle, the final percentage of end-use consumption reduced is the sum of individual measures' stacked savings, divided by original baseline consumption.

Finally, this approach requires clarification, as two different savings types are actually associated with a measure: standalone savings (savings the measure would provide when installed entirely on its own); and stacked savings (savings attributable to a measure when assessed in conjunction with other measures, and accounting for various factors affecting applicability). The former represents savings associated with a single, actual installation; the latter represents average savings a measure would achieve when installed across all homes. Table A-8 summarizes factors affecting overall potential associated with a measure.

Table A-8. Measure Applicability Factors

Measure Impact	Explanation	Sources
Fuel Saturation	The percentage of customers using electric fuel for the specific end use (e.g., water heat, space heat, etc.).	Residential surveys, CBSA.
End-Use Saturation	The percentage of customers with the specific end use. (If not all residential customers have a clothes washer, for example, the end-use saturation would be less than 100%.)	Residential surveys, CBSA.
Measure Share	Used to distribute the percentage of market shares for competing measures (e.g., CFLs and LEDs each have their own measure share of the market).	Residential surveys, CBSA, various secondary sources.
Measure Incomplete Factor	Represents the percentage of buildings without specific measures currently installed.	ENERGY STAR sales records. Residential surveys, CBSA.
Technical Feasibility	Accounts for the percentage of buildings that can have the measure physically installed. Several factors may affect this percentage, including whether the building already has the baseline measure (e.g., dishwasher) and limitations on installation (e.g., size of unit and space available to install the unit).	Secondary sources.
Measure Interaction	Only considered for lighting and HVAC.	Engineering judgment.

15 In some cases, complete interaction may not occur between measures (e.g., wall and ceiling interaction). However, based on engineering experience, interaction is believed substantial. This method provides a somewhat conservative approach to potential estimates in some cases, but not assuming interaction could greatly inflate actual available potential.

Estimate Phased-In Technical Potential

Savings from technical energy-efficiency potential are estimated by incorporating measure impacts into the baseline forecast, using four steps to develop alternative forecasts. These steps are sequential, with each building on the previous scenario:

1. Non-equipment measures[16] in existing construction, in which collective measure energy savings impacts can be applied to end-use consumption estimates.
2. Non-equipment in new construction, in which collective measure energy savings can be applied to end-use consumption estimates.
3. Equipment measures[17] in existing construction, in which all equipment can be upgraded to the highest efficiency level after decay.
4. Equipment measures in new construction, in which all new construction can be upgraded to the highest equipment efficiency level.

This approach requires the preceding sequence to account for interactions between equipment and non-equipment measures. As equipment becomes replaced over time with the highest-efficiency options, average consumption associated with an end use declines, resulting in a reduced absolute impact associated with non-equipment measures. Accounting for this interaction results in more accurate estimates of potential associated with non-equipment measures.

Achievable Technical Potential

This study did not rely on traditional processes for estimating technical potential, followed by economic and achievable potentials. Instead, "achievable technical" potential was estimated to represent the potential available after accounting for market barriers other than cost-effectiveness. This was accomplished by applying expected maximum market penetration percentages to technical potential. These percentages have been based on those used in the 6th Power Plan, and vary by measure (though generally about 85% over the 20-year planning horizon). This study has a 10-year horizon, 2014 through 2028, over which approximately 60% of technical potential is achievable.

Achievable Economic Potential

After assessing achievable technical potential, measures were screened for cost-effectiveness, using Tacoma's avoided costs. Measures with a benefit-to-cost ratio greater than one passed the economic screen, and were included in the achievable economic potential.

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[16] Non-equipment measures reduce end-use consumption without replacing end-use equipment (e.g., insulation).

[17] Equipment measures replace end-use equipment (e.g., high-efficiency water heaters).

Consistency with the Northwest Power and Conservation Council

The Northwest Power and Conservation Council's Methodology for Determining Achievable Conservation Potential—Outline of Major Elements

1) Resource Definitions.

i) Technical Potential: Completed with utility service area specific customer data.

Analysis conducted at sector, building type, end-use, fuel shares, highest efficient technology level.

ii) Economic Potential.

Completed with regional avoided costs forecast developed by Tacoma Power applied to achievable potential.

iii) Achievable Potential.

Completed by applying Power Council, measure-specific, 2010–2028 acquisition ramp assumptions onto Technical Potential. As the study's first year is 2014, this translates to Year 4 within the ramp rates.

(1) Non-lost Opportunity Resources ("Schedulable").

Completed by measure.

(2) Lost Opportunity Resources.

Completed by measure.

2) Technical Resource Potential Assessment.

a) Review wide array of energy-efficiency technologies and practices across all sectors and major end uses.

Analyzed a complete set of relevant measures provided in the Northwest Power and Conservation Council 6th Power Plan.

b) Methodology.

i) Technically feasibility savings = Number of applicable units * incremental savings/applicable unit.

Savings assumptions and applicability factors derived from measures provided in the 6th Power Plan, with updates due to the 2009 WSEC or Regional Technical Forum (RTF) review through August 2011.

ii) "Applicable" Units account for:

(a) Fuel saturations (e.g. electric vs. gas DHW).

Fuel saturations used in the study, based on utility-specific surveys and datasets.

(b) Building characteristics (single-family vs. mobile homes, basement/non-basement, etc.).

Building characteristics, based on detailed county assessor data and comprehensive account classification process conducted by the utility.

(c) System saturations, (e.g., heat pump vs. zonal, central AC vs. window AC).

System saturations, based on regional and utility specific studies.

(d) Current measure saturations.

Measure end-use saturations, based on regional and utility specific studies.

(e) New and existing units.

Based on detailed account data, county assessor data, utility-specific studies, and utility-specific forecasts.

(f) Measure life (stock turnover cycle).

Based on 6th Power Plan measure assumptions.

(g) Measure substitutions (e.g., duct sealing of homes with forced-air resistance furnaces vs. conversion of homes to heat pumps with sealed ducts).

Measure substation specifications inherent in the measures provided in the 6th Power Plan.

iii) "Incremental" Savings/applicable unit accounts for:

(a) Expected kW and kWh savings shaped by time-of-day, day of week, and month of year.

Based on 6th Power Plan measure assumptions, with updates due to 2009 WSEC and/or RTF.

(b) Savings over baseline efficiency.

In general, the methodology to determine baselines is similar to approach used in 6th Power Plan.

(i) Baseline set by codes/standards or current practices.

Baseline assumptions use both codes/standards and current practices, depending on measure technology. Completed with a methodology similar to 6th Power Plan.

(ii) Not always equivalent to savings over "current use" (e.g., new refrigerator savings are measured as "increment above current federal standards, not the refrigerator being replaced).

Applied to specific measure technologies and completed with a methodology similar to 6th Power Plan.

(c) Climate—heating, cooling degree days and solar availability.

Completed with a methodology similar to 6th Power Plan.

(d) Measure interactions (e.g., lighting and HVAC, duct sealing and heat pump performance, heat pump conversion and weatherization savings).

Interaction effects, taken into account in modeling approach to estimating savings potential, similar to the 6th Power Plan.

3) Economic Potential—Ranking Based on Resource Valuation.

a) TRC is the criterion for economic screening, and includes all cost and benefits of measure, regardless of who pays for or receives them.

i) TRC B/C Ratio > = 1.0.

All measures in the economic potential meet or exceed a TRC B/C ratio of 1.0.

ii) Levelized cost of conserved energy (CCE) < levelized avoided cost for the load shape of savings may substitute for TRC if "CCE" is adjusted to account for "non-kWh" benefits, including deferred T&D, non-energy benefits, environmental benefits, and Act's 10% conservation credit.

The TRC was used, including the Act's 10% conservation credit and non-energy benefits.

b) Methodology.

i) Energy and capacity value (i.e., benefit) of savings, based on avoided cost of future wholesale market purchases (forward price curves).

Value of savings, based on forecasted avoided cost of future wholesale market price.

ii) Energy and capacity value accounts for shape of savings (i.e., uses time and seasonally differentiated avoided costs and measure savings).

Value of savings accounts for time of use and differentiated avoided costs.

iii) Uncertainties in future market prices accounted for by performing valuation under wide range of future market price scenarios during the integrated resource planning (IRP) process (See 4.1).

Applied multiple, avoided-price forecast scenarios to determine potential assessment impacts, and used in the IRP process.

c) Costs Inputs (Resource Cost Elements).

i) Full incremental measure costs (material and labor).

Used incremental measure cost data from 6th Power Plan and/or RTF, or Tacoma-specific data sources.

ii) Applicable ongoing O&M expenses (plus or minus).

Used incremental O&M expense data from 6th Power Plan and/or RTF, as available, or Tacoma-specific data sources.

iii) Applicable periodic O&M expenses (plus or minus).

Used periodic O&M expense data from 6th Power Plan and/or RTF, as available.

iv) Utility administrative costs (program planning, marketing, delivery, ongoing administration, evaluation).

Actual administrative costs by program were calculated and applied to the relevant measures.

d) Benefit Inputs (Resource Value Elements).

i) Direct energy savings.

Used savings data from 6th Power Plan and/or RTF through June 2013.

ii) Direct capacity savings.

Not applicable.

iii) Avoided T&D losses.

Applied utility-specific T&D loss assumptions.

iv) Deferral value of transmission and distribution system expansion (if applicable).

Not applicable.

v) Non-energy benefits (e.g., water savings).

Applied non-energy benefit data from 6th Power Plan, RTF (through June 2013), or Tacoma-specific data sources, as available.

vi) Environmental externalities.

e) Discounted Presented Value Inputs.

i) Rate = After-tax average cost of capital weighted for project participants (real or nominal).

Nominal discount rate provided by utility.

ii) Term = Project life, generally equivalent to the life of resources added during planning period.

Measure life as the basis for stream of annual savings.

iii) Money is discounted, not energy savings.

The methodology used in the potential assessment discounts monetary values, and does not discount energy savings.

4) Achievable Potential.

a) Annual acquisition targets established through the IRP process (i.e., portfolio modeling).

Annual acquisition targets developed in the IRP process, based on results of the potential assessments.

b) Conservation competes against all other resource options in the portfolio analysis.

Economic conservation resources, based on an avoided cost forecast. The portfolio analysis concluded conservation is the sole new resource required to maintain load resource balance during the planning period.

i) Conservation resource supply curves separated into:

(1) Discretionary (non-lost opportunity).

Completed in the analysis.

(2) Lost-opportunity.

Completed in the analysis.

(3) Annual achievable potential constrained by historic “ramp rates” for discretionary and lost-opportunity resources.

The 15-year achievable technical and achievable economic potential determined by measure specific Power Council 6^{th} Power Plan ramp rate assumptions, starting at year 4 (2014).

(a) Maximum ramp up/ramp down rate for discretionary of 3x prior year for discretionary, with upper limit of 85% over 20-year planning period.

(b) Ramp rate for lost-opportunity of 15% in first year, growing to 85% in 12th year.

(c) Achievable potentials may vary by type of measure, customer sector, and program design (e.g., measures subject to federal standards can have 100% “achievable” potential).

c) Revise Technical, Economic and Achievable Potential, based on changes in market conditions (e.g., revised codes or standards), program accomplishments, evaluations, and experience.

i) All programs should incorporate Measurement and Verification (M&V) plans that, at a minimum, track administrative and measure costs and savings.

Tacoma Power conservation programs include M&V, and tracking approaches appropriate for each program type.

ii) Use International Performance Measurement and Verification Protocols (IPMVP) as a guide.

Tacoma Power program evaluations incorporate IPMVP techniques.

Appendix B. Federal Facilities Potential

This report relies on two documents provided by BPA to estimate the conservation potential at JBLM. The potential noted here was adjusted in the report to account for accomplishments since this analysis.

Frank Brown of Bonneville Power Administration supplied the end-use conservation document appended below. Tony Koch of Bonneville Power Administration supplied the distribution efficiency document appended below.

Fort Lewis Energy Savings Report

Historical Data

FY2007Energy Cost Total:	$ 20,257,194
FY2007 Total MBtu:	1,907,686
KSF FY2007 (MBtu):	107.84
KSF FY2006 (MBtu):	114.81

Electrical - Project Summary (Data From Items 8 and 9)

	Bldg Count	SqFt	Savings KWH/Yr	Cost Savings/Yr	Constr. Cost	Simple Payback Yrs	Rebate $	Simple Payback with Rebate Yrs
Lighting Retrofits from Level 1 Audits and extrapolated buildings	2,368	16,252,247	12,933,846	$885,376	$9,488,853	10.7	$1,940,077	8.5
Other Electrical from Level 1 Audits and extrapolated buildings	807	14,492,576	7,999,029	$332,110	$1,997,220	6.0	$1,199,854	2.4
Totals:	3175	30,744,823	20,932,875	$1,217,486	$11,486,073	9.4	$3,139,931	6.9

Table 5-3 Stage Three VO Energy Efficiency Savings
Stage Two + EOL Feedback

	Overall	Army Central East	Army Central West	Madigan	Sequalitchew	South
General Information						
Substation Annual Peak MVA	38.24	7.76	7.91	6.36	7.16	9.05
Total Annual Energy (GWh/yr)	248	60.60	48.90	44.60	25.20	68.30
Stage 3 Energy Savings Potential						
Fixed V Reduction Energy Saved (GWh/yr)	2.13	0.22	0.67	0.45	0.15	0.65
LDC Energy Saved (GWh/yr)	2.18	0.80	0.13	0.35	0.44	0.46
Total Energy Savings for Project (GWh/yr)	4.31	1.02	0.80	0.80	0.59	1.11
Reduction in Annual Energy (%)	1.74%	1.69%	1.63%	1.79%	2.33%	1.62%
Substation Fixed Voltage Reduction (%)		0.58%	2.17%	1.58%	0.92%	1.50%
Substation Fixed Voltage Reduction (V)		0.70	2.60	1.90	1.10	1.80
Substation LDC Voltage Reduction (%)		2.00%	0.42%	1.25%	2.75%	1.08%
Substation LDC Voltage Reduction (V)		2.40	0.50	1.50	3.30	1.30
Total Substation Voltage Reduction (V)		3.10	3.10	3.40	4.40	3.10
Total VO Project Installed Cost [(1)]	$850,000	-	-	-	-	-

[(1)] – Costs are reasonable assumptions based on available data. Without a detailed model, the effects of system improvements cannot be measured.

Appendix C. Service Area distribution Efficiency

This report relies on an distribution efficiency study conducted by RW Beck on three representative substations at Tacoma Power. An average substation energy savings was applied to similar substations in the service area.

Table 1-2
Summary of Results

	Overall[1]	Clement	Custer	Highland
General Information				
Total Customers Served (#)	10,332	4,213	3018	3,101
Substation Annual Peak MVA	46.97	21.516	12.06	13.4
Total Annual Energy (MWh/yr)	216,044	98,058	55,868	62,118
Reduction in Annual Energy (%)	1.60%	1.41%	1.95%	1.61%
Average Customer Voltage Change (%)	3.37%	3.29%	3.63%	3.27%
Total VO Project Installed Cost	$181,800	$66,800	$61,000	$54,000
Energy Savings Potential				
Line Loss Saved (MWh/yr)	5.6	2.8	2.8	0.0
No-Load Loss Saved (MWhyr)	29.3	10.1	8.9	10.2
VO Energy Saved (MWh/yr)	3,430.1	1,373.3	1,078.9	992.0
Total Energy Savings for Project (MWh/yr)	3,464.9	1,386.2	1,090.6	1,002.3
Customer Average Energy Reduction (kWh/yr)	332	326	357	320
Benefit Cost Projections				
BPA Levelized Cost per kWh Saved ($/kWh)	0.003	0.003	0.003	0.003
Utility Levelized Cost per kWh Saved ($/kWh)	0.002	0.002	0.003	0.002
Net NPV Utility Annual VO Project Savings ($/yr)	$88,846	$35,812	$27,794	$25,636
Utility Benefit - Cost Ratio	11.9	12.9	11.1	11.6

1. Overall column treats all work as one project, not as the sum of the individual projects. As such, gains are shared between all feeders which offsets the limitations of the BPA incentive payments.

Tacoma Power Service Area Projected Distribution Efficiency Potential	
Previous Study Results	
Three Substation Study Result Economic Potential (MWh)	3,464.9
Average Savings per Substation from study (MWh)	1,155.0
Substation Counts, Accomplishments, and Achievable Units	
Number of Applicable Similar Substations in Service Area (Technical)	24.0
Achievable Number of Substations over 10-Years	14.3
Previously Accomplished Substations	3.0
Remaining Achievable Number of Substations	11.3
Estimated Substations for Target	2.3
Potentials and Estimated Target	
Estimated Economic Technical Potential of the 24 Applicable Substations (MWh)	27,719.2
Achievable Technical Potential (MWh)	16,492.9
Economic Achievable Potential (MWh)	16,492.9
Remaining Economic Achievable Potential	13,028.0
Estimated Biennium Target (MWh)	2,605.6
Achievable Ramp Assumptions	
Achievable Ramp (Power Council 6th Ramp 2014-2023) with 85% Achievable Factor	60%

APPENDIX 5: Comprehensive Review of Resource Alternatives

Tacoma Power has evaluated several potential portfolio resources and new technologies. This appendix provides a comprehensive review of the resources and technologies reviewed. Each resource herein is identified as being a baseload, intermediate or peaking resource. In addition, a basic overview of technology characteristics, cost, availability, and environmental attributes are provided in the analysis.

Hydroelectric Generation

Hydroelectric power generation is the largest source of renewable energy in the Pacific Northwest. However, hydroelectric generation constructed prior to 1999 is not an "eligible" renewable resource under the Energy Independence Act.

There are four principle types of hydroelectric projects: impoundment, run-of-river, irrigation and efficiency upgrades. Impoundment dams store water to be used in different seasons or even years to generate electricity. Impoundment dams typically serve purposes beyond power generation, including flood control, recreation, barge transportation, and irrigation. Run-of-river facilities have very limited storage capability – usually a few hours to, at most, a few days. The primary purpose of run-of-river facilities is to generate electricity as an intermediary or baseload resource. Opportunities to construct new impoundment or run-of-river facilities are virtually non-existent due to environmental regulations and the scarce supply of good locations for siting. Most available potential sites for new hydroelectric facilities are on irrigation canals. Electricity from these types of facilities is usually seasonal, coincidental with the irrigation season, and considered to be a secondary importance to the delivery of water for irrigating crops.

A fourth type of hydroelectric resource is efficiency upgrades. This resource adds to, refurbishes, or alters an existing hydroelectric facility for an increase in generation while using the same amount of water. Hydroelectric efficiency upgrades are considered separately because they qualify as renewable under the Energy Independence Act. Some upgrades are as simple as changing operating protocols, while others could require major new components like replacing turbines or adding a new powerhouse.

Technology Conventional hydroelectric facilities have historically used a barrage device or dam to restrict the flow of water through a river or stream in order to store the kinetic energy of the water. Kinetic energy is then converted to electric energy through a controlled release of water through a turbine generator. New in-stream hydrokinetic technology uses underwater turbines to harness the natural flow of a river. This generates electricity without relying on a diversionary or impoundment device.

Two types of non-conventional hydroelectric generation are low-head in-stream hydrokinetic conversion and pumped storage. Low-head hydroelectric plants often require no dam or, for those that do, a dam only a few meters high. Common low-head facilities make use of agricultural irrigation ponds or municipal water supply reservoirs. Electricity is then generated as a secondary benefit from the main use of the water. Depending on location, a low-head generation plant may require new transmission lines or upgrades to existing transmission.

Pumped storage involves pumping water into a storage reservoir when the cost of the electricity is low and then using that water to generate electricity during peak periods or when the value of the electricity produced is higher. Pumped storage can also be used to store energy that would otherwise be lost. Such as when electrical supplies exceed demand and operators must spill or restrict the amount of power that could otherwise be generated. The energy returned from pump storage is typically about 75 percent of the energy input.

Project Sizing The nameplate capacity of conventional hydroelectric plants varies widely from a few hundred kilowatts to several thousand megawatts, but there is little prospect for new large scale hydro projects in the Pacific Northwest. There may be opportunities for new relatively small scale projects of less than 10 MW. However, majority of new hydroelectric plants proposed are extensions of or an addition to an existing hydroelectric facility.

Non-conventional hydroelectric generation plants can also vary largely in their nameplate capacities. Most low-head projects are small, having nameplate capacities of less than 1 MW. However, there exists possibility of larger projects at locations such as agricultural irrigation canals or the diversion channels of large hydroelectric facilities.

In addition to building new hydroelectric facilities, improvements to hydroelectric facilities (characterized as incremental hydro) can be made. Incremental hydroelectric involves improving the operation and/or mechanical efficiency of existing hydroelectric facilities. For example, fixing leaky valves, installing more efficient turbine blades, replacing inefficient transformers could all be considered incremental hydro improvements.

Resource Characteristics Due to its low operating cost and high capacity factors, conventional hydro power is used primarily as a baseload resource. However, capability also exists to use these resources as an intermediate or peaking resource. Capacity can become an issue during dry years when water conditions limit river flows and the amount of snowpack in surrounding mountain areas. However, when sufficient water exists, hydro facilities are normally available for generation except during periods of routine maintenance.

Hydroelectric power produces no greenhouse gasses, but because it usually impedes the normal flow of water in a river, provisions must be made to allow for fish migration. This includes mandatory spill levels, river temperatures and construction of fish ladders to allow safe passage for fish.

Pumped storage has the ability to provide firm capacity as well as peak energy. Additionally, it can provide balancing reserves using variable generation capabilities and through the creation of load when in pumping mode.

Availability and Outlook It is unlikely that additional large scale conventional hydroelectric plants will be built in the Pacific Northwest. However opportunities for incremental hydro continue to be explored by most hydro plant owners. Generally, upgrades to hydroelectric plants do not require upgrades to existing transmission facilities. In addition, the extra power generated from these types of improvements usually qualifies as renewable power under the Energy Independence Act.

Pumped storage is commercially viable and used in many regions of the country. However, it has not been widely used in the Northwest because the region has had ample capacity with the existing generation supply for peak power periods. However, the increase in variable energy resources, such as wind and solar, creates a need for energy storage and shaping technologies, such as pumped storage projects. There are several open permits in the region for building pumped storage facilities and it is expected that the region will see additional pumped storage plants in the coming years. Pumped storage costs vary significantly from project-to-project and this resource usually requires a development lead-time of five to seven years.

Wind

Wind power is the conversion of wind energy into electricity by wind turbines. Wind resources have been the fastest growing source of “eligible” renewable energy in the Pacific Northwest in recent years. The Pacific Northwest currently has more than 6,000 MWs of installed nameplate wind capacity operating or under construction. Over 4,500 MW’s of this capacity is in the BPA balancing authority area. In addition, some Northwest utilities, including BPA, purchase wind power from Wyoming and Montana, which have over 2,000 MWs of wind power.

Most wind generation in the Northwest is sited in a 160 mile corridor of the Columbia River Basin, from The Dalles, OR to Pomeroy, WA. These wind projects typically produce power at roughly 30 percent of installed capacity, meaning that on average they to produce 30 percent of the energy they would as if they were operating at their peak output 100 percent of the time.

According to February 2013 NWPCC estimates, wind power costs vary according to the specific geographic area where the wind output is generated. Levelized costs range from $100 to $140/MWh including transmission to the nearest wholesale delivery point. The cost breakdown by area is summarized below:

- Washington/Oregon Wind Cost $100.00/MWh
- Idaho Wind Costs $110.00/MWh
- Montana to Southern Idaho $120.00/MWh
- Montana to Washington/Oregon $140.00/MWh

While this does include an estimated cost of balancing reserves, interconnection and transmission within BPA’s main grid, this cost component can vary significantly with the differences in concentration of wind-powered generation connected to different balancing authorities in the region. The importance of managing this cost component is rapidly increasing as high wind penetration rates become a significant factor in transmission system operation and management.

Technology The typical wind generation facility, or wind farm, consists of an array of wind turbines that usually range in size between one and three megawatts each. As the technology has advanced, wind turbines have become taller and larger with improved capacity and efficiency.

In addition to land based wind generation, some offshore wind generation has been constructed in other countries. Offshore wind generation is often more efficient with larger turbines but the first offshore wind farms are not likely to be operational in the US until after 2017.

Project Sizing Land based wind farms are usually configured in arrays of wind turbines. These arrays typically have name plate capacities of 100-300 MW in size whereas; offshore wind plants can be as large as 1000 MW's.

Resource Characteristics Wind power is an intermediate resource that uses no fuel and releases no greenhouse gasses. The biggest drawback for wind generation is its relative expense compared to other types of generating resources; the generation usually has high variability in its output and little to no dispatch ability. Utilities using wind generation must have other sources of electricity available to ramp up or down in response to changes in wind speed. Wind turbines can cycle from not generating to full generation and back to no generation within a single hour. This variability must be matched with a reserve energy requirement and often requires a resource that can cycle up and down quickly in response to changes. This variability in generating output limits the amount of wind resources that can be relied upon for helping to meet peak loads.

Availability and Outlook The majority of wind generation currently available in the Pacific Northwest has been provided to utilities through long-term power purchase agreements. Wind generation continues to be an attractive renewable resource for the area's utilities but construction of new facilities has slowed in the last two years. Many utilities are experiencing slow demand growth and there continue to be challenges in building the necessary transmission infrastructure to accompany new wind facilities. Another barrier for new wind generation is the fact that the best wind generation sites have already been used.

Even with these obstacles, wind generation remains one of the most viable renewable sources for meeting I-937 requirements in the foreseeable future. The NWPCC predicts an additional 500 - 1000 MW of wind generation will likely come on-line in the Pacific Northwest over the next three years.

The first US offshore wind project, located in Cape Cod, Massachusetts, is expected to begin construction by the end of 2013. Other offshore wind generation developments have gained interest but new generation facilities are not expected to be available before 2017. The Annual Energy Outlook of 2013 by the Energy Information Agency estimates offshore wind generated electricity at $221/MWh.

Solar

Solar power has become a much more viable renewable energy source in the last few years. This is especially true in areas with significant sunlight. There are two methods for converting solar radiation into electricity, photovoltaic and thermal. Electricity from both these types of facilities is directly correlated with sunlight, though some solar thermal systems have limited heat storage capabilities.

The construction of both large scale solar generation facilities and distributed generation solar resources have significantly increased in recent years. The southwest has seen a large increase in the number of generators installed on the roof of commercial buildings and personal residences.

Technology The best known type of solar generation uses photovoltaic cells to convert solar radiation into DC voltage. While photovoltaic cells are not as efficient as solar-thermal generation, they have many advantages. The primary advantage is that they are simple (i.e., no moving parts) and scalable. With the use of a converter, this energy can be used immediately to meet load at the point of generation. Photovoltaic solar panels can be installed on roof tops and the power generated can be used on-site, reducing the load on the electrical distribution system. Designs are able to blend with existing roofing, making them more attractive and they have the ability to be installed anywhere the sun shines.

With thermal generation, solar radiation gets focused toward a central point using parabolic mirrors. To increase efficiency, the mirrors are often designed to track the sun's progress through the sky. The focused sun is used to create steam that runs a turbine.

Both thermal generation and photovoltaic generation have advantages and disadvantages. Thermal generation is more expensive and requires large areas of land in locations that receive significant amounts of sunlight year round. Photovoltaic generation is approximately 80 percent less expensive per kW of generated power than solar thermal, and can more easily be incorporated into a distributed generation strategy by installing the equipment on rooftops.

Project Sizing Thermal solar generation plants can range in size from a few megawatts to several hundred megawatts. The primary restriction lies in the amount of land or usable roof space available.

Resource Characteristics Solar is an intermediate renewable resource with no greenhouse gas emissions. However, it is highly dependent on the weather and, in the case of photovoltaic generation, is limited to daylight hours for power production. Solar thermal generation stores solar radiation in a secondary medium, but the length of storage time varies. These limitations give solar power relatively low capacity factors.

Photovoltaic panels have the highest dependability of any generation source at better than 99%. This, along with their ease of use as a distributed generation source, makes them good candidates as renewable resources.

Availability and Outlook Areas of central Washington, Oregon and Southern Idaho have climates that are most favorable for solar generation. Winter generation capabilities above the 40° north latitude line are limited. This limitation reduces the capacity factor for commercial plants and makes them less cost effective. As technology continues to improve, solar panels become more efficient in cloudier climates.

Utility-scale photovoltaic solar power directly converts sunlight to electricity using solid state cells. The direct current output is converted to an alternating current output to allow connection to the grid or local distribution system. This technology produces variable power, subject to declining production with cloud cover and, of course, at night. It would require balancing reserves. The NWPCC estimates utility scale photovoltaic generation levelized costs for a 20 MW plant would be approximately $200 per MWh but the recently executed Power Contracts have been at levels around $75 to $85 per MWh. Costs have declined significantly in the last few years. Financial incentives are not included in the levelized cost estimate but are factored into the recently executed power sales agreements. Public support for this technology could potentially make development even more feasible, though the Northwest is not an optimal locale for the highest power production from solar plants.

Solar thermal power generation uses lenses or mirrors to concentrate solar radiation on a heat exchanger to heat a working fluid. Solar thermal power is best suited for dry, clear locations such as the Southwestern U.S. It would also require major transmission investments to bring Southwest power to serve Northwest loads. Several hundred average megawatts of generation could be available to the region from concentrated solar power plants in Nevada; however, transmission to carry this power is not currently available. The most recently published cost information about this resource is estimated at more than $260/MWh, several percent of which would be transmission costs, but our own research suggests this figure is dated given the rapidly evolving solar industry.

Biomass

Biomass is a family of generating technologies and fuel sources, each of which has its own attributes, consequences and advantages. This diversity makes it difficult to assess the "average" or "typical" environmental attributes of biomass generation. The most common forms of biomass are wood waste, landfill gas, solid waste digester gas and municipal solid waste. The most common form of electricity production is from direct combustion. Direct combustion is used to generate electricity from municipal solid waste, landfill gas, and from the residues of timber harvesting. In many cases, electricity is a by-product from a co-generation facility where the combustion process creates steam for heating or for use in an industrial process as well as for electricity production.

Biomass generation qualifies as a renewable resource under the Energy Independence Act for the portion of generated electricity that was not powered by treated wood chips, wood derivatives from old growth forests, municipal waste, black liquor from pulp mills and other sources, or supplementary fossil fuels.

Biomass products can also be used to make synthetic gas for use in an integrated gasification combined cycle generation facility. At municipal waste facilities, biomass can be processed using an anaerobic digester to produce methane gas. The methane is then burned in a combustion turbine to generate electricity. Another use of biomass products is creating ethanol via a fermentation process. The ethanol can be used as a fuel additive or in rare cases directly combusted to generate electricity.

Most bio-residues available to fuel electric power generation in the Northwest include wood residues, agriculture field residue, pulping (black) liquor, animal manure and landfill and waste water treatment gas. All these resource types have been developed in the region. The Sixth Power Plan estimates that more than 800 aMW of energy from various biofuels may be available for development in the Northwest at costs ranging from $77 to $123/MWh. These biofuel resources are expected to be available in smaller quantities depending on the location and at varying costs, depending on whether each project fulfills a dual purpose, such as cogeneration or uses for waste heat and by-products.

Technology Biomass has been used for many years in co-generation facilities. Washington State currently has several co-generation facilities operated by companies such as Weyerhaeuser and Kimberly-Clark.

In Tacoma's service territory, there is an anaerobic digester facility currently in operation. The facility supplies power to the central municipal waste treatment plant. The by-product of the digester is sold as sterile compost, a product more rich in nutrients than compost created from gardeners' standard composting process.

Project Sizing Biomass facilities vary greatly in size, from as little as a few hundred kilowatts to more than 50 megawatts, depending on the fuel source. Typical plants range between 10 and 30 MW's while smaller anaerobic digester facilities are usually around one megawatt in size.

Resource Characteristics Biomass plants are a baseload resource and typically have a high dependability, especially when they use natural gas as a backup fuel supply. (While the plant burns natural gas the electricity produced is not eligible as a renewable resource.)

Biomass facilities tend to only be in areas where there is little to no cost involved in transporting fuel. Anaerobic digesters are ideal facilities to locate at sites of waste collection. Sites that can best profit from digester facilities are dairy farms where the compost material from the digester can be used to top dress fields and improve grazing land. Putting anaerobic digesters at agricultural facilities also has the distributed generation benefits of relieving the use of electric distribution system.

Availability and Outlook The Pacific Northwest has several opportunities for biomass energy production. Within the Tacoma Power service area; there are agricultural facilities that produce enough biomass to support small digesters.

Natural Gas Simple & Combined Cycle Combustion Turbines

Natural Gas Simple Cycle Combustion Turbines (SCCT) utilize a traditional combustion turbine to generate electricity. SCCTs operate at relatively low thermal efficiencies and are used predominately as peaking resources. Natural Gas Combined Cycle Combustion Turbines (CCCT) combine traditional combustion turbines with a secondary steam turbine to capture and utilize waste heat. CCCTs typically serve as baseload resources and usually have high capacity factors. Natural Gas turbines are currently the only viable option for fossil fuel generation in the state and the use of natural gas as a fuel source does not qualify as renewable in the State of Washington.

Technology Combustion turbines run natural gas through a derivative of a jet engine to generate electricity. Combustion turbines are typically segmented into two categories: Simple Cycle Combustion Turbines (SCCT) and Combined Cycle Combustion Turbines (CCCT). SCCTs operate at low thermal efficiencies and are used predominately as peaking resources. Combined-cycle generating turbines add exhaust heat recovery steam generators to one or more natural gas-fired turbine generators. Use of the exhaust heat to generate additional electricity greatly increases the thermal efficiency of the plant. Contemporary CCCTs can convert more than 50 percent of the chemical energy in natural gas into electric energy. CCCTs have been widely used in bulk power generation.

Project Sizing SCCTs typically range in size from 10 to 150 MW. CCCTs are usually larger and range in size from 100 to 500 MW's.

Resource Characteristics Natural gas fired combustion is amongst the cleanest of all fossil fuel generation. The primary emissions include NOx, CO_2, particulates, CH_4 and negligible amounts of SO_2. The facilities have an industrial look and need to be sited near a major natural gas line and transmission line. The operator must secure natural gas supply contracts and transmission rights to effectively run these resources. Combined-cycle combustion turbines, unadjusted for emissions cost, have the lowest levelized energy cost for natural gas resources at $68 to $90/MWh and a levelized capacity cost of $92 per kilowatt-year. According to the Institute for Energy Research, Simple Cycle Combustion Turbines cost on average $130/MWh.

Availability and Outlook Both CCCTs and SCCTs are readily available. They can often be permitted and constructed within a couple of years.

Geothermal

Geothermal power plants produce electricity by converting energy from below-ground thermal reservoirs, such as those that create hot springs and geysers, into steam to drive a turbine generator. Geothermal generation is considered a baseload resource and produces a steady output that does not require balancing reserves. There are commercial geothermal projects currently operating in the Northwest and several others under development and exploration in Idaho, Oregon and Washington. Geothermal resources qualify as a renewable resource under the Energy Independence Act.

Technology The three methods used to generate electricity from geothermal sources are flash steam, dry steam, and binary-cycle. Flash steam technology takes high pressure water and injects it into a low pressure tank where it "flashes" into steam that is then run through a turbine. The exhaust steam is condensed and re-injected into the thermal well. Flash steam technology requires the water temperature to be 300° F or greater.

Dry steam takes the steam directly from the earth and puts it through a turbine generator. This method has limited use since it requires locating a thermal source at or very close to the surface, such as a geyser. It also can have significant maintenance costs as this type of steam often contains many impurities. The caustic and debris laden steam gives dry steam turbines a very short useful life.

The third method, binary-cycle can use water temperatures less than 300° F. This method takes hot water from geothermal sources and uses it to heat a secondary fluid. This secondary fluid can be water but is typically another material with a lower boiling point. Because of advances in binary-cycle technology, thermal wells with water temperatures as low as 160°F can be used to generate electricity.

Project Sizing Geothermal plants depend on the location to determine the size of the facility but operational facilities in the northwest are typically between 10 and 25 MW's.

Resource Characteristics Geothermal power is attractive because it is a renewable resource that can be used for baseload generation and typically has capacity factors of 90-98%. Another benefit of geothermal generation is that geothermal plants have very small installation footprints.

Drawbacks for geothermal power plants include high upfront capital costs and limited site locations. Most of the identified sites in the Pacific Northwest are in rural locations, far from existing transmission lines. Therefore significant capital investments would be needed to build the transmission lines necessary to connect the plant to the grid. These costs are comparable to those expected for connecting other renewable resources.

Availability and Outlook Geothermal energy has significant potential in the Northwest but it has not received the same attention as other renewable resources in the region. The most likely locations for new geothermal development are in southern Idaho and eastern Oregon. The Geothermal Energy Association has estimated that nationwide energy from geothermal sources could provide 20,000 MW's of electricity by 2025. The Sixth Power Plan has estimated that 370 aMW of geothermal energy could be available in the Northwest during the planning period at an approximate cost of $80 per MWh.

Demand Response

Demand response is a strategic load-management tool used by utilities to help manage peak-load capacity constraints through voluntary customer load reductions. The program is designed to enable customers to contribute to energy load reduction during times of peak demand. The reduction in customer load transfers resources from peak periods to off-peak periods. Smart Grid technologies can provide the basic infrastructure for accomplishing demand response programs, which modify consumer energy consumption. On a regional basis, demand response programs usually offer financial incentives for load reduction during times of peak demand, especially with commercial and industrial customers.

Even though Tacoma Power is not currently capacity constrained like utilities in the Northeastern or Southeastern regions of the country, demand response is generating increased interest as a contingency tool in case capacity conditions change in the future. Energy consumption trends could warrant more effective peak-load management.

Technology There are various technologies and/or programs that can be included in the category of Demand Response resources. However, in order to be considered a viable resource supply option, the resource must satisfy the criteria of being cost-effective. This means that a careful delineation of costs and benefits must be identified within a framework like the NWPCC's Total Resource Cost Test or the Participant Test that measures the economic values of such programs. Some of the various benefits usually provided by Demand Response programs or technologies include:

- Avoided Generation Capacity Costs
- Avoided Transmission & Distribution Costs
- Electric Reliability through improved outage management
- Environmental protection resulting from less water spills from our hydro damns
- Customer benefits in the form of lower costs, lower prices and technology upgrades like In Home Displays and Programmable Controlled Thermostats.

Project Sizing Typical projects result in the shaving of loads in peak periods and in specific locations, resources have proven to reduce peak system loads by several percent. The size is completely dependent on the specific location and details of the program or technology employed.

Availability and Outlook Since 2009, sixteen Northwest utilities have partnered with BPA in pilot demonstration programs about demand response effectiveness. These pilots have cost approximately $4.5 million for demand response research.

Tacoma Power has studied potential demand response programs as an additional resource supply option. Our results have concluded that demand response programs yield a small benefit for the utility and our ratepayers given the relatively small differential between heavy load and light load hours. Tacoma Power is also an active participant with the Demand Response Committee for the Pacific Northwest Power & Conservation Council (NWPCC). The Committee is responsible for verifying that demand response programs meet the rigorous test as a cost-effective resource in order to be considered a generation supply option in the resource stack at both the regional and utility level.

The addition of variable wind resources in the Northwest and BPA's oversupply protocol may provide additional technological opportunities for demand response in the region. As a result, BPA has committed additional funding to ensure the region can maximize the potential benefits of demand response through the following:

- $3.2M allocated to demand response commercial demonstration projects in FY14 and FY15
- Demonstration goals of 50-100MW
- Plan to work with 4-6 utilities and/or aggregators

Ocean Energy

There are several technologies in development which will convert energy from the oceans into electricity. The current types of ocean energy facilities could provide highly reliable generation as they follow well known and dependable tidal patterns. However, ocean energy is not dispatchable and thus an intermediate or baseload resource. In addition, ocean energy is not yet commercially available and many questions persist regarding its cost and technological reliability.

Technology The two most applicable technologies to the Pacific Northwest are tidal stream and tidal barrage. Tidal stream facilities utilize tidal currents to turn turbines, whereas tidal barrage facilities harness the energy associated with rising and lowering water levels.

A tidal stream power plant would consist of an array of turbines, most likely similar to wind farm turbines, installed on the seabed at sites where there are regular current flows, preferably at narrow sections where flows are amplified. The turbines would convert the currents produced by the diurnal tides into electricity. The technology to generate electricity from the tides is relatively new. However, because the concept is similar to the technology used to generate power from wind, in-stream tidal turbine developers will be able to draw on the lessons learned from the early wind developers.

Tidal barrage is another emerging technology that taps the energy of the ocean. Tidal barrage energy conversion devices are even more widely diverse than those being developed for tidal energy conversion, but they all work to convert the kinetic motion of waves into electrical energy.

Project Sizing Currently most projects are only a few hundred kilowatts but as technologies evolve and successful pilot studies are completed, larger projects can be expected to be developed.

Resource Characteristics Of the emerging renewable technologies, in-stream tidal power offers a benefit that few other renewable sources can: It is a 100 percent predictable renewable energy source. Once the tidal currents have been measured, the amount of electricity available can be predicted years into the future. Final predictions would depend upon the amount of energy in the current, turbine efficiency, and environmental impacts, all of which are still being investigated.

Energy from ocean waves could become the largest, most available environmentally friendly resource on the planet. Wave energy is completely renewable. There are, however, two drawbacks to wave energy conversion. First, the cost of installing submarine transmission cables as far as five miles off shore and in water several hundred feet deep may be prohibitively expensive. Second, the size of the waves are weather dependent, suggesting some challenges in predicting precise output.

Availability and Outlook There are currently no ocean energy resources available in the Pacific Northwest. However, there are numerous local feasibility studies and sites in development. Most of these sites are off the coasts of Washington and Oregon. Additional wave energy projects will likely begin to become available in the next few years but costs are likely to remain higher than comparable resource alternatives.

Fuel Cells

Fuel cells use a chemical process to produce electricity by combining hydrogen and oxygen (from the air) to form water. Current methods used to obtain hydrogen typically involve fossil fuel consumption and/or the use of nuclear reactors. Fuel cells are relatively small units, approximately 1 MW. However, they can be installed in an array to increase overall output. Fuel cells are an emerging commercial technology with relatively high costs and uncertain reliability. Fuel cell use is presently limited to off-grid and back-up power applications.

Fuel cell technology has advanced a great deal since its development in the 1960s, but the cost of generating electricity from fuel cells is currently still prohibitively expensive. In particular, the cleanest fuel cells use pure hydrogen as fuel, and at this time there is no economical, environmentally friendly way of producing pure hydrogen.

Bloom Energy

An intriguing electric supply option emerging with a promise to challenge the traditional generation footprint is "Bloom Energy". Bloom Energy is variant of fuel cell technology and is being developed by a firm in California.

Technology Electricity is generated thru a fuel cell reaction—feeding oxygen and fuel (hydrogen) into the cell to generate electricity. Bloom boxes are also capable of making the process reversible. When hooked up to an intermittent power source such as a wind turbine or solar panel, the refrigerator-size unit makes and stores hydrogen and oxygen. And at night or when the wind dies down, it can change direction to use the stored gases to make electricity.

Project Sizing The Bloom Energy Server (aka the Bloom Box) provides 100 kilowatts (kW) of electricity. Bloom inventor, Dr. Sridhar, says that customers can get between a 40 and 100 percent reduction in their carbon footprint as compared with the U.S. grid, depending on if they are using natural gas or renewable methane.

Unlike conventional alternative technologies, Bloom Energy purports to be a baseload resource thereby avoiding the problem of the intermittency characteristic of wind or solar. Bloom Energy is not currently an eligible renewable resource under the Energy Independence Act.

Resource Characteristics The cost of a 100KW Bloom Box is estimated at $700,000 to $800,000, or $7,000 to $8,000 per kW. Bloom Energy founder KR Sridhar says that the payback on investment for their customers is 3-to-5 years in energy cost savings. The 3 to 5 year claimed payback is with California state and federal subsidy but it is unclear what the payback would be without such subsidies.

Availability and Outlook As Bloom Energy continues to develop and the technology costs lessen, it is possible to see more use of the Bloom Energy in the region. However, at this time it is too early to forecast wide spread usage in the planning horizon.

Nuclear

Nuclear power generation facilities utilize uranium to power an atomic reaction that generates heat. This heat is used to create steam that turns a conventional electric generating turbine. Nuclear facilities are very large baseload plants that are generally located in remote locations. Most of the currently operating nuclear facilities enjoy very high capacity factors and relatively low production costs.

Some consider nuclear energy a renewable energy source because the nuclear fuel can be created in a laboratory. However, there remains much debate about proper treatment of nuclear facilities' radioactive waste. In addition, the upfront capital costs and the large gap of time between licensing and bringing a facility on-line can make nuclear facilities a risky investment. If the technology to recycle spent fuel rods is perfected, or if new legislation emerges, nuclear power may become a more attractive alternative.

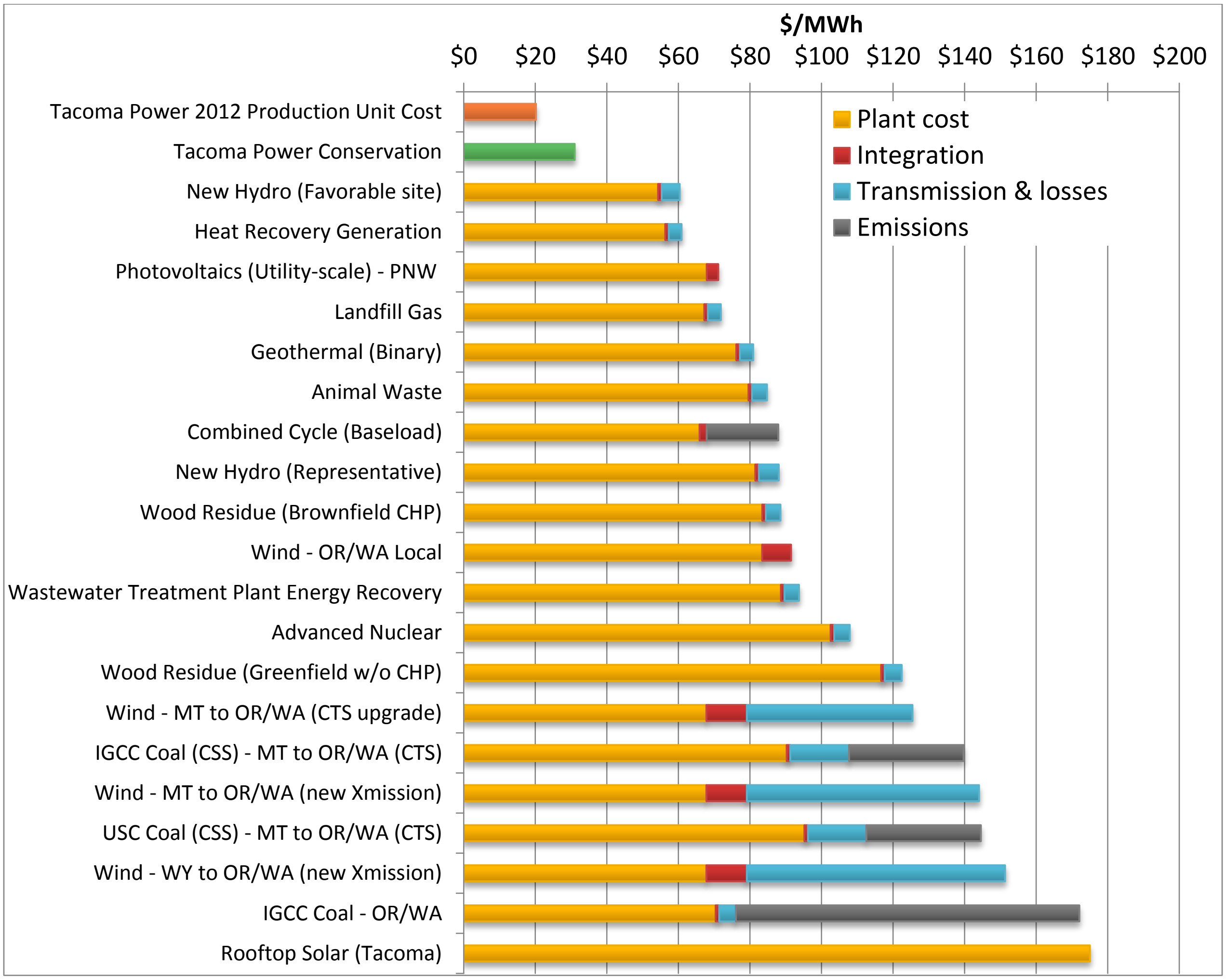
Coal

While coal-fired generation makes up a relatively small part of the Pacific Northwest's resource portfolio, it is the most common electric generating resource in the United States. Though the technology has evolved significantly to maximize electric output and minimize emissions, coal fired generation still emits far more pollution per MWh than any other major resource. Coal fired generation plants typically range in size from 500 to 2000 MW. These are typically large facilities requiring significant amounts of land to operate. New pulverized coal plants are effectively prohibited by Washington state law (RCW 80.80.040) without carbon capture and sequestration, and this technology is not currently commercially viable. As a result, there is little likelihood that this resource technology will be available to Tacoma Power during the planning period of this IRP.

Cost of Alternative Resources

The following graph is a combination of Tacoma Power's staff analysis and information from the NWPCC's Sixth Power Plan. The Council's most recent (February 2013) levelized cost estimates for hydro power and a wide range of alternative generation technologies are included and projected over the next twelve years. These costs reflect bus bar, integration, transmission and CO_2 components. PV Solar is projected to cost nearly $200 per MWh by the NWPCC but has been adjusted to reflect more discussions Tacoma Power has had with other utilities and term sheets offered to the utility.

The information in the table suggests that an aggressive deployment of renewable generation in the Northwest is unlikely, given the cost structure for the respective resources. Combined with the intermittent feature of many renewable resources, the cost premiums make such acquisitions unattractive. If Tacoma Power adopts a renewable acquisition strategy to meet our renewable resource obligations, our customers will be at risk of rate increases for electric power. The levelized cost of most renewables warrant Tacoma Power refraining from adopting additional renewable resources and our current strategy is to acquire cost-effective conservation while persisting in the maintenance of owned hydroelectric generation sources. A more detailed overview of this analysis is included in Appendix 6: Comprehensive Overview of Scenario Alternatives.



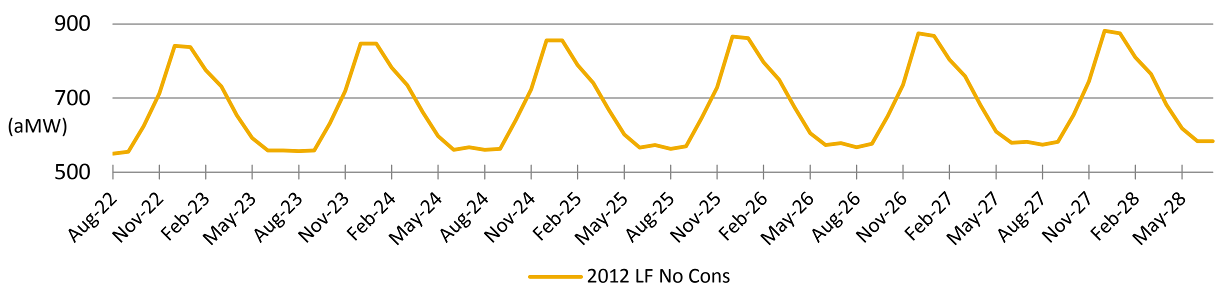
* Resulting resource costs are a combination of staff analysis and Northwest Power and Conservation Council 's Mid-term Assessment

APPENDIX 6: Comprehensive Overview of Scenario Alternatives

Building on the review of resource alternatives (Appendix 5), this section provides the result of additional analyses that incorporate those resource decisions that are most likely to align with Tacoma Power's needs. The following resource types were selected for further analysis: biomass, combustion turbines, pumped storage, renewable energy credits, solar/photovoltaic, and wind. Each of these resources have unique characteristics and operational behaviors that can challenges in determining how best to perform resource analysis. However, for this IRP Tacoma Power has taken each resource type and developed the resource into a specific scenario for incorporation into in our modeling environment. The modeling environment allows staff to simulate the operation of our resource portfolio with the additional resource and inspect portfolio performance with the additional resource. Each scenario has been developed from staff analysis, term sheet offers provided to the utility, and industry information organized into a likely potential scenario to meet Tacoma Power's future resource needs.

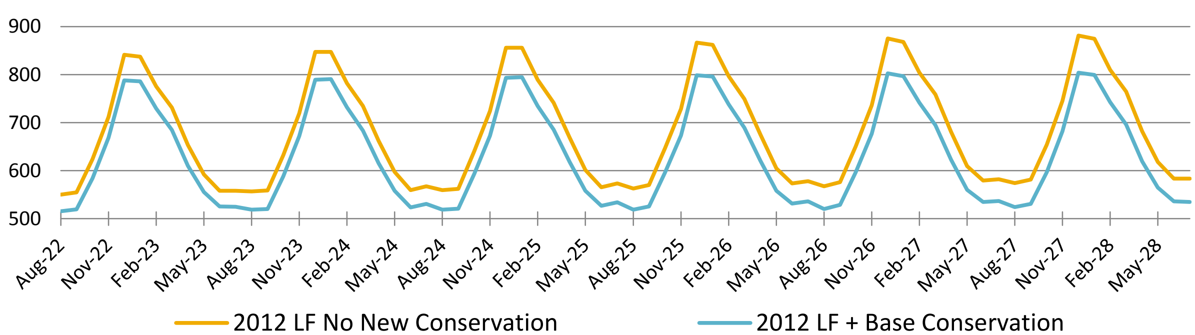
Base Case

As explained in the main body of the IRP, modeling the base case is the starting place for Tacoma Power's portfolio analysis needs. The base case establishes a comparison portfolio, upon which each of the other scenarios are compared to. In order to model the base case Tacoma Power utilized the 2012 Load Forecast for the period between August 2022 and July 2028.



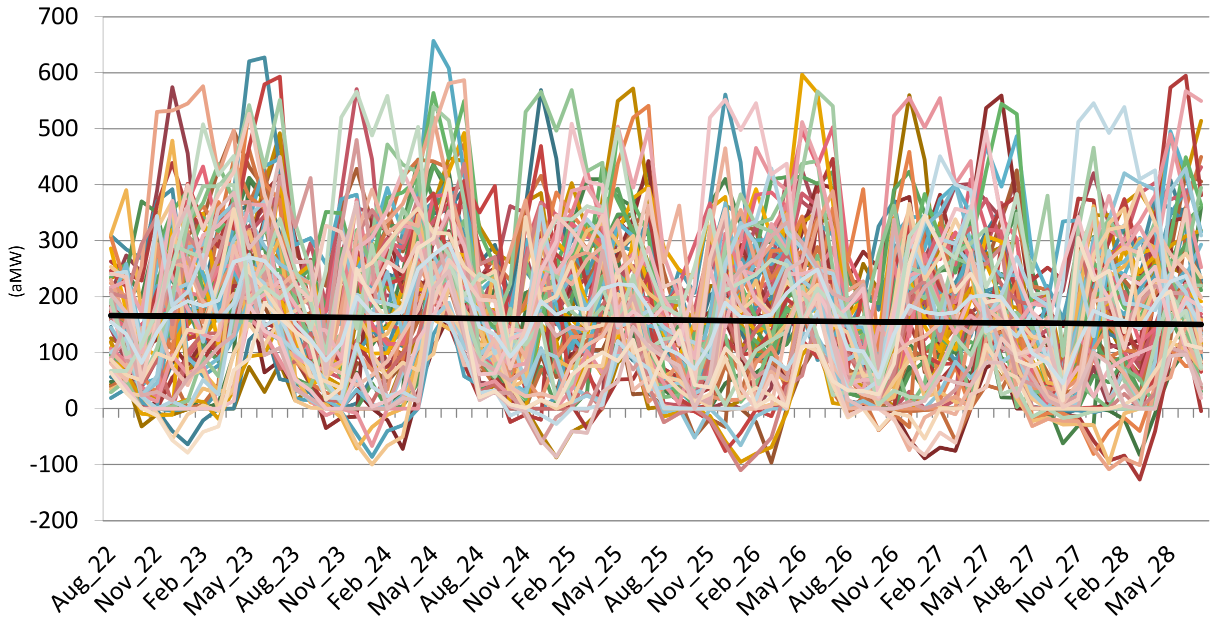
Load Forecast before new Conservation

Tacoma Power's total achievable economic potential conservation is then added to the load forecast, effectively reducing the total load of Tacoma Power's system.



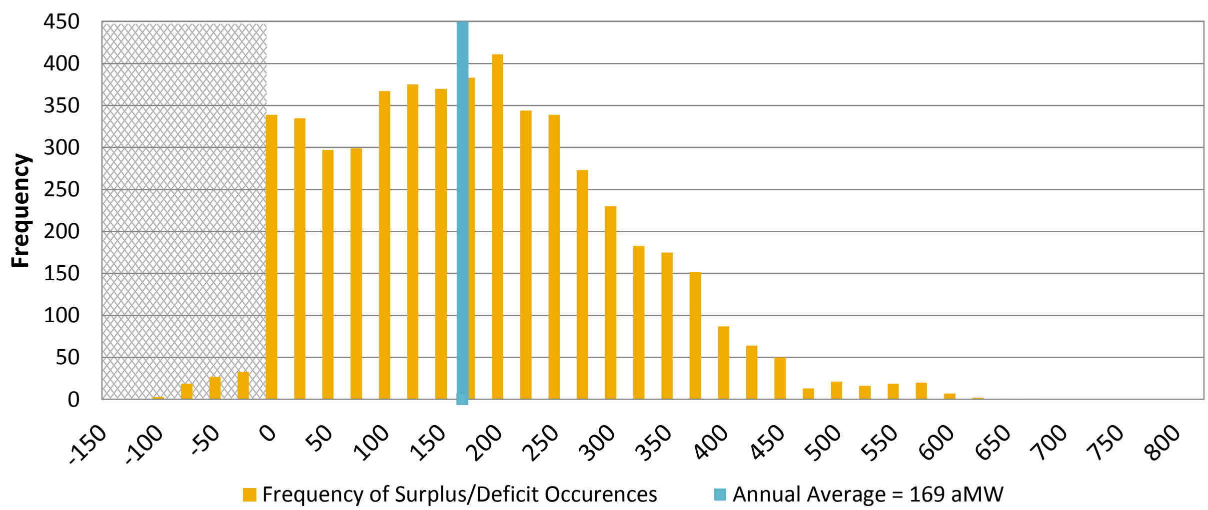
Load Forecast with new Conservation

Using the adjusted load forecast that includes the base achievable economic potential conservation (59.5 aMW) we are able to simulate the operations of our portfolio for the target time period between 2022 and 2028. The following charts are a result of these simulations using the Vista model.



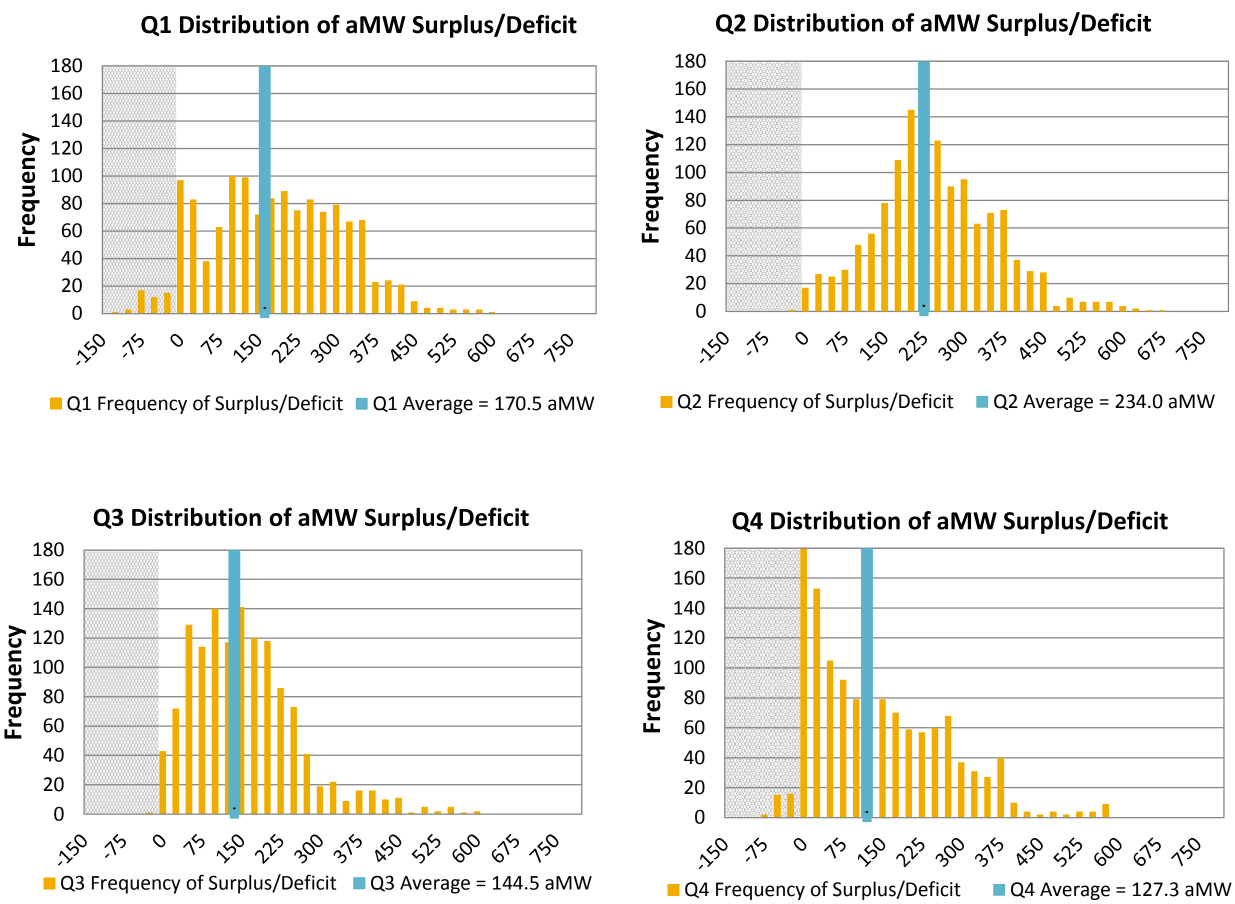
Composite portfolio output under each historical water year

Each line in the above chart reflects the Tacoma Power's portfolio, under a specific historical water year, likely capability to meet the projected load forecast. The black line in the middle represents average of all conditions. For the base case the average amount of surplus drops from 187 aMW in 2022 to 150 aMW in 2028. This same information can be displayed in a histogram to see the distribution of values across the whole time period.



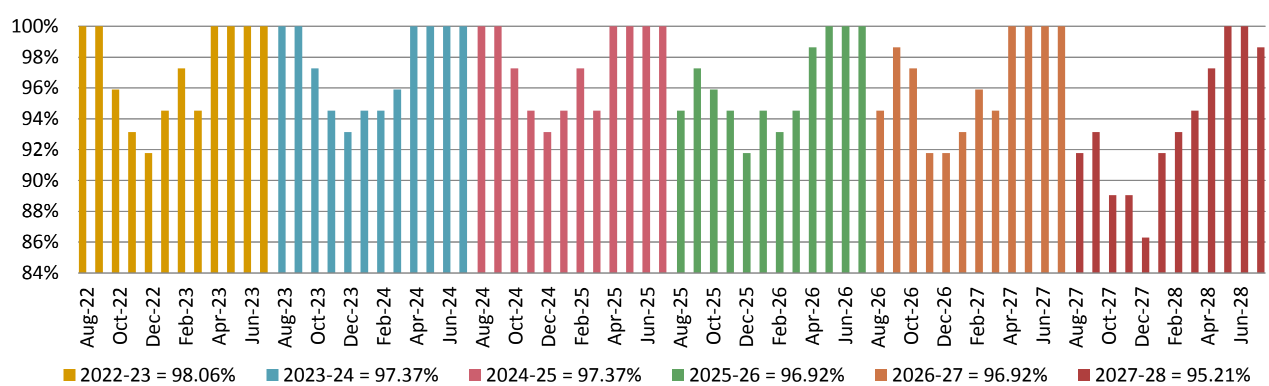
Frequency of surplus and deficit periods from portfolio simulation

This same information can be broken into quarterly amounts in order to see a more complete view of the quantity of surplus and deficit periods.



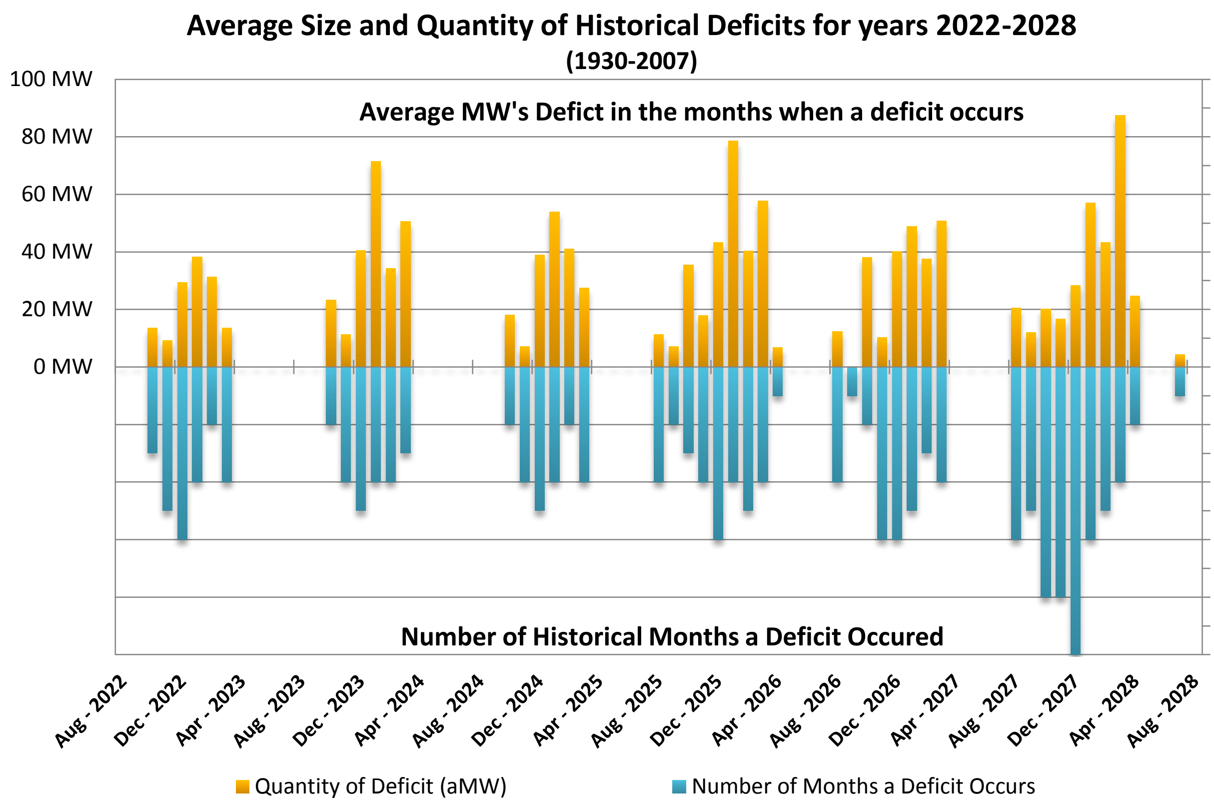
Quarterly frequency of surplus and deficit quantities of portfolio simulation

The simulation reveals that Tacoma Power is surplus in 96.5 percent of the historical water conditions. This can better be seen in the following chart which details the percentage of months surplus in each of the historical water conditions. Each month is simulated several times under each of the various historical water conditions and the chart illustrates that for many of the months, Tacoma Power is not deficit in any of the periods.



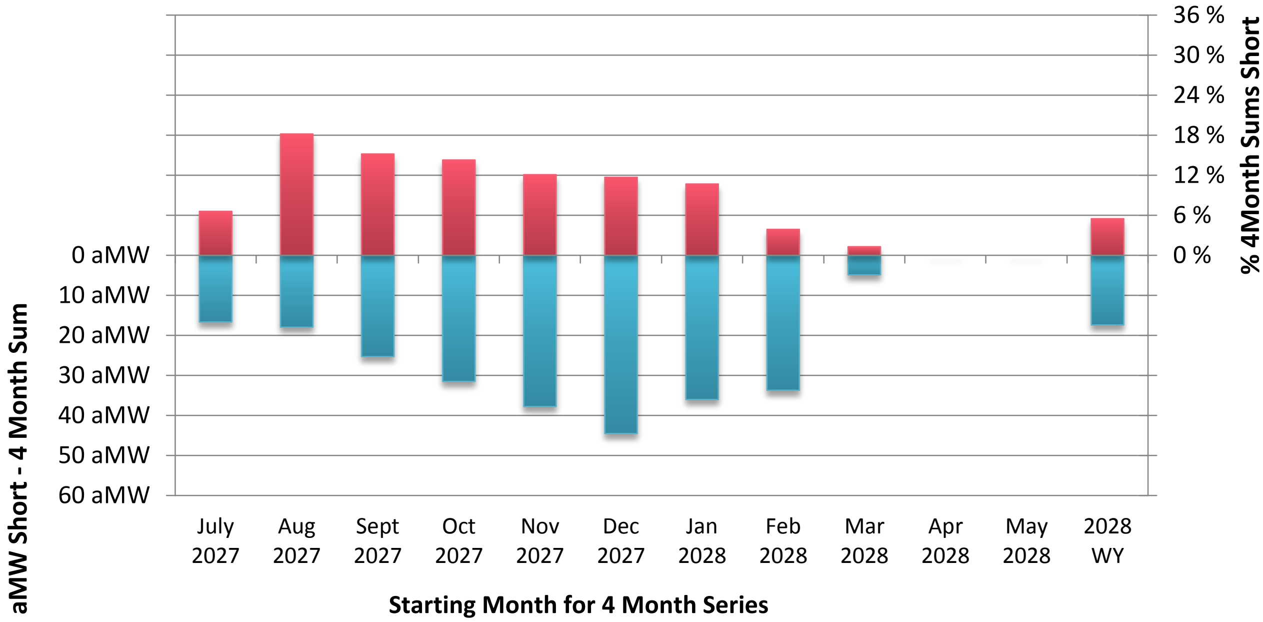
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In October of 2022 there were only 3 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in those three months was 13.49 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



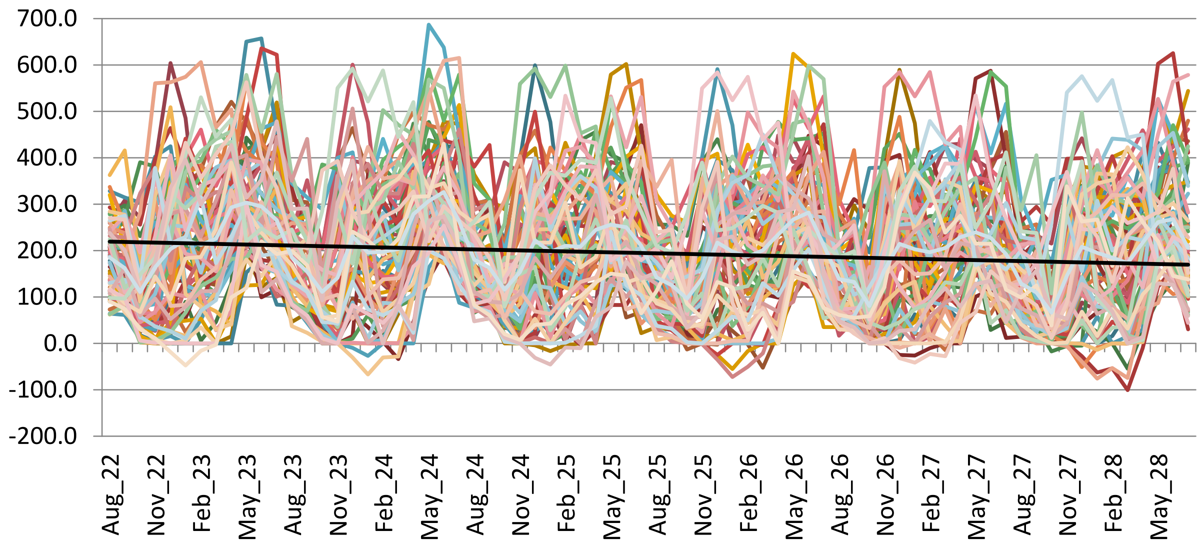
Size and quantity of historical deficits

The final portion of the base case analysis is the incorporation of variable loads and power prices. The chart below is a summary of the Crystal Ball analysis by displaying 4-month averages for the incorporation of +/- 15 aMW of load and the historical water years. This chart displays the results using the 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus power. However, it is apparent from the chart below that Tacoma Power remains surplus majority of the time. In the colder months, November through February, Tacoma Power is short in less than 12% of the 4 months series that start in those months. The average quantity of additional power purchased in these months is less than 45 aMW. A new load does add risk to the portfolio, especially in low water years. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 10+ aMW, Tacoma Power could be short by 115 aMW for the 4 month period.



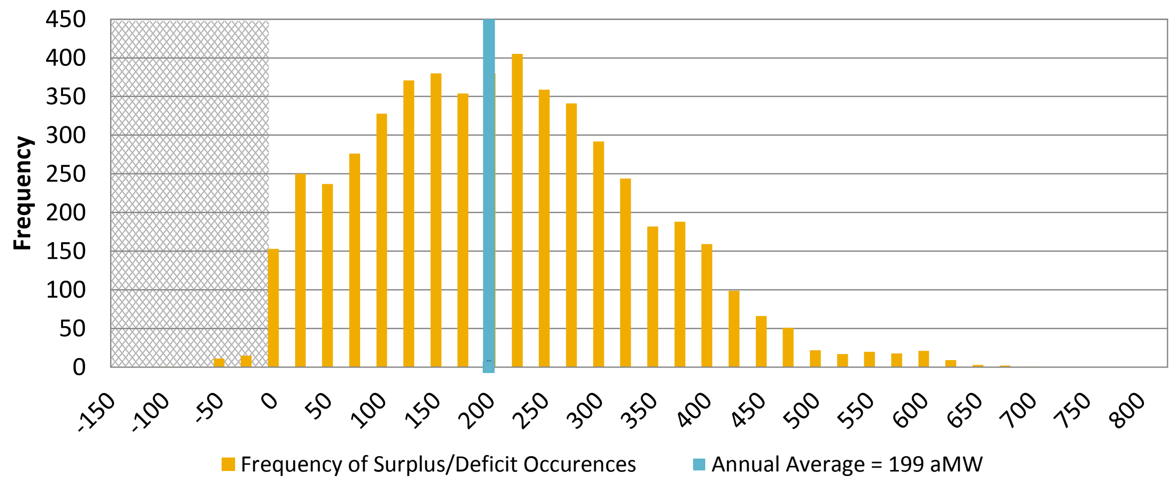
Combustion Turbine

Tacoma Power evaluated the addition of a combustion turbine to our resource portfolio. Given the results of the base case analysis, significant additional baseload resource capabilities are not expected to be needed in the next 10 years. A Combined Cycle Combustion Turbine (CCCT) is slow to cycle on and off and the size of the plant would increase the baseload generation of Tacoma Power's generation portfolio. This slightly reduces the number of deficit periods but mostly just results in Tacoma Power having that much more surplus in the surplus periods. To analyze the effects of additional capacity resources, Tacoma Power modeled a 30 aMW single cycle turbine (SCT). Using the same loads as what was used in the Base Case analysis, the following charts are the results of simulations using the Vista model.



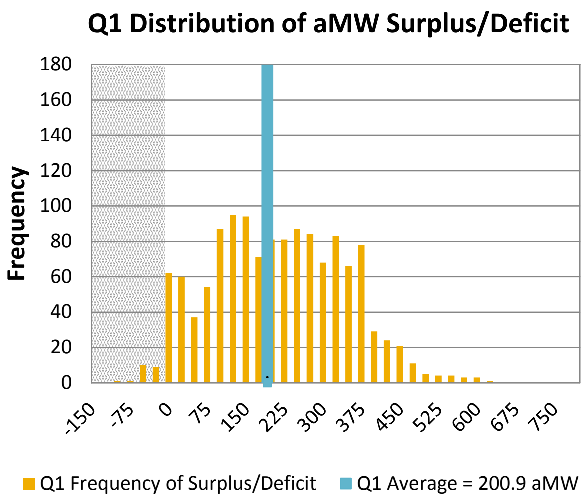
Composite Portfolio output with 30 MW SCCT under each historical water year

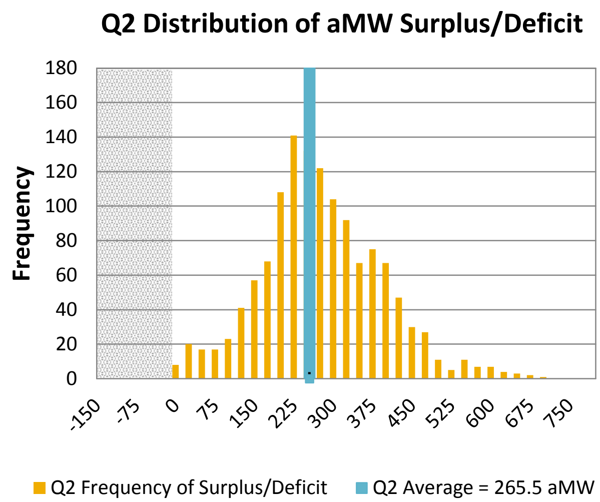
The average annual amount of surplus drops from 220 aMW in 2022 to 180 aMW in 2028. The following histogram displays the same information across the entire time period analyzed.

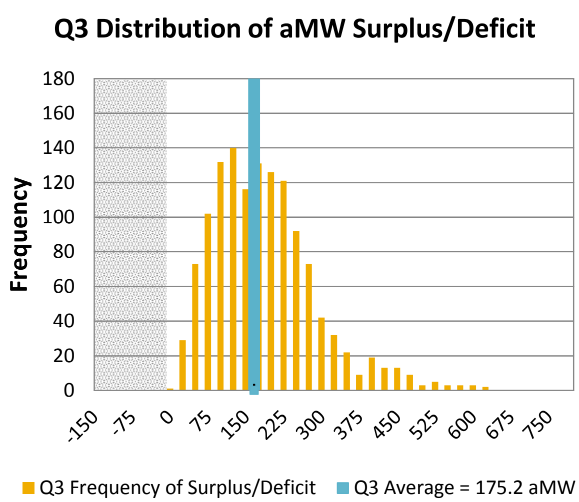


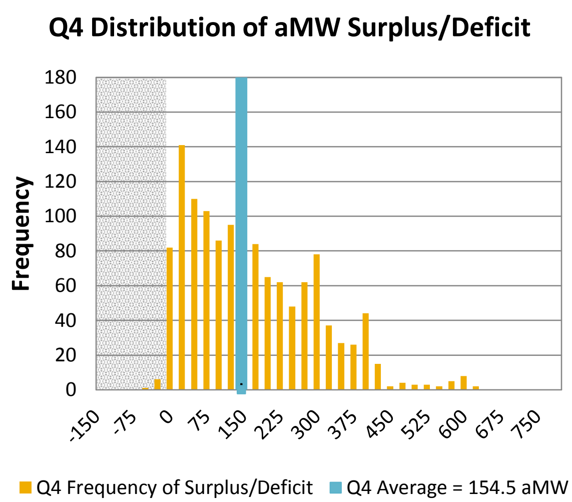
Frequency of Surplus and Deficit Periods from portofolio simulation with 30 MW SCCT

The annual average surplus of the entire portfolio over the whole period analyzed is 199 aMW. There are a fewer number of periods where a deficit occurs and the following charts illustrate the data on a quarterly basis.



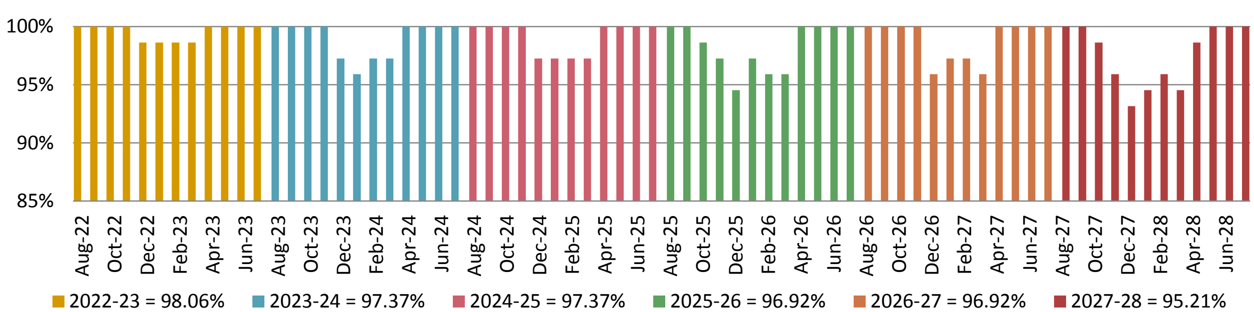






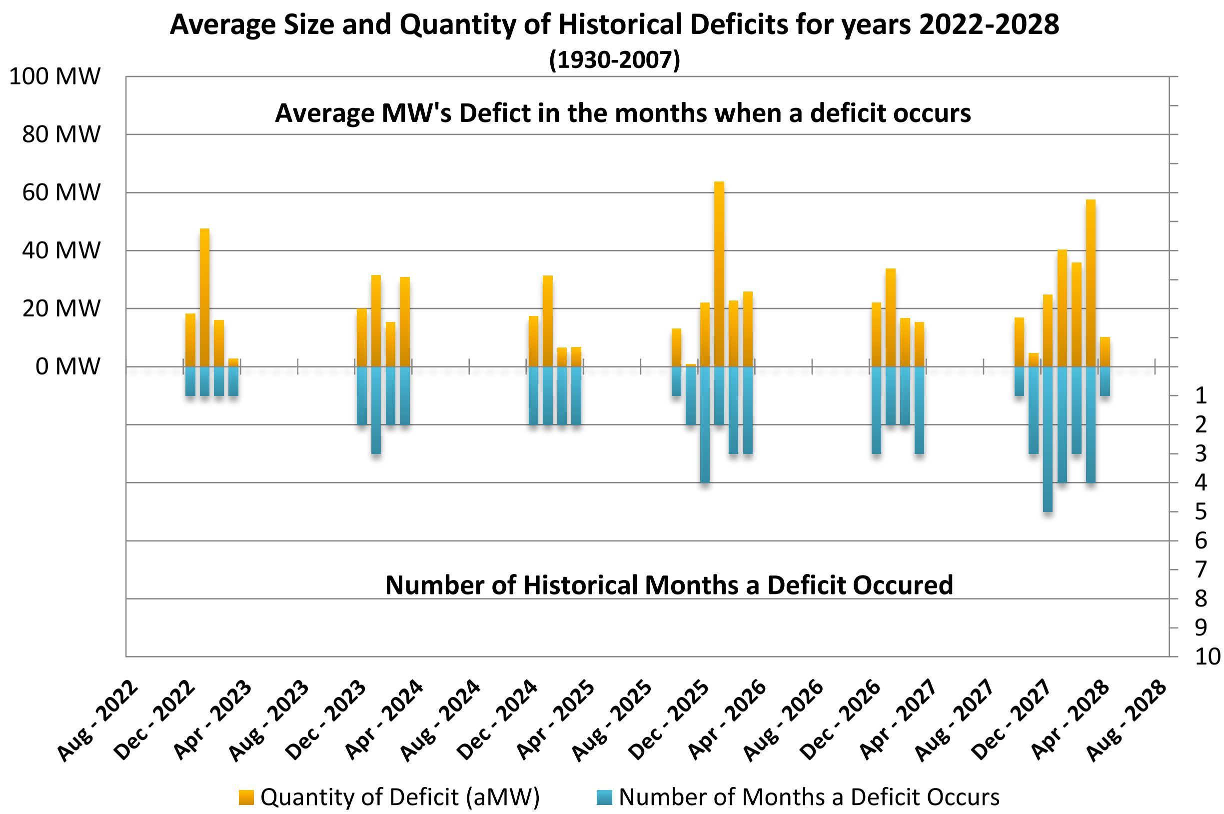
Quarterly frequency of Surplus and Deficit quantities for Portfolio Simulation with 30 aMW SCCT

Tacoma Power is surplus in 99.9% of the historical water conditions. The following chart illustrates the percentage of months surplus in each of the historical water conditions.



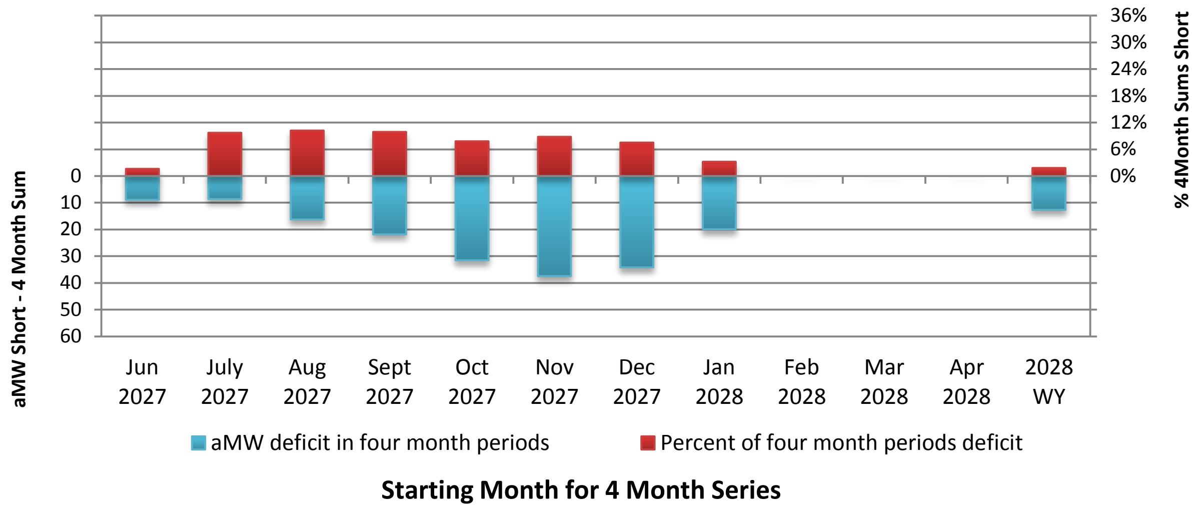
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In October of 2022 there was only 1 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in that month was 7.05 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



Size and Quantity of Historical Deficits

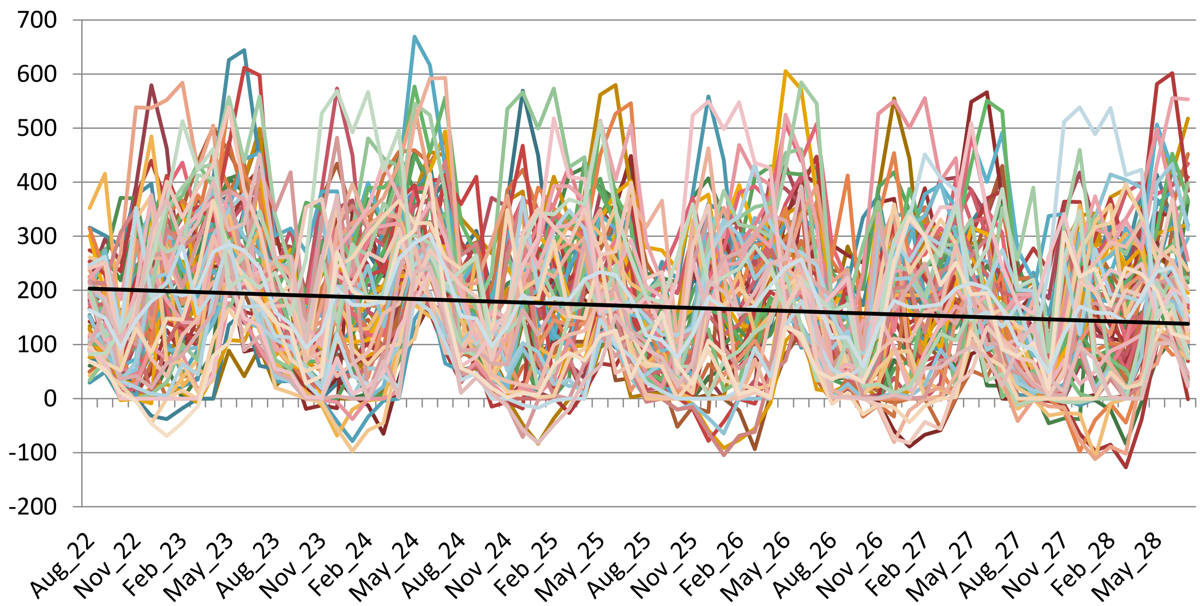
The final chart from the analysis is a reflection of the additional analysis adding load and price variability. The chart is a summary of 4-month averages for the incorporation of +/- 15 aMW of load and the variability associated with historical water years. This chart displays the results of 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus available. In the colder months, November through February, Tacoma Power is short in less than 9% of the 4 months series that start in those months. The average quantity of additional power purchased in these months is approximately 37 aMW. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 10+ aMW, Tacoma Power could be short by 89 aMW for the 4 month period.



Even during periods when the LRB is negative, the levelized cost of the SCCT is almost always above the expected wholesale price at the Mid-Columbia market. There is more risk associated with the extra surplus Tacoma Power would have to sell in majority of the periods at a cost that is less than what the resource would cost to own and operate. It is not recommended that Tacoma Power take steps to acquire this resource in the near term.

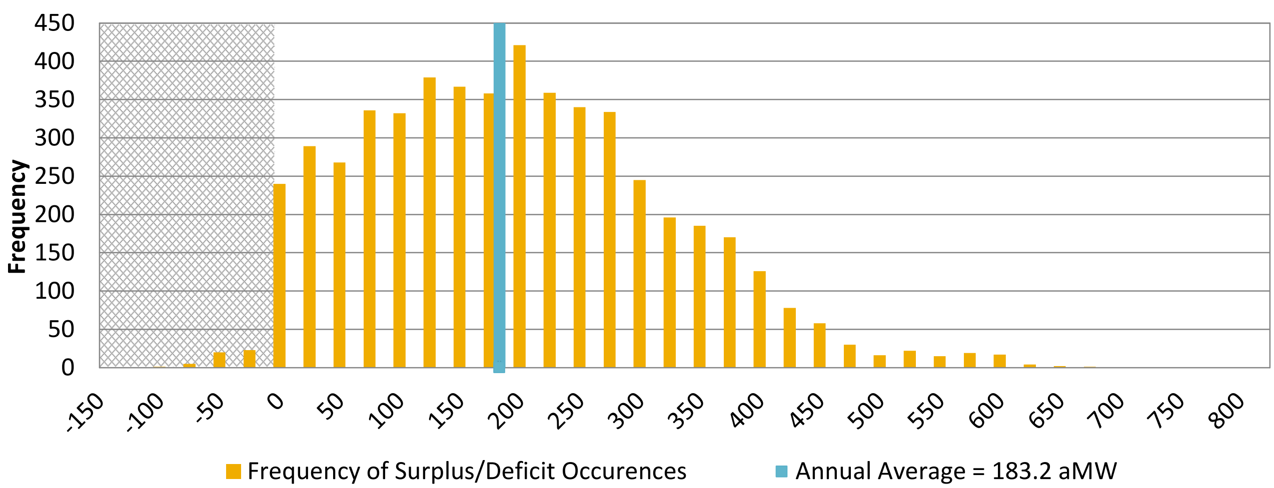
Wind

A scenario of continual interest in the last several years is how the addition of a wind resource would impact Tacoma Power's portfolio. Tacoma Power decided to model a wind scenario based on a single site with a 25 MW nameplate value and approximately 28 percent capacity factor. Tacoma Power shaped owned hydro resources around the hypothetical wind plant in VISTA. Using the same loads as what was used in the Base Case analysis, the following charts are the results of simulations using the Vista model.



Composite Portfolio output with 25 MW Wind Plant in each historical water year

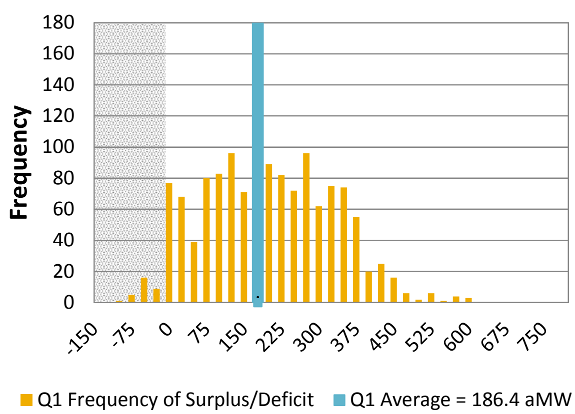
The average annual amount of surplus drops from 205 aMW in 2022 to 165 aMW in 2028. The following histogram displays the same information across the entire time period analyzed.



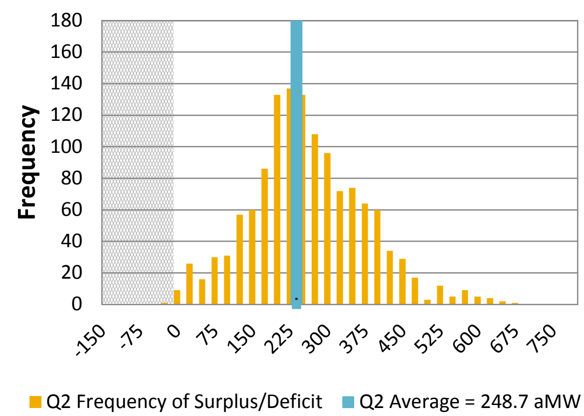
Frequency of Surplus and Deficit Periods from portofolio simulation with 25 MW Wind Plant

The annual average surplus of the entire portfolio over the whole period analyzed is 183.2 aMW. There are a fewer number of periods where a deficit occurs as compared with the base case and the following charts illustrate the data on a quarterly basis.

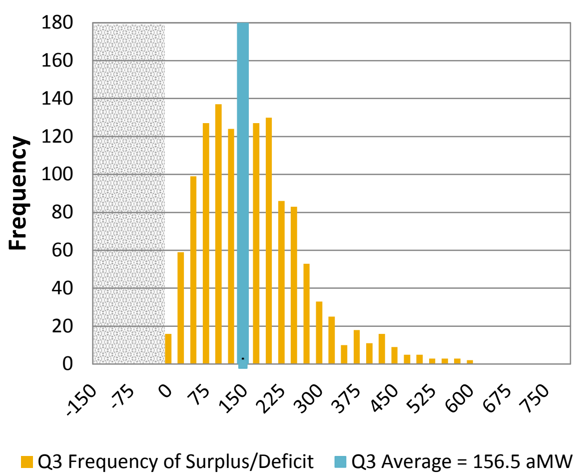
Q1 Distribution of aMW Surplus/Deficit



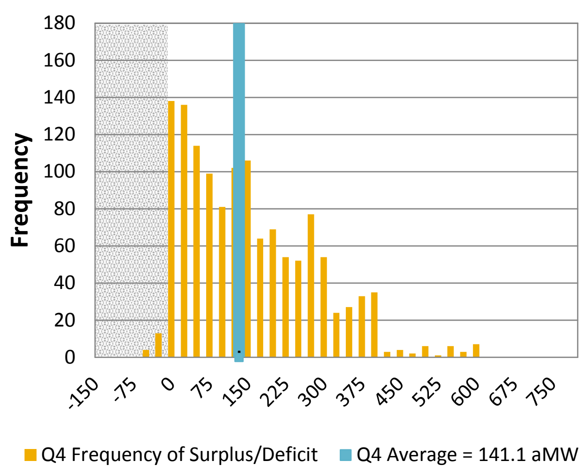
Q2 Distribution of aMW Surplus/Deficit



Q3 Distribution of aMW Surplus/Deficit

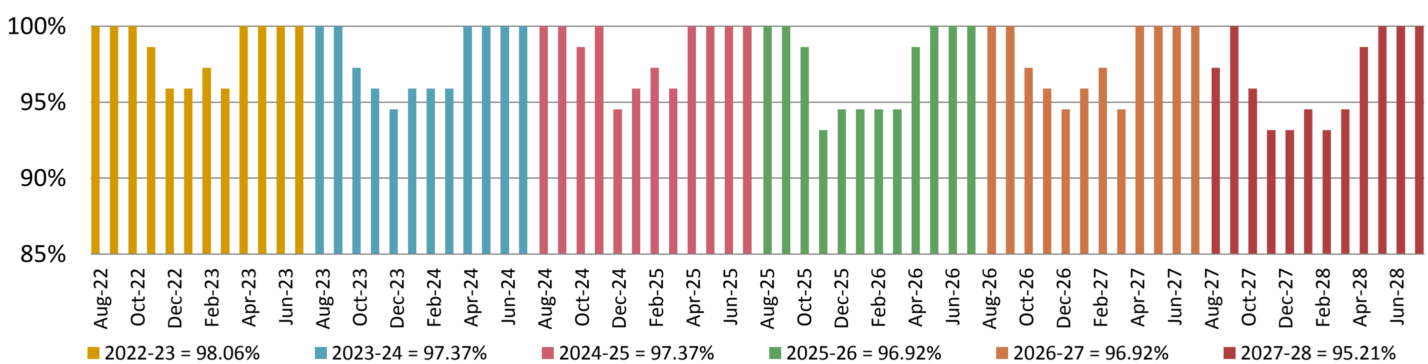


Q4 Distribution of aMW Surplus/Deficit



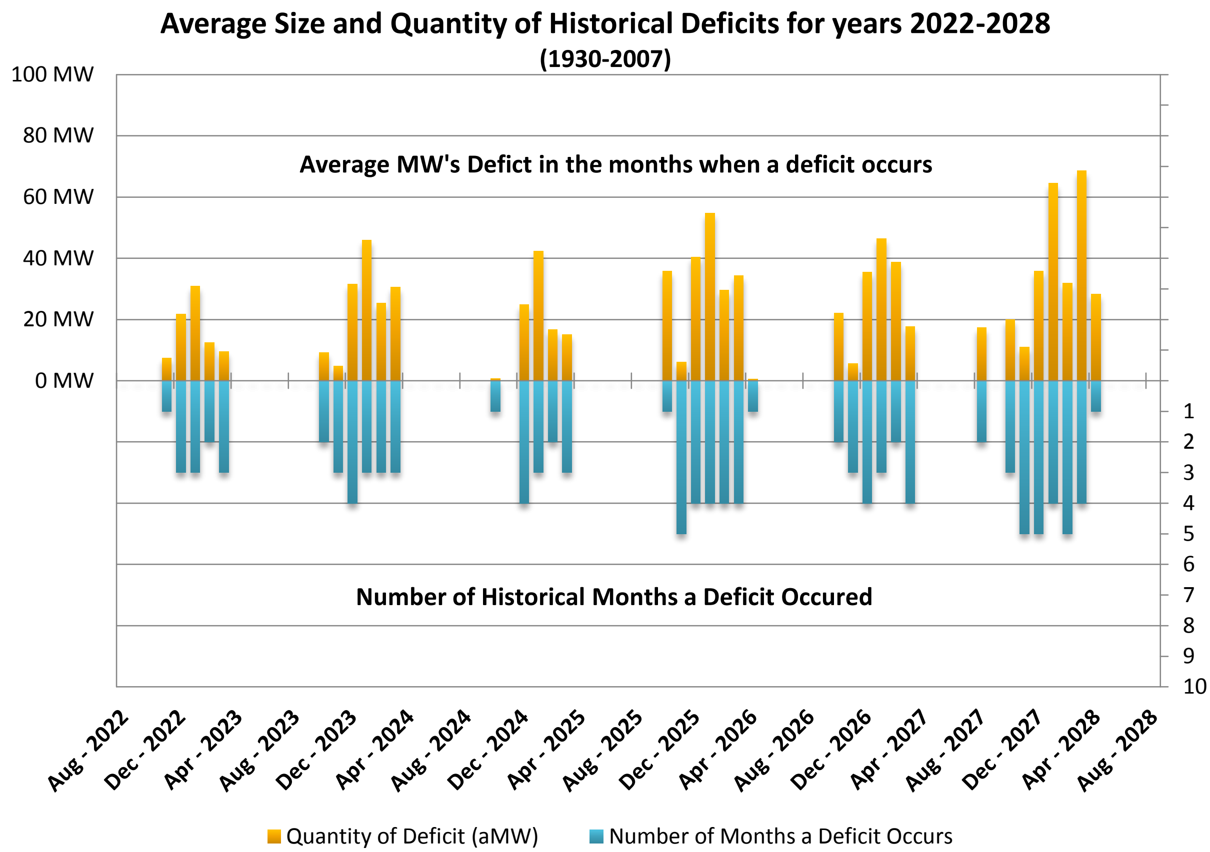
Quarterly frequency of Surplus and Deficit quantities for Portfolio Simulation with 25 MW Wind Plant

Tacoma Power is surplus in 99.7% of the historical water conditions. The following chart illustrates the percentage of months surplus in each of the historical water conditions.



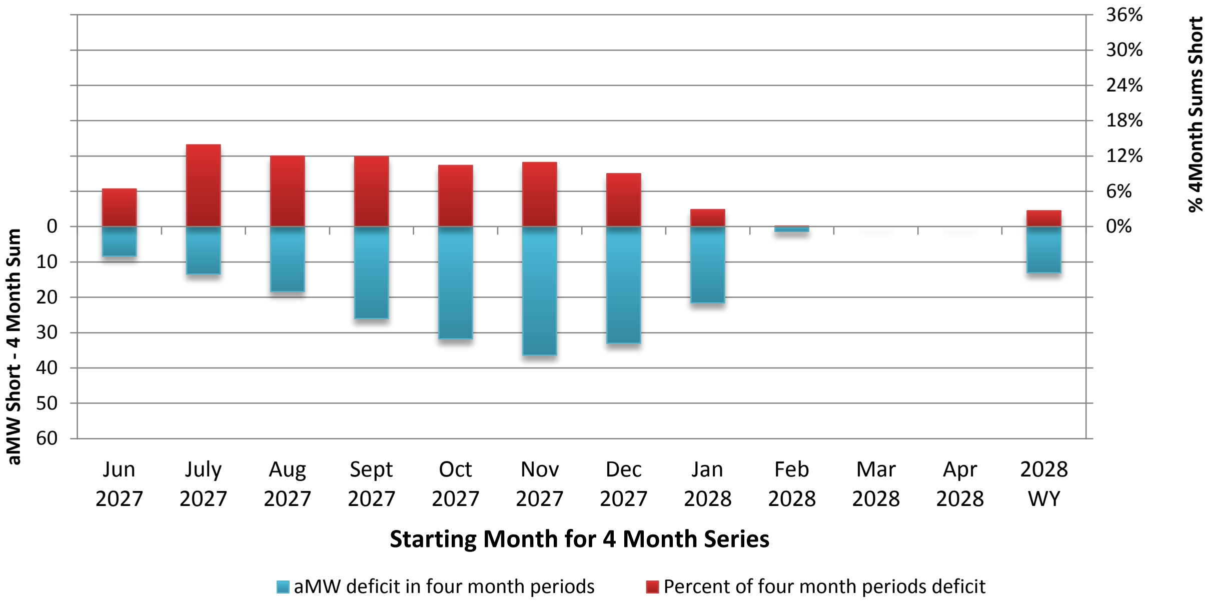
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In November of 2022 there was only 1 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in that month was 7.55 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



Size and Quantity of Historical Deficits

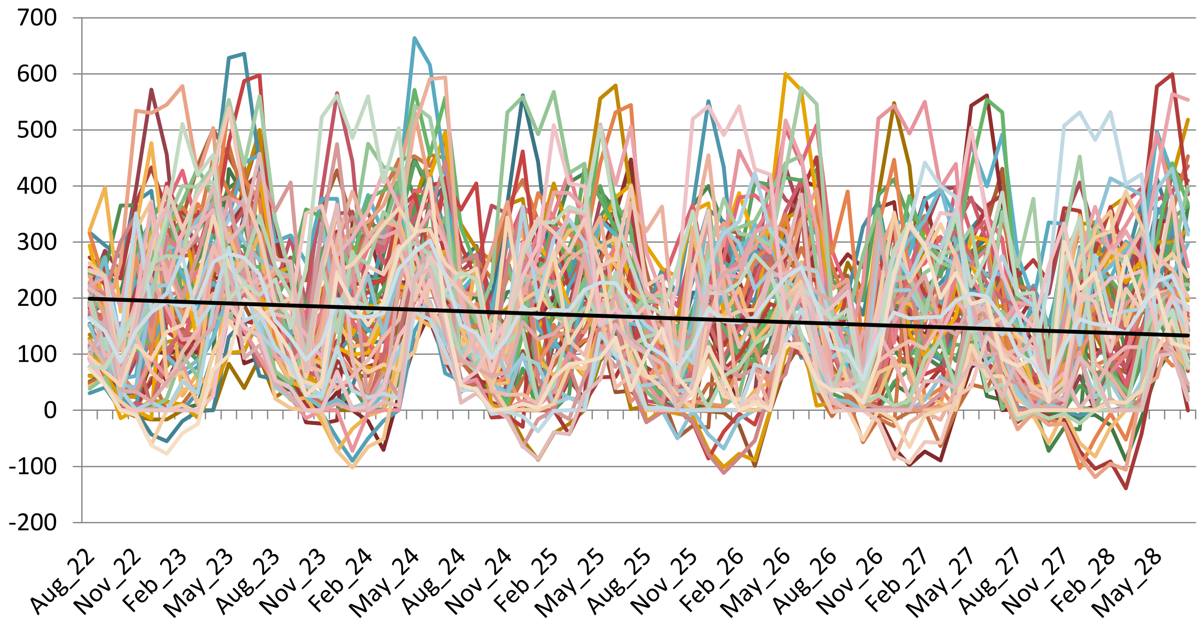
The final chart from the analysis is a reflection of the additional analysis adding load and price variability. The chart is a summary of 4-month averages for the incorporation of +/- 15 aMW of load and the variability associated with historical water years. This chart displays the results of 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus available. In the colder months, November through February, Tacoma Power is short in less than 11% of the 4 months series that start in those months. The average quantity of additional power purchased in these months is approximately 36 aMW. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 10+ aMW, Tacoma Power could be short by 100 aMW for the 4 month period.



Even during periods when the LRB is negative, the levelized cost of Wind resources are almost always above the expected wholesale price at the Mid-Columbia market. There is more risk associated with the extra surplus Tacoma Power would have to sell in majority of the periods at a cost that is less than what the resource would cost to own and operate. The additional renewable benefits of the resource are also not enough to balance the costs, benefits, and risks associated with the resource. It is not recommended that Tacoma Power take steps to acquire this resource in the near term.

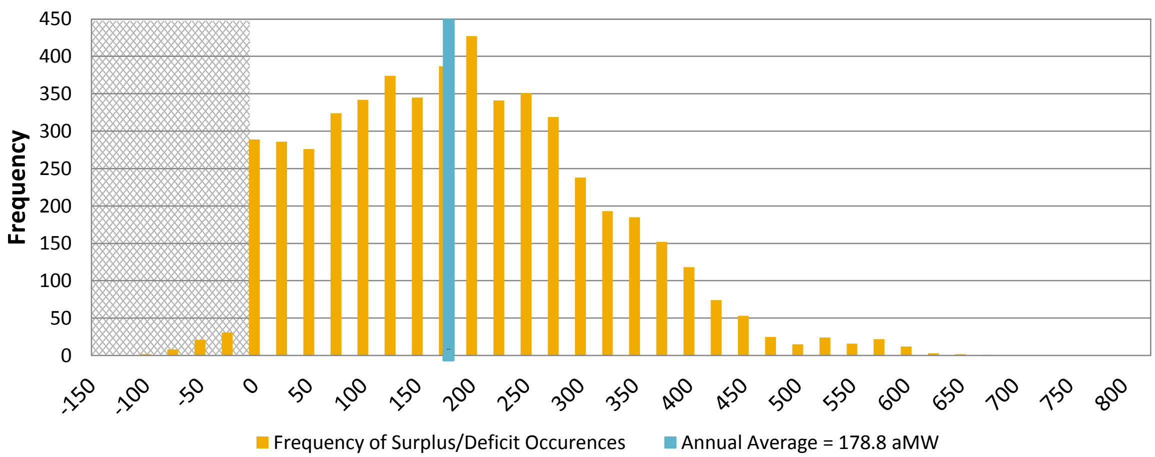
Biomass

A few different biomass facilities have been constructed near Tacoma Power's service territory in recent years. The renewable attributes often make the resource attractive to help in meeting renewable portfolio standard requirements. Tacoma Power modeled the addition of a small biomass facility that totaled 12 MW of nameplate capacity. In total, the plants produce approximately 9.7 aMW and it was modeled as a dispatchable resource, mostly producing generation during the daytime in the VISTA model. Using the same loads as what was used in the Base Case analysis, the following charts are the results of simulations using the Vista model.



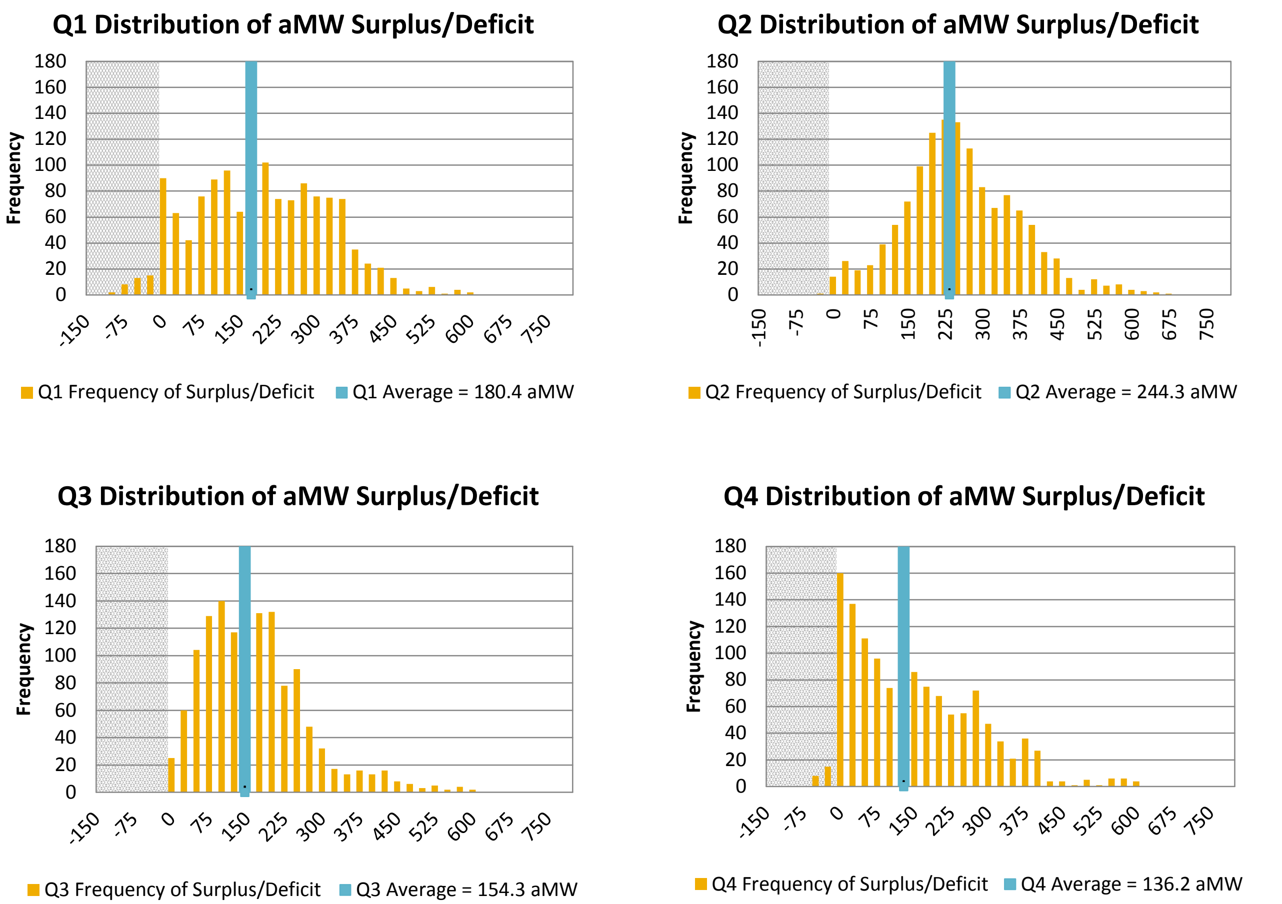
Composite Portfolio output with 12 MW Biomass Facility in each historical water year

The average annual amount of surplus drops from 199.9 aMW in 2022 to 160.2 aMW in 2028. The following histogram displays the same information across the entire time period analyzed.



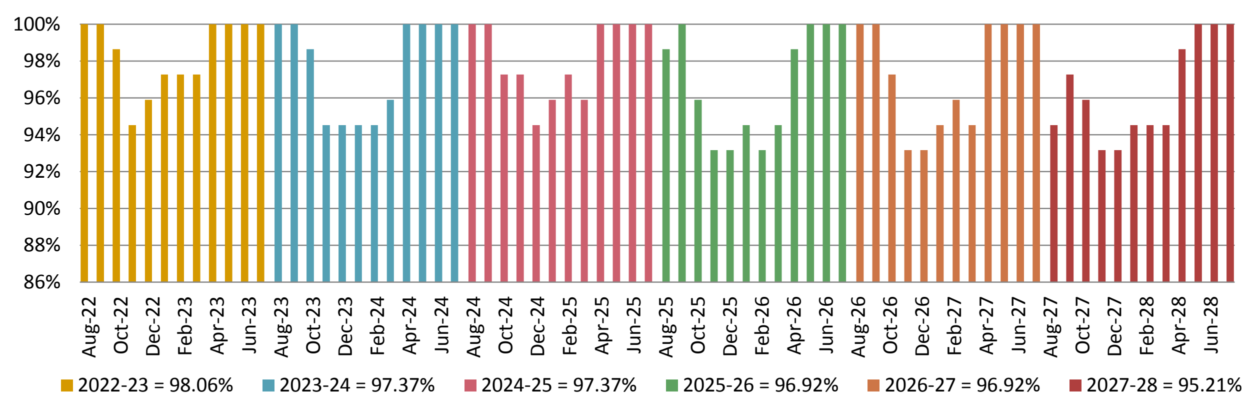
Frequency of Surplus and Deficit Periods from portofolio simulation with 12 MW Biomass Facility

The annual average surplus of the entire portfolio over the whole period analyzed is 178.8 aMW. There are a fewer number of periods where a deficit occurs as compared with the base case and the following charts illustrate the data on a quarterly basis.



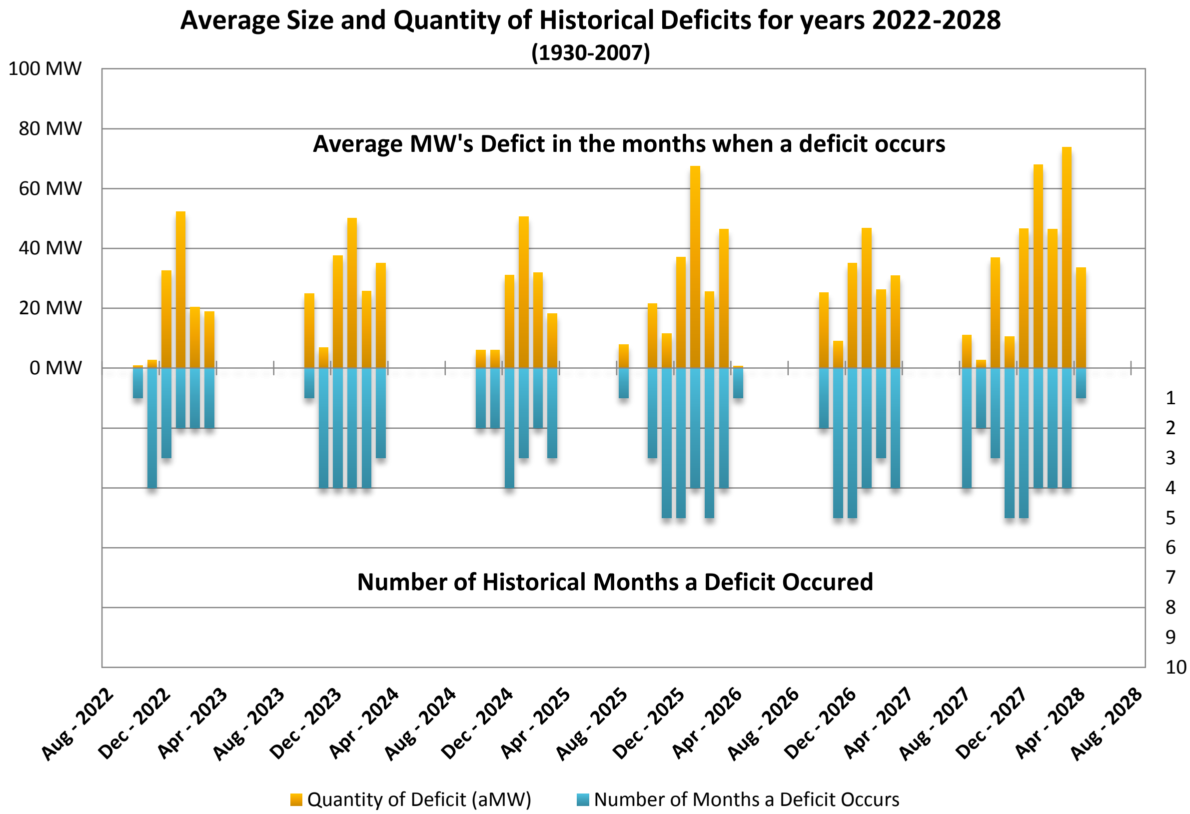
Quarterly frequency of Surplus and Deficit quantities for Portfolio Simulation with 12 MW Biomass Facility

Tacoma Power is surplus in 99.6% of the historical water conditions. The following chart illustrates the percentage of months surplus in each of the historical water conditions.



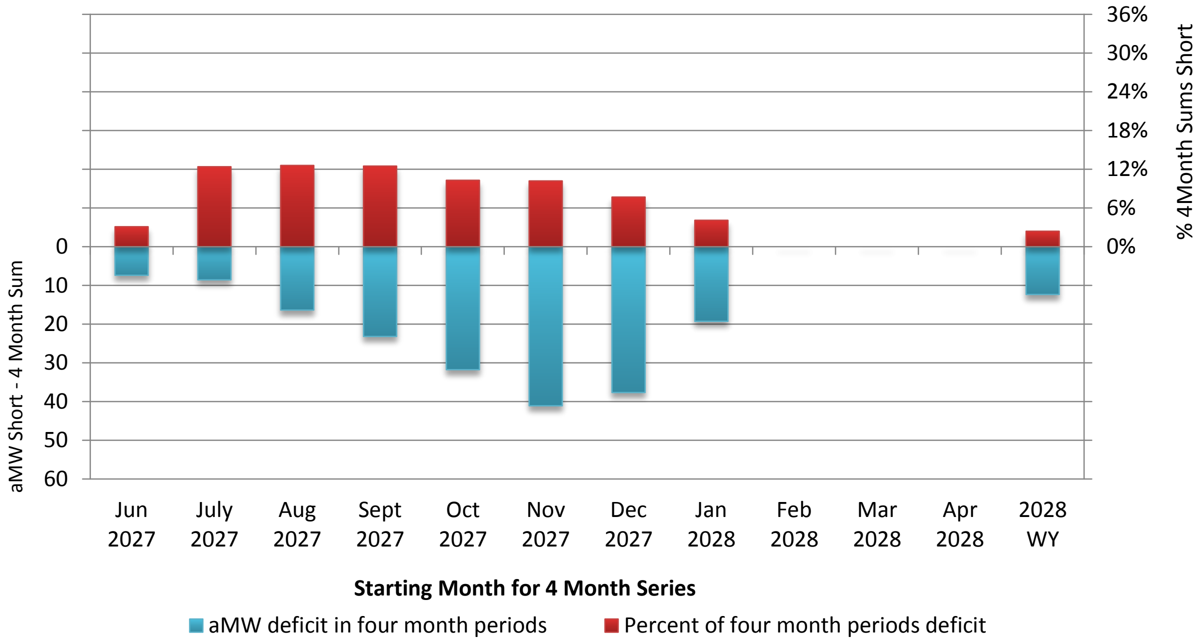
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In October of 2022 there was only 1 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in that month was 0.93 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



Size and Quantity of Historical Deficits

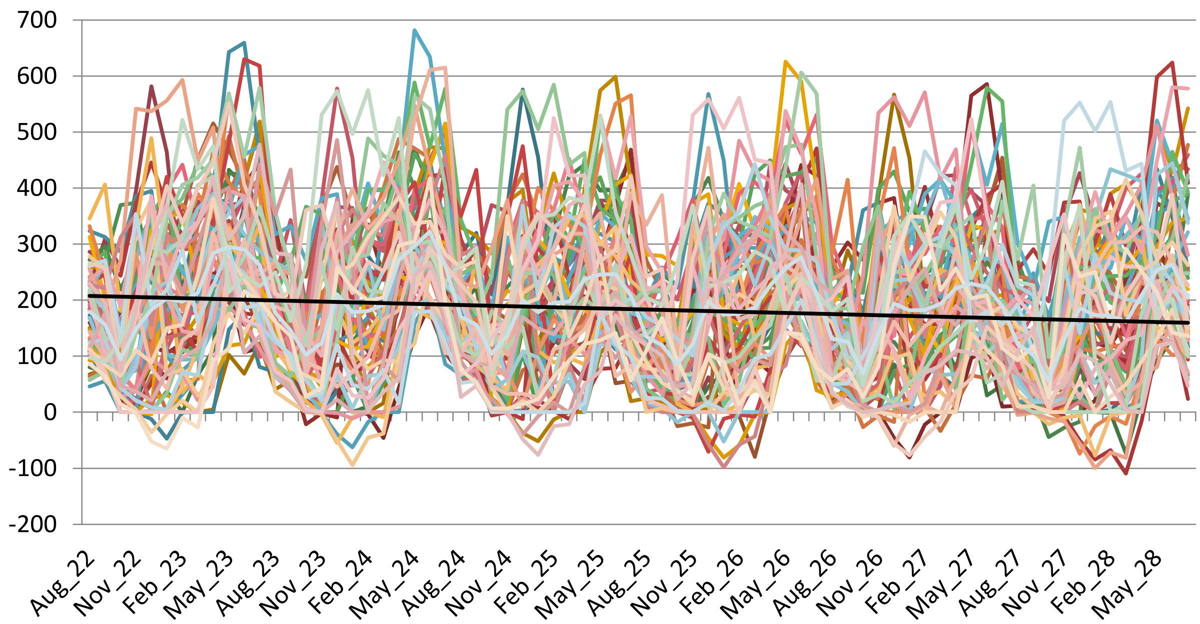
The final chart from the analysis is a reflection of the additional analysis adding load and price variability. The chart is a summary of 4-month averages for the incorporation of +/- 15 aMW of load and the variability associated with historical water years. This chart displays the results of 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus available. In the colder months, November through February, Tacoma Power is short in less than 10% of the 4 months series that start in those months. The average quantity of additional power purchased in these months is approximately 41 aMW. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 10+ aMW, Tacoma Power could be short by 98 aMW for the 4 month period.



Despite the small size, because it is dispatchable, the resource reduces the frequency of a deficit LRB by approximately 2 percent. However, BioFuel is an expensive resource and in most scenarios the cost of the resource exceeds the value of the excess energy that would likely be sold back into the Mid-Columbia wholesale energy market. The additional renewable benefits of the resource are also not enough to balance the costs, benefits, and risks associated with the resource. It is not recommended that Tacoma Power take steps to acquire this resource in the near term.

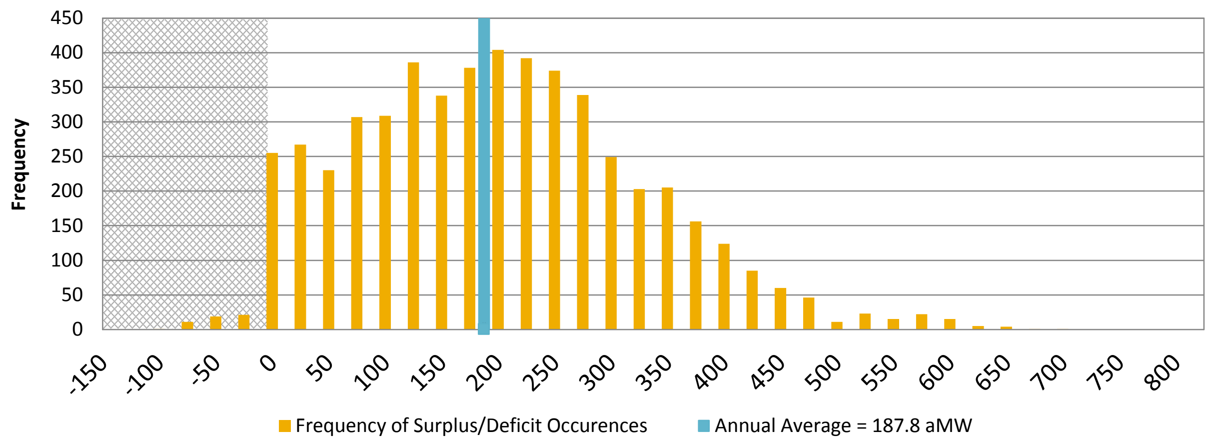
Solar

Solar resources have been making significant strides to become increasingly cost competitive with thermal generators. Tacoma Power modeled a solar scenario based on the addition of a 25 MW solar facility with a generation profile coincident with a recently evaluated term sheet. The term sheet was provided by an independent third party for a new solar facility in the northwest that Tacoma Power would be able to acquire and deliver to our service area if desired. Using the same loads that were used in the Base Case analysis, the following charts are the results of simulations using the Vista model.



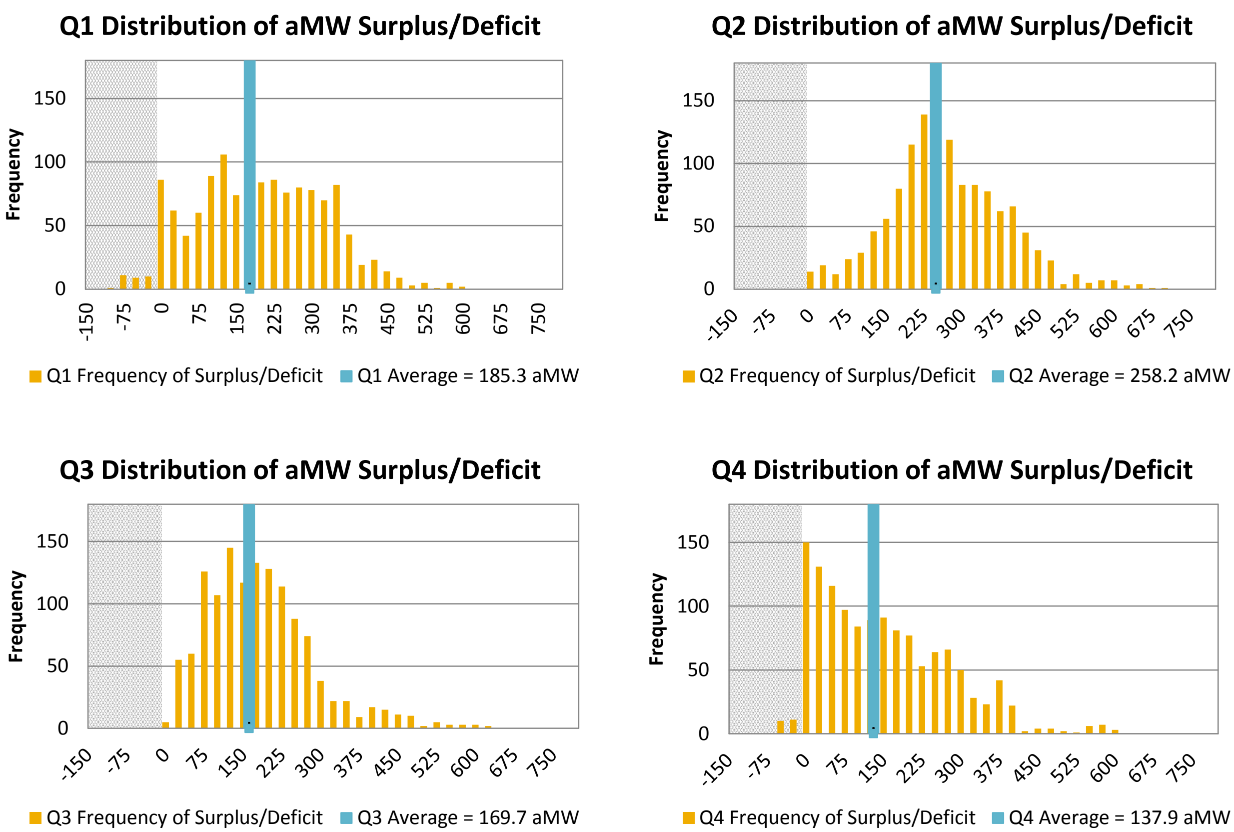
Composite Portfolio output with 25 MW Solar Facility in each historical water year

The average annual amount of surplus drops from 208.9 aMW in 2022 to 169.2 aMW in 2028. The following histogram displays the same information across the entire time period analyzed.



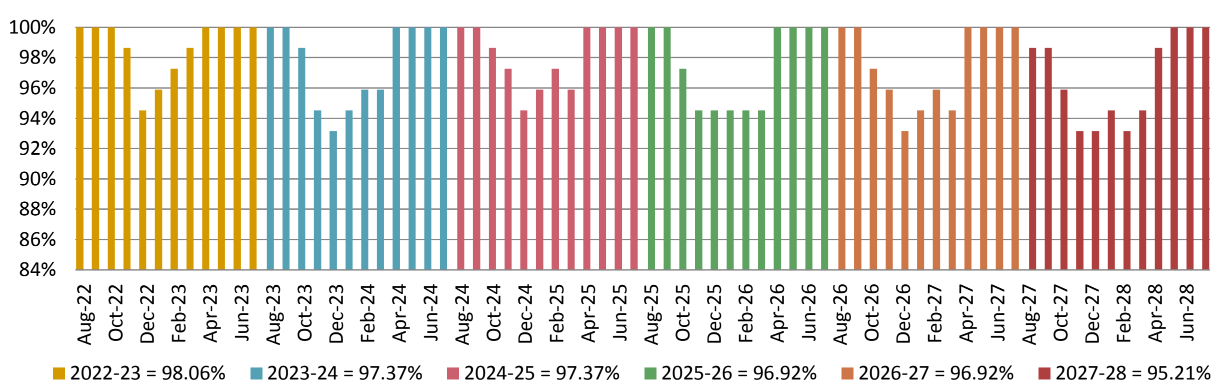
Frequency of Surplus and Deficit Periods from portofolio simulation with 25 MW Solar Facility

The annual average surplus of the entire portfolio over the whole period analyzed is 187.8 aMW. There are a fewer number of periods where a deficit occurs as compared with the base case and the following charts illustrate the data on a quarterly basis.



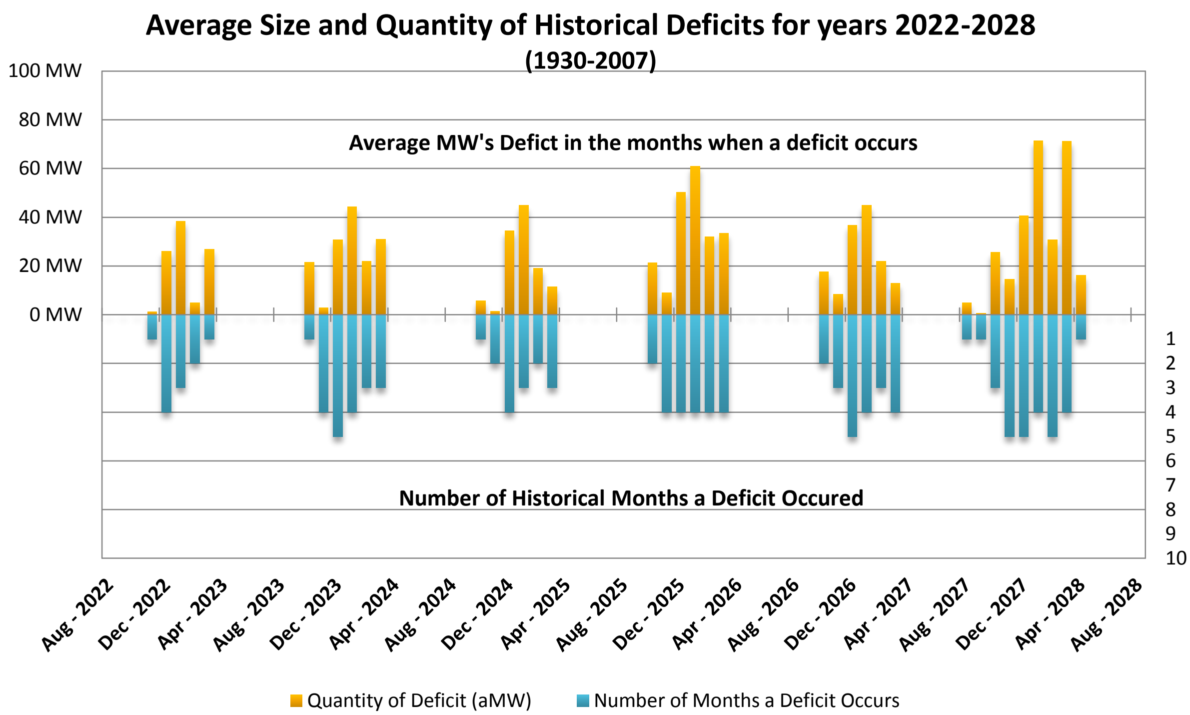
Quarterly frequency of Surplus and Deficit quantities for Portfolio Simulation with 25 MW Solar Facility

Tacoma Power is surplus in 99.7% of the historical water conditions. The following chart illustrates the percentage of months surplus in each of the historical water conditions.



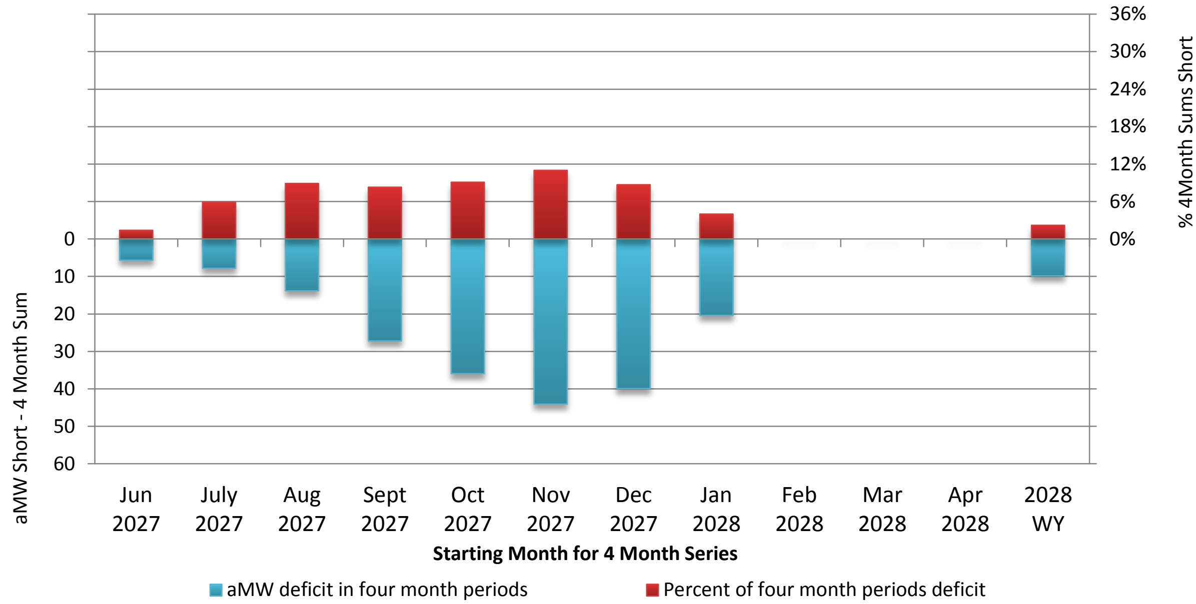
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In November of 2022 there was only 1 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in that month was 1.26 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



Size and Quantity of Historical Deficits

The final chart from the analysis is a reflection of the additional analysis adding load and price variability. The chart is a summary of 4-month averages for the incorporation of +/- 15 aMW of load and the variability associated with historical water years. This chart displays the results of 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus available. In the colder months, November through February, Tacoma Power is short in less than 10% of the 4 months series that start in those months. The average quantity of additional power purchased in these months is approximately 41 aMW. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 10+ aMW, Tacoma Power could be short by 110 aMW for the 4 month period.



The modeled generation profile was effective in reducing the deficit LRB periods for the scenario where there was a new high load. However, the effective reduction was mostly only in the summertime when the solar generation was at its peak. In the wintertime, the generation profile does not complement Tacoma Power's load profile very effectively. Lastly, there are integration challenges associated with the resource and with abundant new solar resources in the WECC region, there is an expectation that more integration issues will emerge before the 2020's. The additional renewable benefits of the resource are also not enough to balance the costs, benefits, and risks associated with the resource. It is not recommended that Tacoma Power take steps to acquire this resource in the near term.

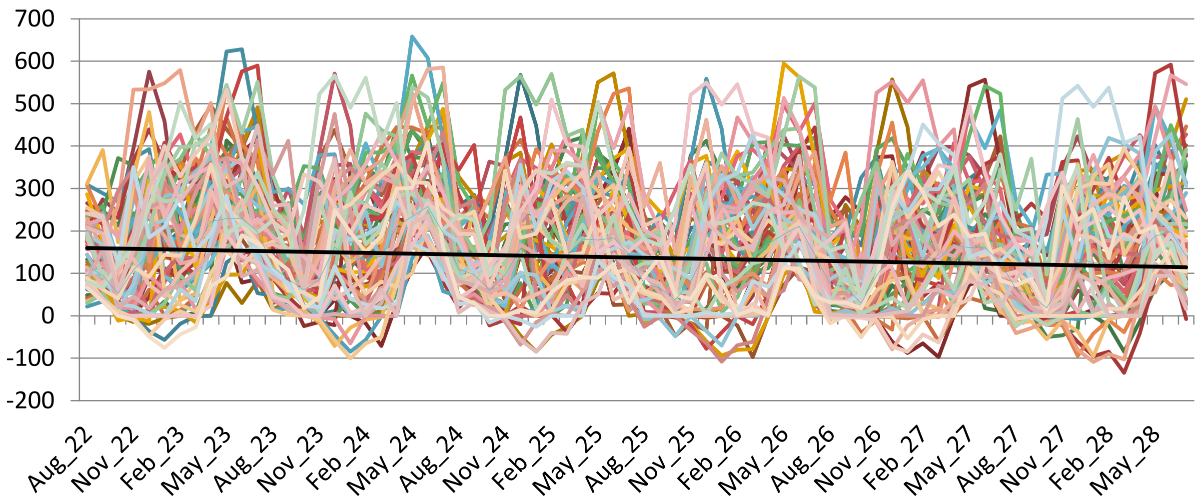
Pumped Storage

Pumped Storage facilities have been gaining significant interest in the region as a means of assisting in the balance of renewable generation. Pumped Storage facilities are designed to use more energy to push water up-hill than they do to produce power when the water is released. This resource has the potential to produce a financial buffer by displacing deficit LRB periods into a lower priced time frame. The resource generates revenue savings in very low and very high water years when price volatility can be high. Additionally, because of the way the resource operates, it can also be used to increase loads during periods when Tacoma Power's hydro generators are running at high levels of output and loads are at low levels. This usually occurs during the spring runoff period when ambient temperatures are mild and there is low load during the Light Load Hours. For these reasons Tacoma Power decided to briefly analyze a pumped storage scenario with 50 MW of capacity.

The scenario does not effectively reduce the frequency of deficit LRB periods. Nor does it help much with the magnitude of high new load periods in low water year scenarios. However, it is recommended that Tacoma Power acquire more refined cost data for the modeled plant in this scenario. Currently Tacoma Power has used the most recent EIA estimates and these estimates show a wide range of levelized costs, from $58 per MWh to $149 per MWh. With a resource cost at the lower end of these estimates there is potential for pumped storage facilities to provide sufficient benefits for the utility. It is recommended in the action plan for Tacoma Power to complete a more in-depth analysis on this type of resource in the near future.

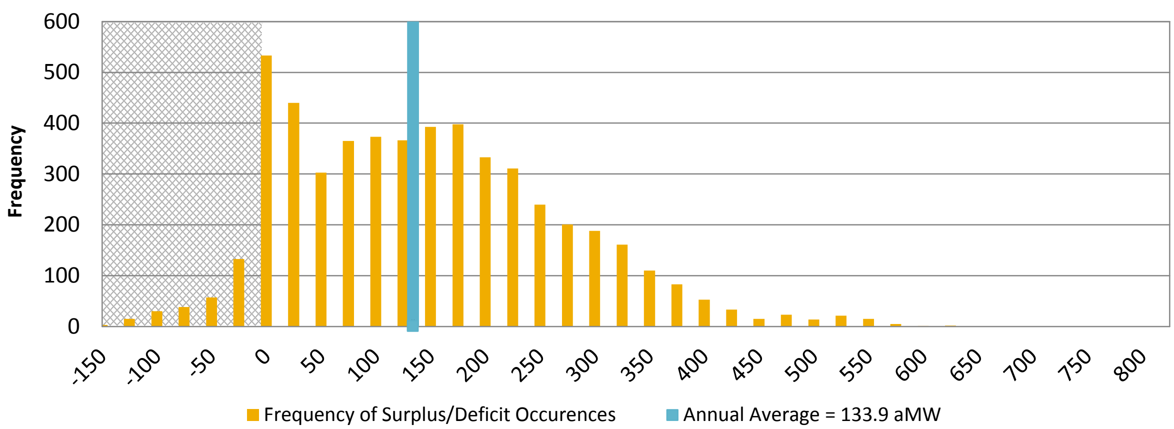
Increasing Loads

Increasing loads, above what is included in the current load forecast, is the greatest potential risk for Tacoma Power in the near future. An increasing number of months when there is a deficit LRB in combination with higher loads and periods of low water during the winter season can have negative impacts on Tacoma Power's portfolio. In low water years there is often a greater occurrence of high electricity prices and this poses the greatest near-term risk for Tacoma Power. Tacoma Power modeled a few increasing load scenarios and an increase of 12 to 15 aMW is generally manageable. The addition of 20 to 35 aMW of load are likely to be more difficult to integrate with the existing portfolio. It should be noted that much of the specific analysis depends upon the way the load is actually shaped throughout the days and seasons of the year. Certain hours within the day or seasons of the year tend to be more difficult to manage than other periods of the year. The following results are from the integration of a new 35 aMW load but if Tacoma Power were to receive a new load of this magnitude, specific analysis should be performed based on the actual shape of Tacoma Power's load profile with the potential new load.



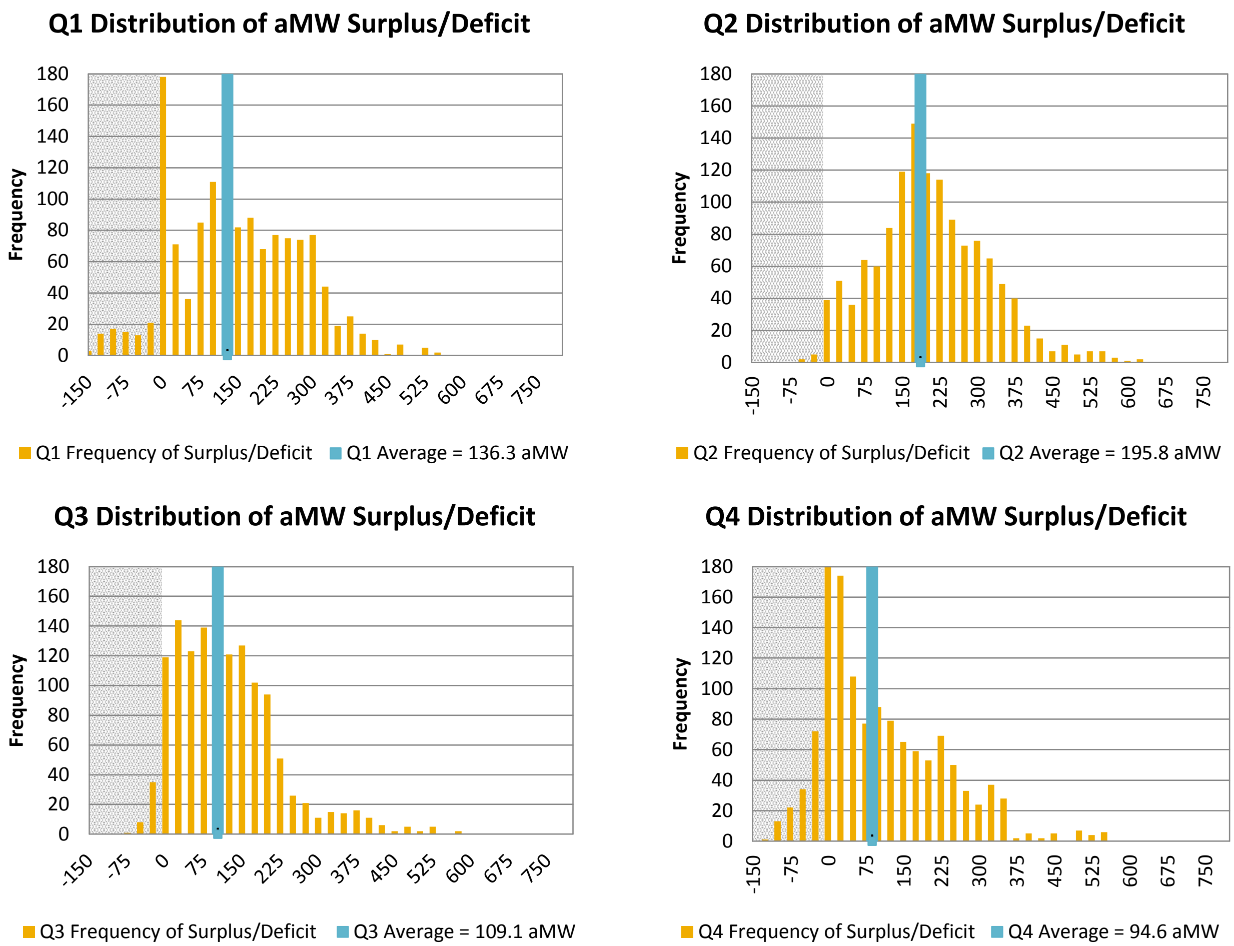
Composite Portfolio output with 35 aMW's additional load in each historical water year

The average annual amount of surplus drops from 154.8 aMW in 2022 to 115.5 aMW in 2028. The following histogram displays the same information across the entire time period analyzed.



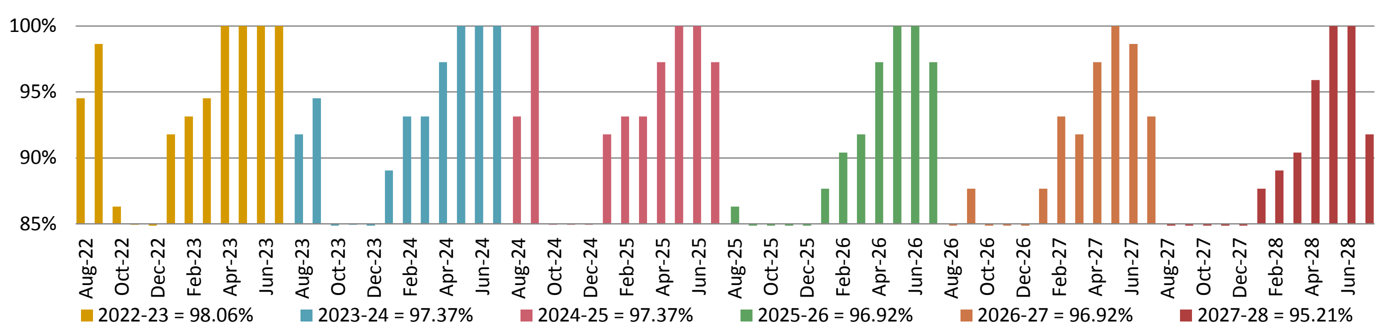
Frequency of Surplus and Deficit Periods from portofolio simulation with 35 aMW's additional load

The annual average surplus of the entire portfolio over the whole period analyzed is 133.9 aMW. There are a fewer number of periods where a deficit occurs as compared with the base case and the following charts illustrate the data on a quarterly basis.



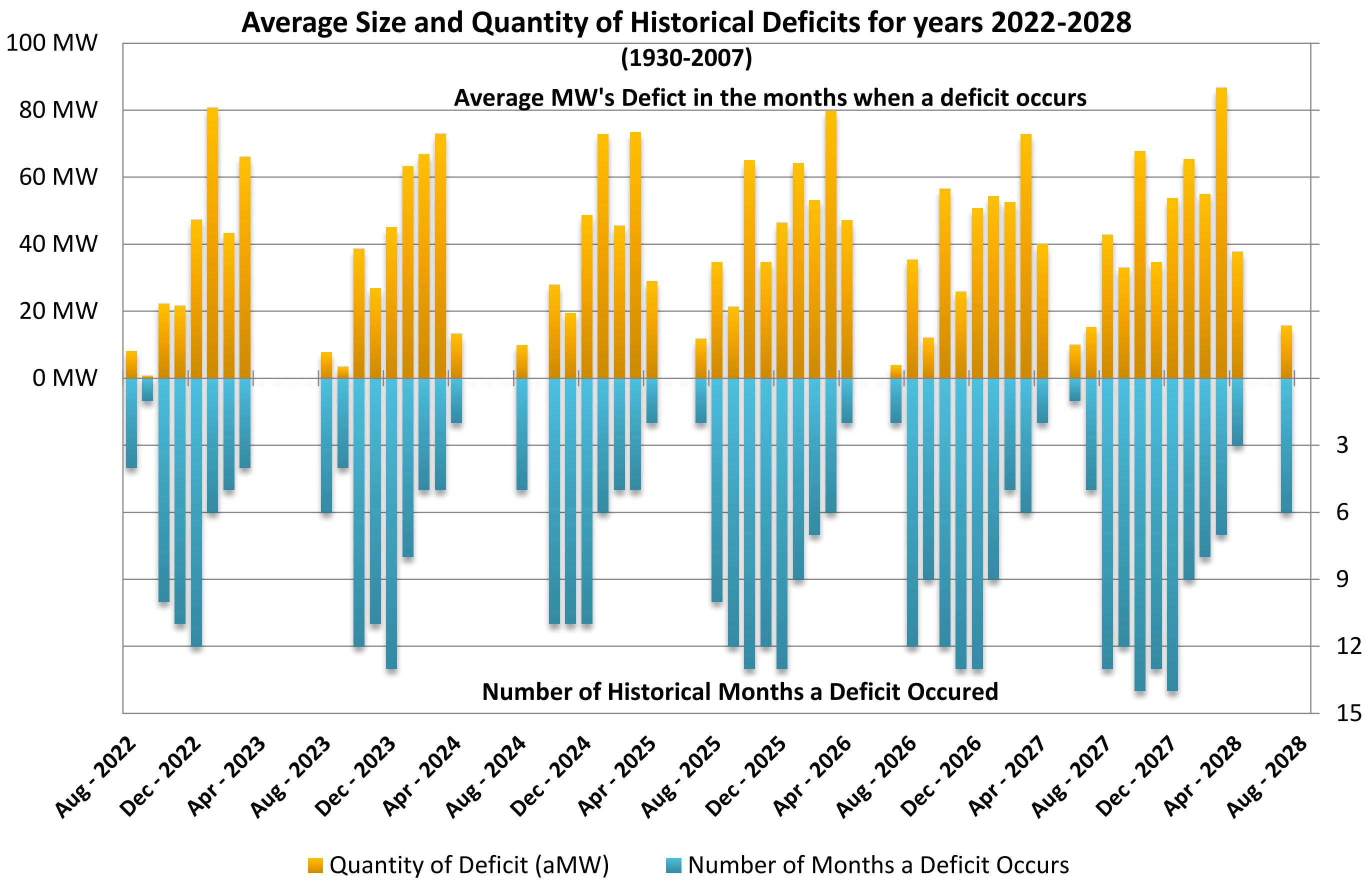
Quarterly frequency of Surplus and Deficit quantities for Portfolio Simulation with 35 aMW additional load

Tacoma Power is surplus in 97.4% of the historical water conditions. The following chart illustrates the percentage of months surplus in each of the historical water conditions.



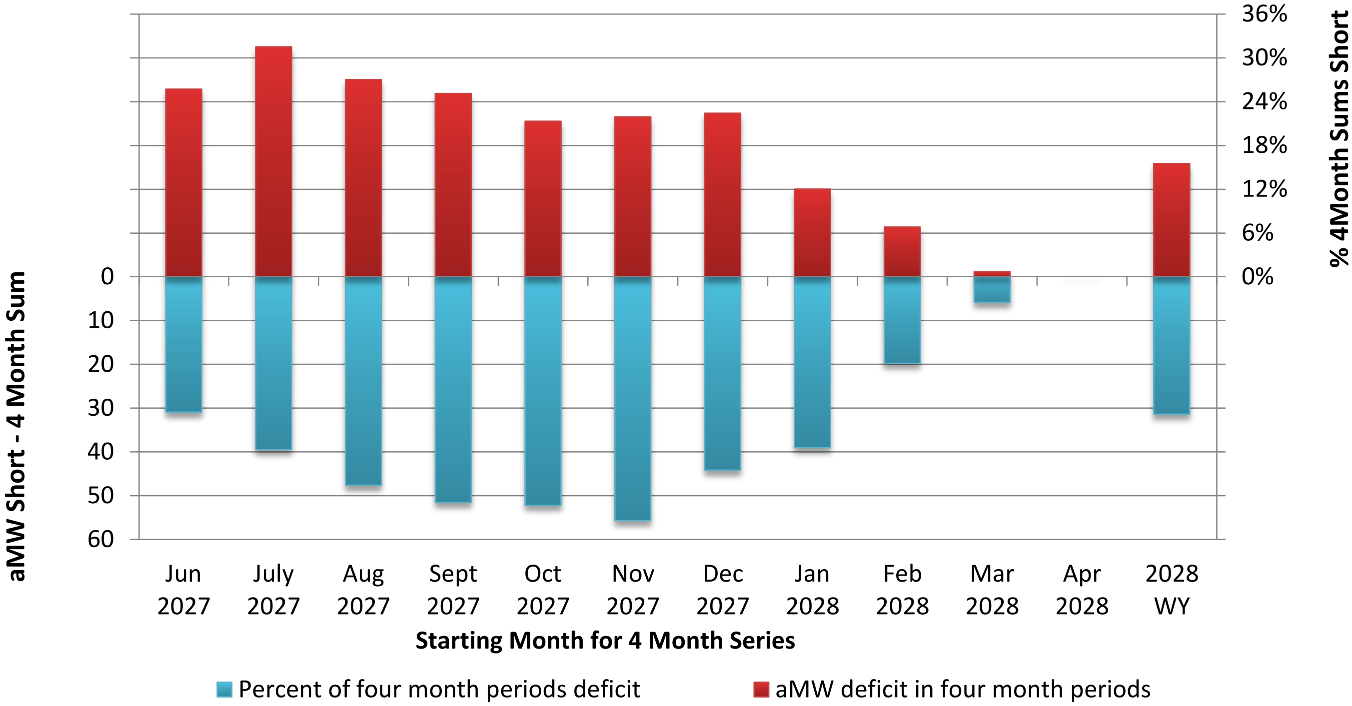
Percent of months surplus under historical water years

The following chart is another illustration of the complete period analyzed. The yellow bars display the average number of MW's that Tacoma Power is deficit for the periods where a deficit occurs. Deficit periods only occur in poor water years and this provides some context for the average quantity of MW's Tacoma Power would need to acquire to meet forecasted load if that water year were to reoccur. The blue bars represent the quantity of historical months that a deficit occurs. In August of 2022 there were only 4 months of the entire historical water year data that Tacoma Power would be deficit and the average number of MW's deficit in that month was 8.07 aMW. Where no lines exist there were no deficit periods, this is typically during the Spring and Summer months. This chart helps to demonstrate the quantity and magnitude of Tacoma Power's changing deficit position over the period.



Size and Quantity of Historical Deficits

The final chart from the analysis is a reflection of the additional analysis adding load and price variability. The chart is a summary of 4-month averages for the incorporation of an additional +/- 20 aMW of load and the variability associated with historical water years. This chart displays the results of 2027 and 2028 water year because that is the final year analyzed in this IRP and when Tacoma Power expects to have the least amount of surplus available. In the colder months, November through February, Tacoma Power is short approximately 22 % of the 4 months series that start in those months. This could cause Tacoma Power to revise it's forward sales strategy and at a minimum should require additional analysis with specifics about the additional load. The average quantity of additional power purchased in these months is approximately 56 aMW. For approximately 1% of the scenarios with a critical water year and a new unexpected load of 20+ aMW greater than the new 35 aMW load, Tacoma Power could be short by 155 aMW for the 4 month period.



The results of modeling this scenario illustrate how Tacoma Power is at the greatest risk in the future from a new large load being added to our service area. Additionally, an element not included in this analysis is the additional obligations related to Initiative 937. Tacoma Power would need to acquire additional eligible renewable resources to meet adjusted renewable compliance targets that included this new load. Because these new loads do not exist today, it is not recommended that we acquire additional resources before sufficient need arises. Tacoma Power is still surplus in majority of the historical water conditions analyzed but there are critical water periods that could become a challenge without additional planning and discussion. If Tacoma Power were to acquire an additional load of this nature, it is recommended that a holistic strategy be developed that takes into account the specific timing, size, and operational characteristics of the new load while also considering effects on wholesale power sales and renewable compliance targets for Tacoma Power.

Resource Acquisition Strategy

Tacoma Power's best resource strategy at this time is to delay the acquisition of additional physical generating resources. Under current forecasts, Tacoma Power's LRB exhibits an adequate level of resource capabilities to meet our customer's needs. Following this strategy leaves Tacoma Power short on the quantity of renewable generation needed to meet Washington's Renewable Portfolio Standard. As such, Tacoma Power's approach will be to acquire renewable energy credits as a compliance strategy. Additional details about Tacoma Power's renewable compliance strategy are included in Section 4: Renewable Compliance Update.

Tacoma Power's greatest risk potential is that a new large load would initiate a request for power services from Tacoma Power. The size, timing, variability, and location are all important determining factors affecting the operations of Tacoma Power's resource portfolio and how we are ultimately able to provide services to the load. It is not advised to acquire an additional resources at this time to mitigate this risk however, Tacoma Power's current policies and contracts were developed to help protect the existing customer base from these risks. Tacoma Power's Customer Service Policy includes provisions to allow for negotiation of the rates for a new load greater than 8 aMW and the BPA Slice/Block Power Sales Agreement includes specific provisions for new loads greater than 10 aMW. Additionally, subsequent IRP's will be developed in the coming years that look at changes to our forecasted load and when new customers are added, our load projections are adjusted accordingly. Tacoma Power is continually monitoring new loads, resources and impacts that affect our power supply portfolio.

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2013 IRP

Stakeholder Presentation 1

March 18, 2013

Welcome & Introductions

- Manager of the 2013 IRP

  Travis Metcalfe

  tmetcalfe@cityoftacoma.org

  (253) 502-8149

- Welcome from Chris Robinson, Power Manager

- Stakeholder Introductions
  - Name
  - Whom you are representing

What we plan to cover today

- What is the IRP and why we prepare it
- Review of 2012 IRP Update
- Overview of our Process for 2013
- Tacoma Power Supply Side Resource Overview
- Load Forecast Overview
- Overview of Conservation Program
- Loads and Resources aligned with Washington's Renewable Portfolio Standard (I-937)
- The focus of Meeting #2

What is an Integrated Resource Plan (IRP)?

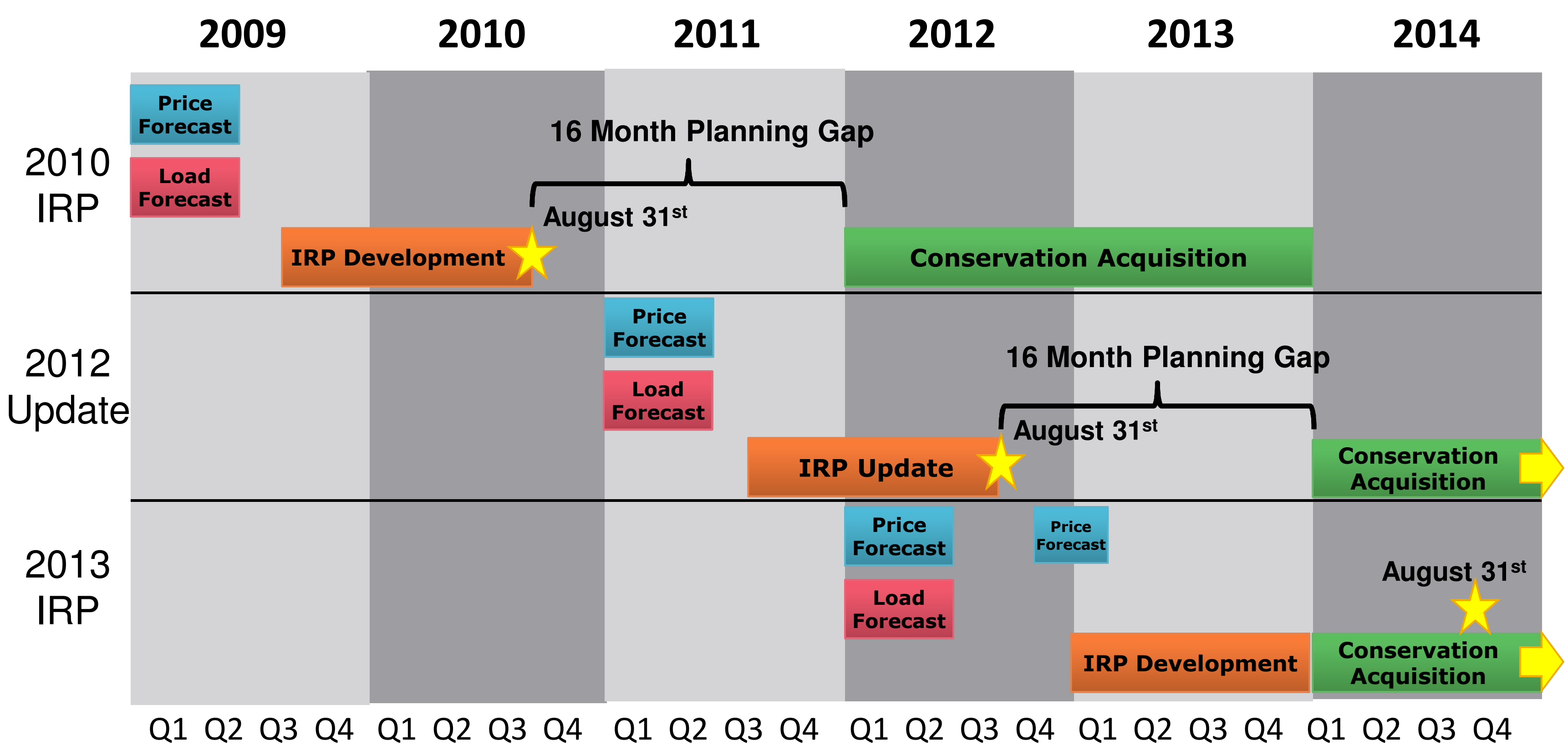
- The Integrated Resource Plan (IRP) is a Strategic Planning Process used by utilities to:
  - Assess whether there is a need to acquire additional resources to meet projected retail demand
  - Determine the combination of new resources that are most cost-effective and impose the least risk
- Statutory Obligation per *RCW* 19.280
  - Resource Plan or Update due by September 1 of even years
- Tacoma Power has been preparing IRPs, formerly known as "Least Cost Plans," since 1990
  - The most recent plan was issued in 2010 with an update in 2012

2012 IRP Update

- Assessed Tacoma Power's progress toward implementing our "2-year Action Plan"
  - Conservation Acquisition
  - Climate Change Assessment
  - Operating Flexibility
  - Renewable Portfolio Standards
- Update the inputs to our 2010 IRP and address any significant changes
- 2012 2-year Action Plan
  - Continuing to pursue cost effective conservation should be sufficient to meet retail load through 2020
  - 11 aMW of Conservation in 2012-2013
  - Continue to explore Tacoma Power's operational flexibility to market additional products and integrate variable energy resources

Why 2013?

- Changing the timing of IRP in 2013
  - better align with our current analytical planning processes
  - better contribute to our 2-year Conservation Acquisition Cycles



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2013 IRP Focus

- Questions to be addressed through analysis, discussion, and development of the 2013 IRP Action Plan
  - How much Conservation should Tacoma Power pursue in the 2014/2015 time period in order to:
    - Mitigate future risk and uncertainties
    - Delay the acquisition of unnecessary additional supply side resources
  - What is the recommended approach for complying with Tacoma Power's 2016 and 2020 I-937 - Renewable Portfolio Standard Requirements?
  - What future energy and capacity portfolio best conforms to the needs of the utility?

2013 IRP Workgroup Overview

Price & Gas Forecasts
* Cathy & Bill

Modeling & Analysis
*Travis

Conservation Assessment
*Rich

Contract & Supply Resources
*Tom & Bill

Management Review
*Travis
Chris Robinson
Nicolas Garcia
Dolores Stegeman
Steve Bicker

Load Resource Balance & Resource Adequacy
*Monthly/Annual – Jim
*Capacity - Todd

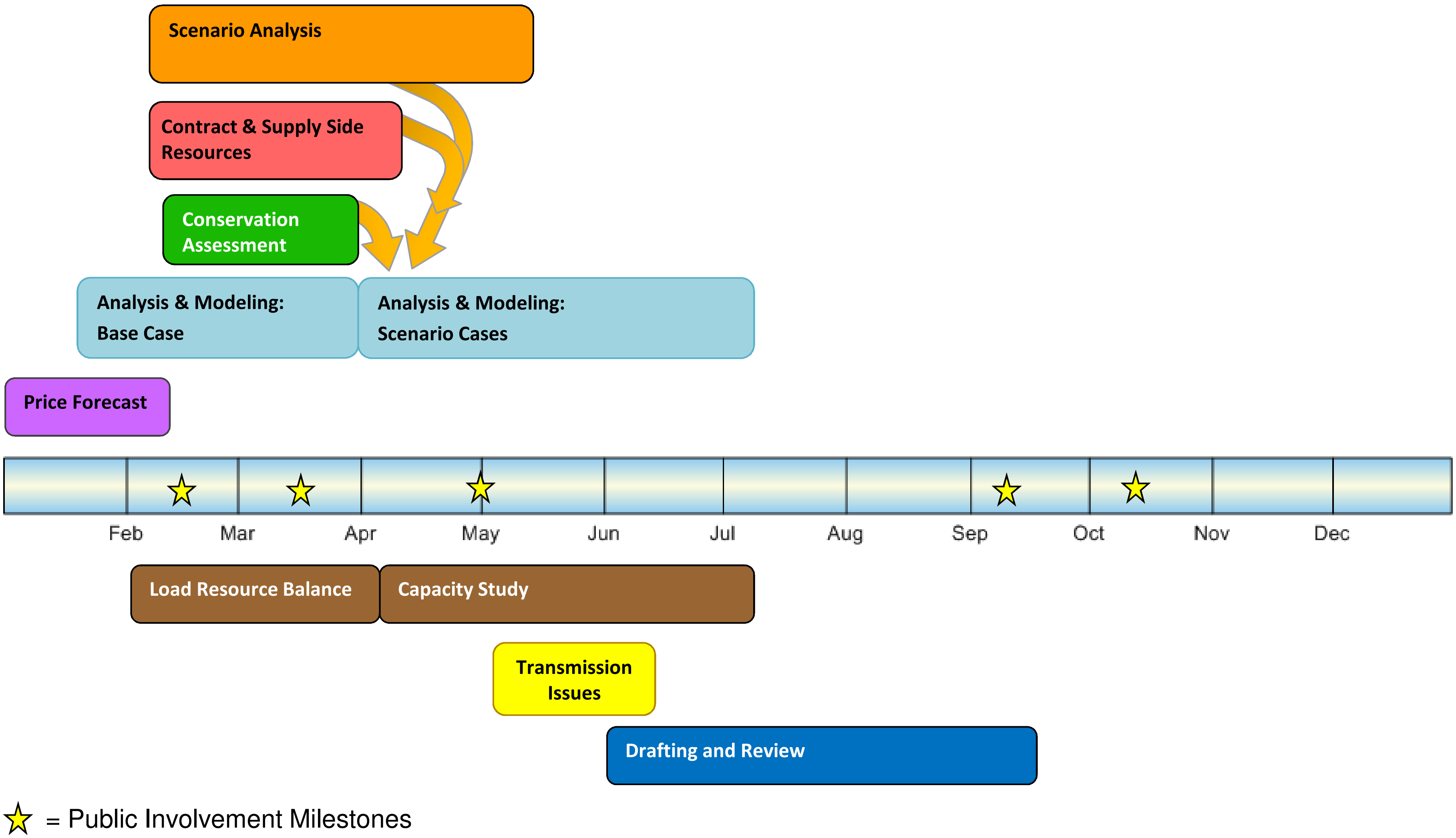
Transmission Issues
*Marc

Scenario Analysis
*Travis & Cathy

Stakeholder Group
*Travis
- Stakeholders -

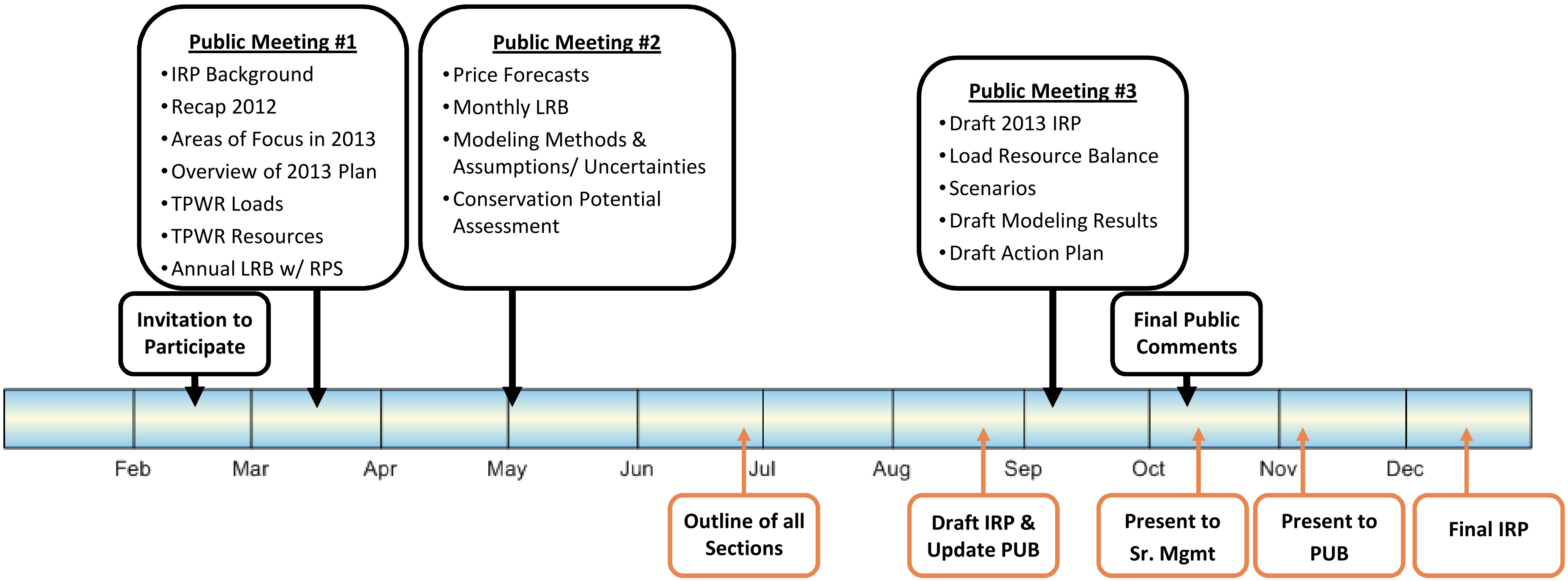
* Lead of Workgroup

2013 IRP Workgroup Timelines



Public Involvement Timeline

Public Involvement Events



Internal Development Milestones

Fulfillment of Statutory Obligations

Statutory Obligation (Chapter 19.280 RCW)	Requirement Addressed
(a) A range of forecasts, for at least the next ten years, of projected customer demand which takes into account econometric data and customer usage;	Input to Modeling and Analysis Section
(b) An assessment of commercially available conservation and efficiency resources. Such assessment may include, as appropriate, high efficiency cogeneration, demand response and load management programs, and currently employed and new policies and programs needed to obtain the conservation and efficiency resources;	Conservation Acquisition Section
(c) An assessment of commercially available, utility scale renewable and nonrenewable generating technologies including a comparison of the benefits and risks of purchasing power or building new resources;	Contract and Supply Resource Assessment Section
(d) A comparative evaluation of renewable and nonrenewable generating resources, including transmission and distribution delivery costs, and conservation and efficiency resources using "lowest reasonable cost" as a criterion;	Contract Supply and Resource Assessment Section
(e) The integration of the demand forecasts and resource evaluations into a long-range assessment describing the mix of supply side generating resources and conservation and efficiency resources that will meet current and projected needs at the lowest reasonable cost and risk to the utility and its ratepayers; and	Results of Modeling and Analysis Section
(f) A short-term plan identifying the specific actions to be taken by the utility consistent with the long-range integrated resource plan.	Action Plan Section

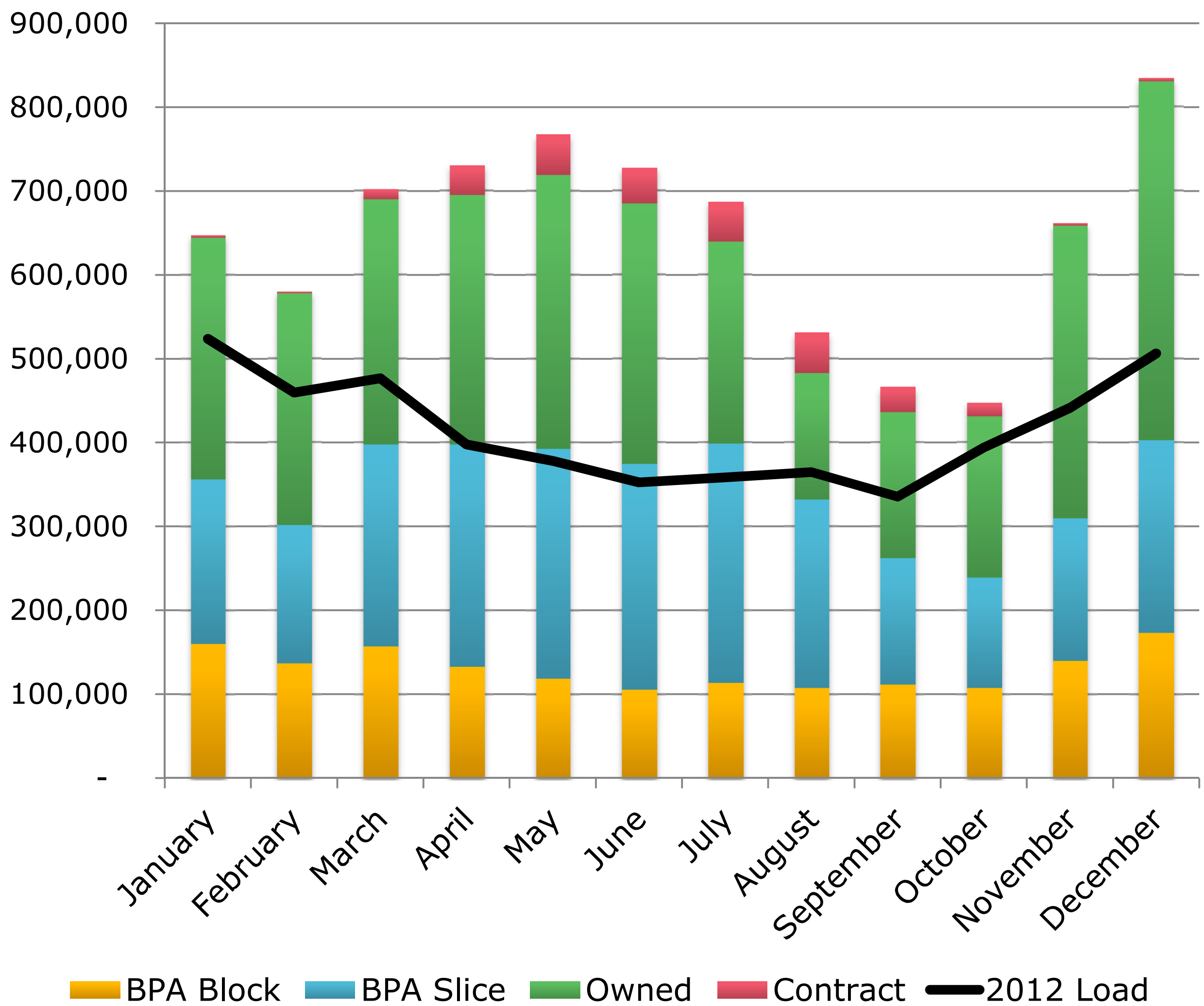
Supply Side Resources Overview

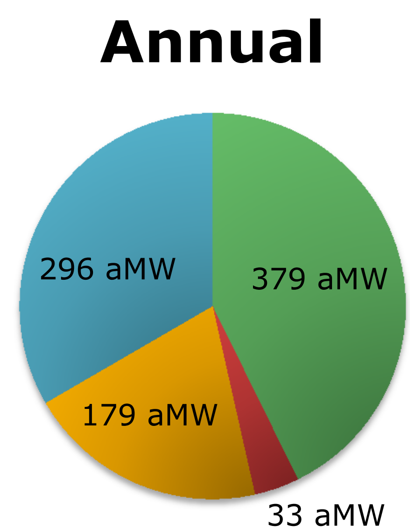
Rick Applegate, Utilities Economist

Resources Overview

- Generation Overview
  - 2012 Generation by Resource
- Resource Overview
  - Bonneville Power Administration (BPA)
  - City owned hydroelectric facilities
  - Other contract resources

2012 Generation





	aMW	%
BPA Block	179	20%
BPA Slice	296	33%
Owned	379	43%
Contract	33	4%
Total	**887**	**100%**

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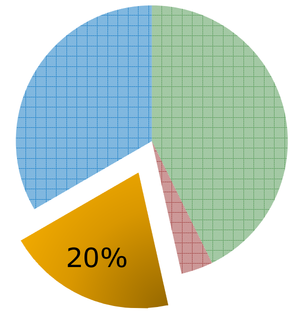
Bonneville Power Administration (BPA)

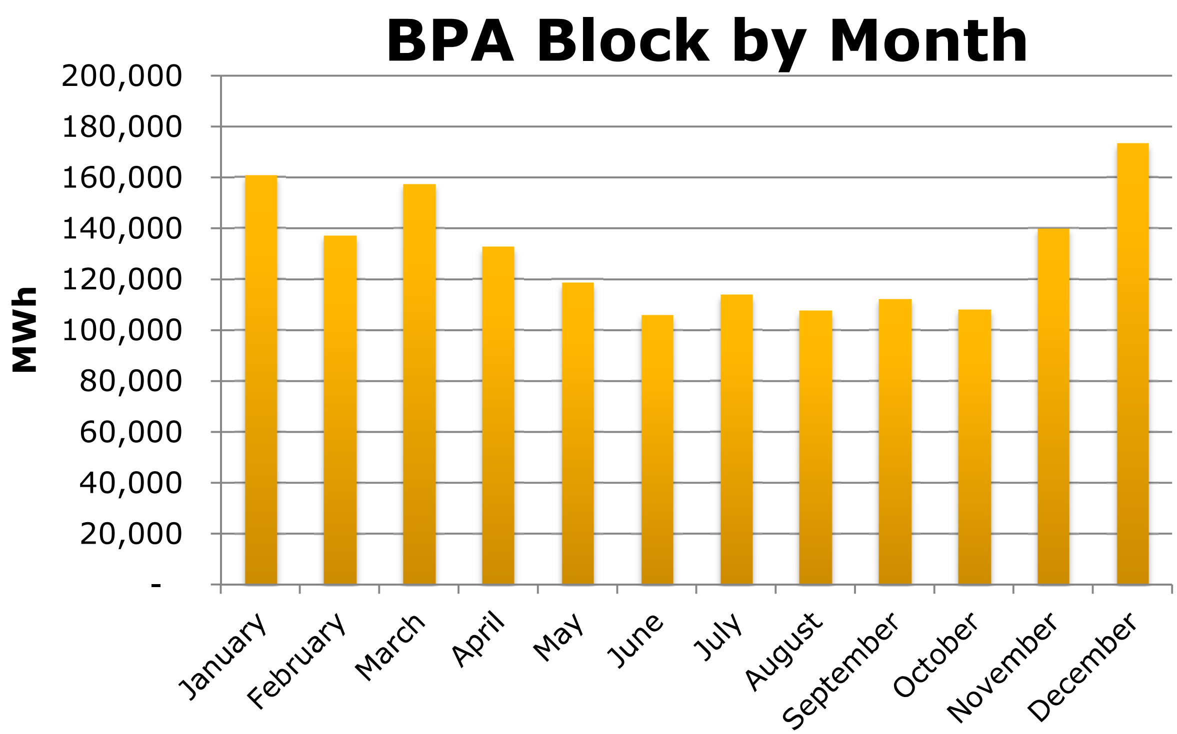
- Federal Power Marketing Authority
- Preference Power for Qualifying Utilities
- Net Requirements
- Power Sales Agreement:
  - Block product
  - Slice product

Columbia Generating Station, formerly WNP-2

BPA Block Power

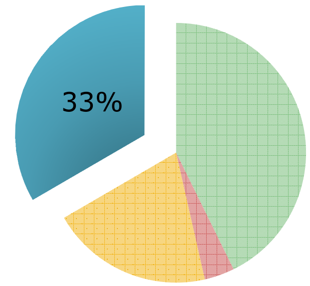
- Contract High Water Mark (CHWM)
- Tier 1 System
- Annual Block Amount
- Flat Within-Month Shape

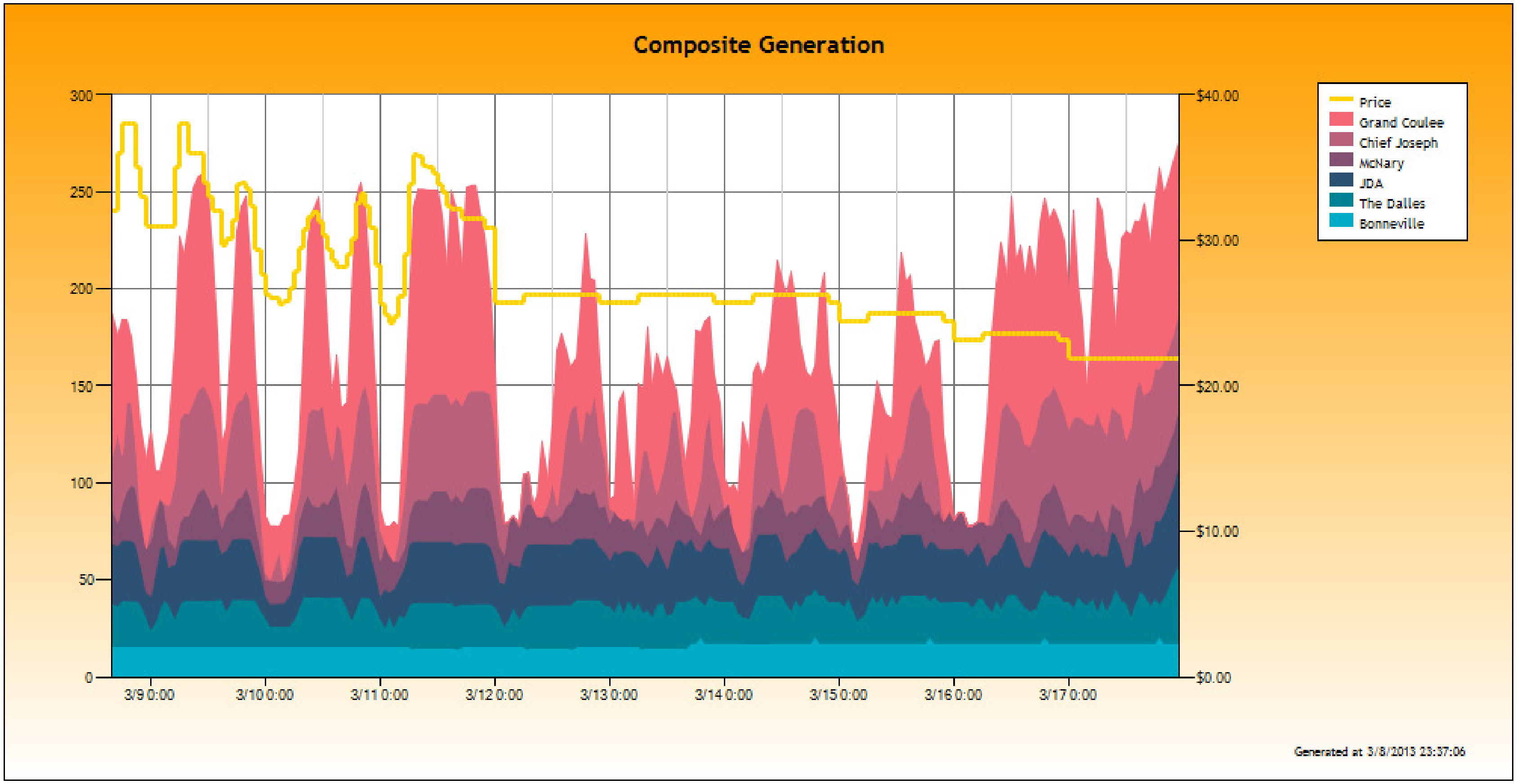




BPA Slice Power

- Slice Percentage – 2.98% of BPA Projects
- Critical Slice – Approximately 210 aMW
- Slice Computer Application manages resource





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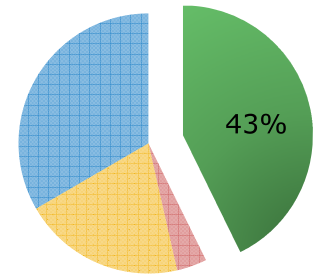
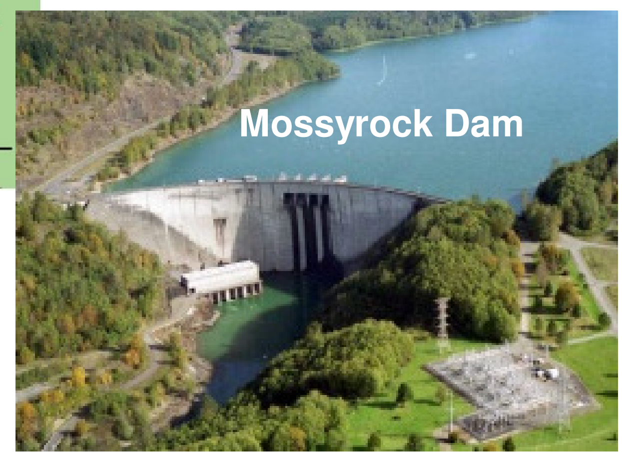
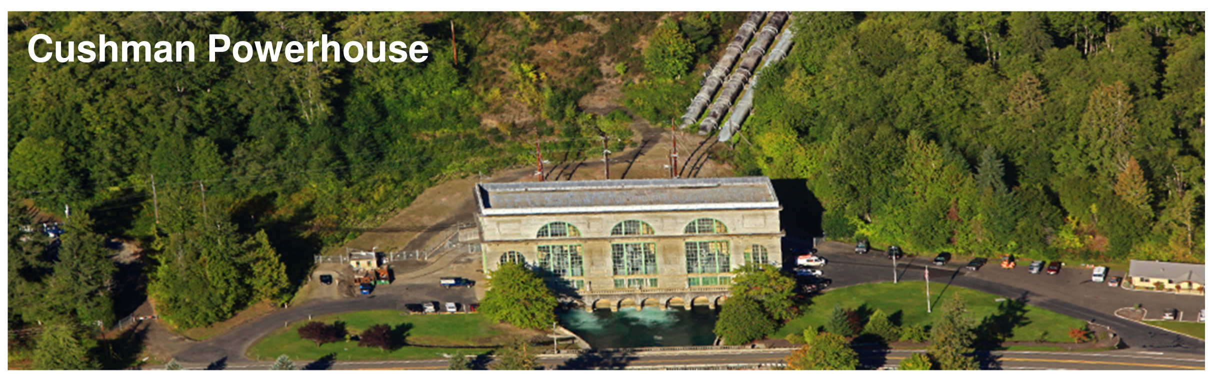
City Owned Hydroelectric Facilities

- River Systems
  - Cowlitz River:
    - Mayfield
    - Mossyrock
  - Nisqually River:
    - La Grande
    - Alder
  - Skokomish River:
    - Cushman 1
    - Cushman 2
- Small Facilities:
  - Wynoochee
  - Hood Street Canal



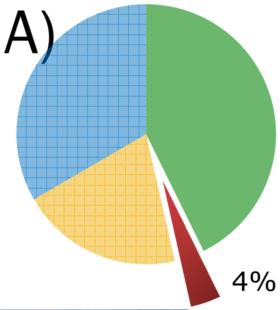
Tacoma Power Hydroelectric Facilities





Contract Resources

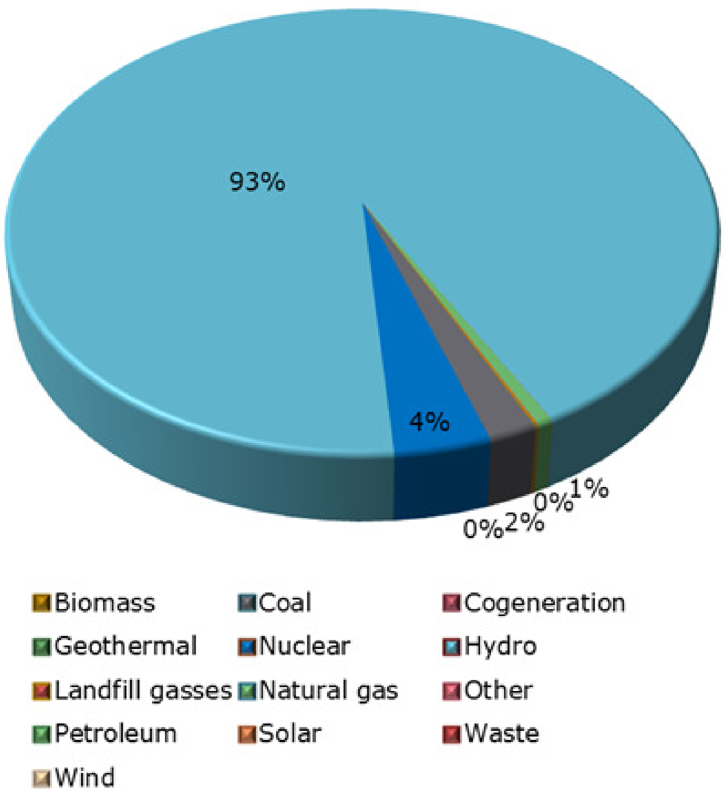
- Grand Coulee Project Hydroelectric Authority (GCPHA)
  - 5 Projects are part of 3 irrigation districts in Eastern Washington
  - Contracts expire between 2022-2027



- Priest Rapids Project
  - Grant County Public Utility District
  - Contract expires in 2052

- Short-term transactions in the Wholesale power market
  - purchase and sell energy to balance loads and resources
  - optimize the value of power portfolio
  - Tacoma Power purchased 262,000 MWh (30 aMW) in 2012
  - Tacoma Power sold 3,127,000 MWh (356 aMW) in 2012

Tacoma Power's 2011 Fuel Mix



Fuel	Market Purchases* (MWh)	Resources* (MWh)	Total (MWh)	Percent
Biomass	2,148	3,131	5,279	0.10%
Coal	99,217	0	99,217	1.96%
Cogeneration	0	0	0	0.00%
Geothermal	0	0	0	0.00%
Hydro	135,608	4,594,631	4,730,240	93.36%
Landfill gasses	409	0	409	0.01%
Natural gas	27,154	3,220	30,374	0.60%
Nuclear	3,375	194,779	198,154	3.91%
Other	324	0	324	0.01%
Petroleum	1,002	0	1,002	0.02%
Solar	0	0	0	0.00%
Waste	1,596	0	1,596	0.03%
Wind	0	0	0	0.00%
Total	**270,834**	**4,795,761**	**5,066,595**	**100.00%**

* Market Purchases include those made directly by utilities, as well as the fraction of delivered BPA power that can be attributed to BPA's purchases of market power. Claims on Resources include those made directly by utilities, as well as the fractions of delivered BPA power that can be attributed to specific plants.

20-year Load Forecast Overview

Molly Ortiz, Utilities Economist

Agenda

- Customer Base
- Purpose of Load Forecast
- Comparison to Previous Forecasts
- Models & Methods

2012 Customer Base

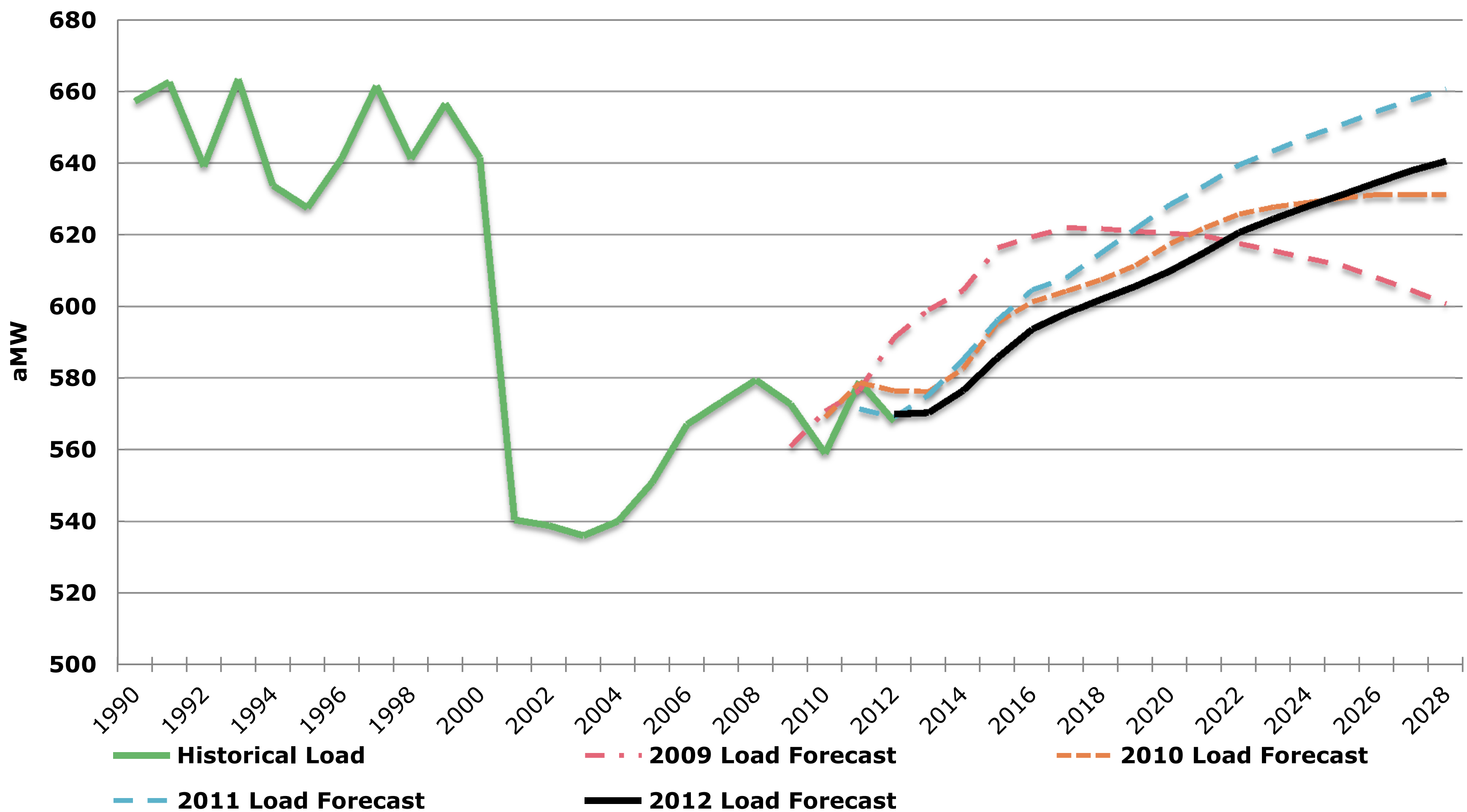
Annual-2012*	Total kWh	% of Retail kWh	Customers
Residential	1,891,356,675	39.8%	150,310
Small General	306,835,256	6.5%	15,079
General	1,539,351,676	32.4%	2,751
High Voltage General (HVG)	467,929,722	9.9%	6
Contract Industrial (CP)	504,873,611	10.6%	2
Street Lights & Traffic Signals	30,716,966	0.6%	864
Private Off-Street Lighting	7,222,622	0.2%	3,457
System	4,748,286,528	100.0%	172,469

*Based on Sales Statistics from Finance

Purpose of Load Forecast

- Budget & Financial Modeling
- Cost-of-Service and Rate Setting
- Bonneville Power Administration (BPA) & Pacific Northwest Utilities Conference Committee Submittals (PNUCC)
- Integrated Resource Planning
- North American Electric Reliability Corporation (NERC)

Annual Historical Load and Load Forecasts



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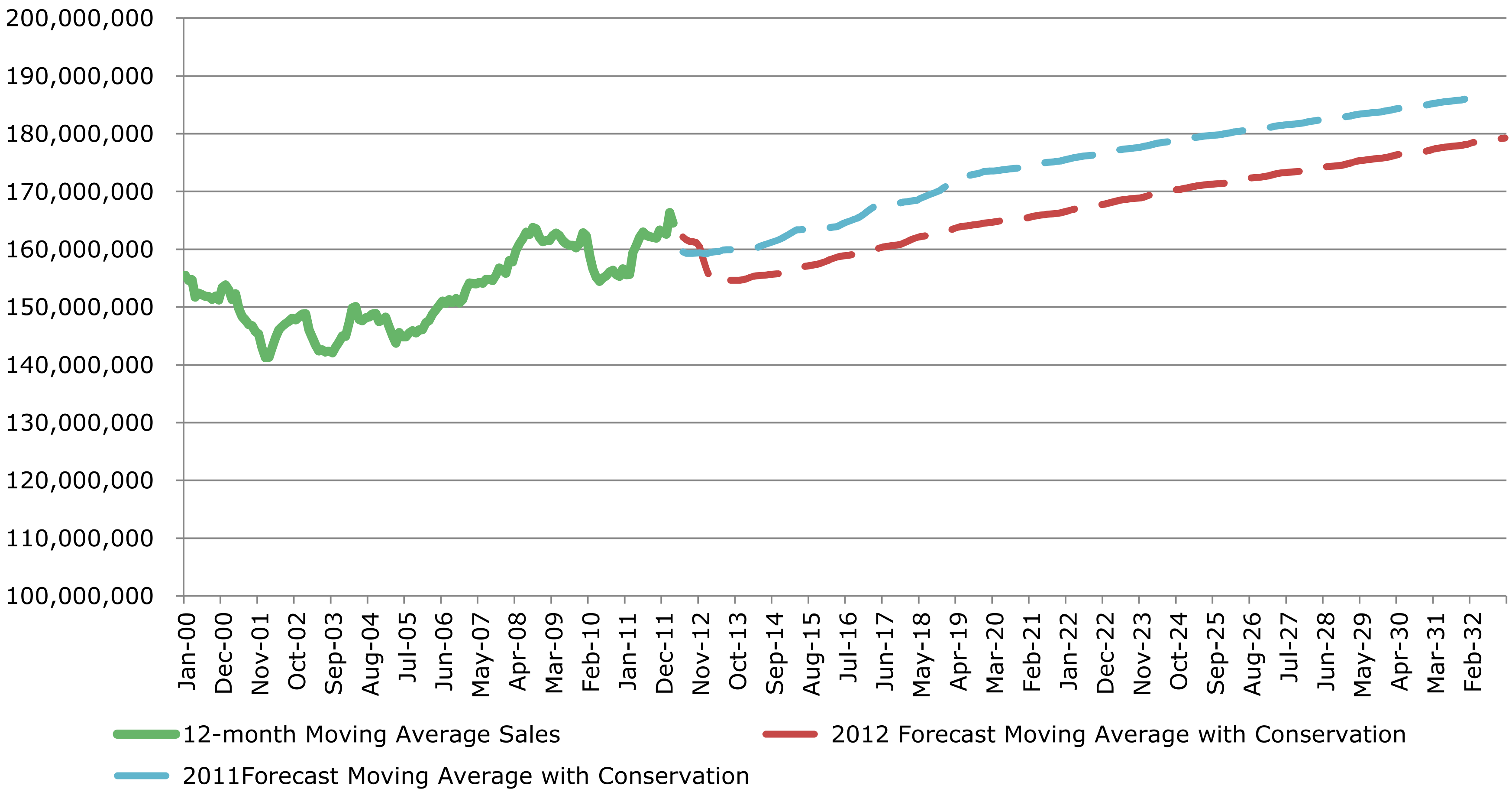
Models & Methods

Forecast Structure

- 3 Econometric Class Models
  - Residential, Small General & General Service Classes
  - Sales a function of:
    - Price
    - Economic Activity
    - Number of Customers
    - Weather
- 2 Direct Estimates
  - High Voltage General & Contract Industrial
  - Sales estimated based on:
    - Customer expectations
    - Past Consumption Patterns
- 2 Simple Specifications
  - Street Lights & Private Off Street Lighting
    - Growth rates applied based on past consumption

Residential Model



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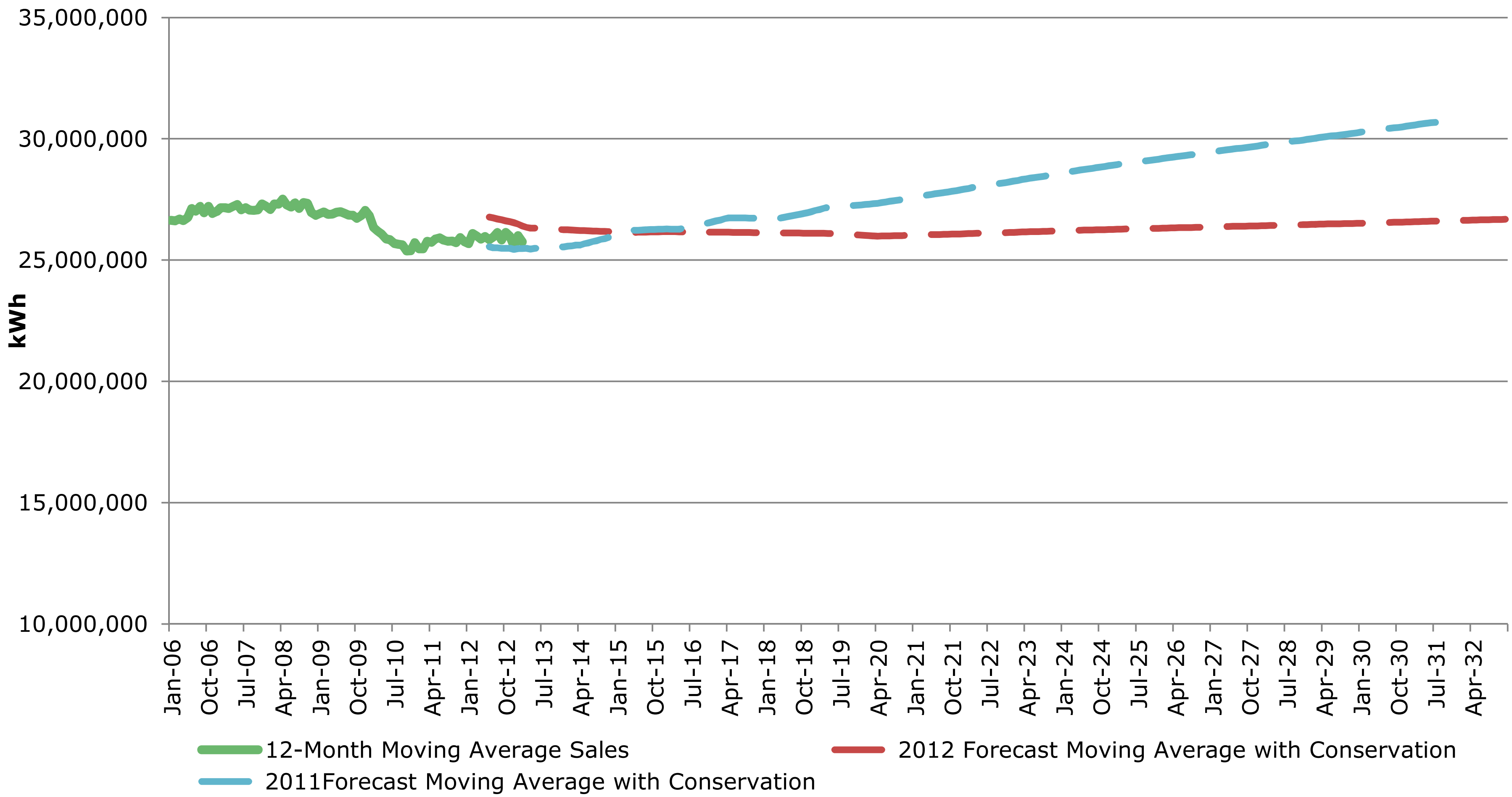
Small General Service Model



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General Service Model

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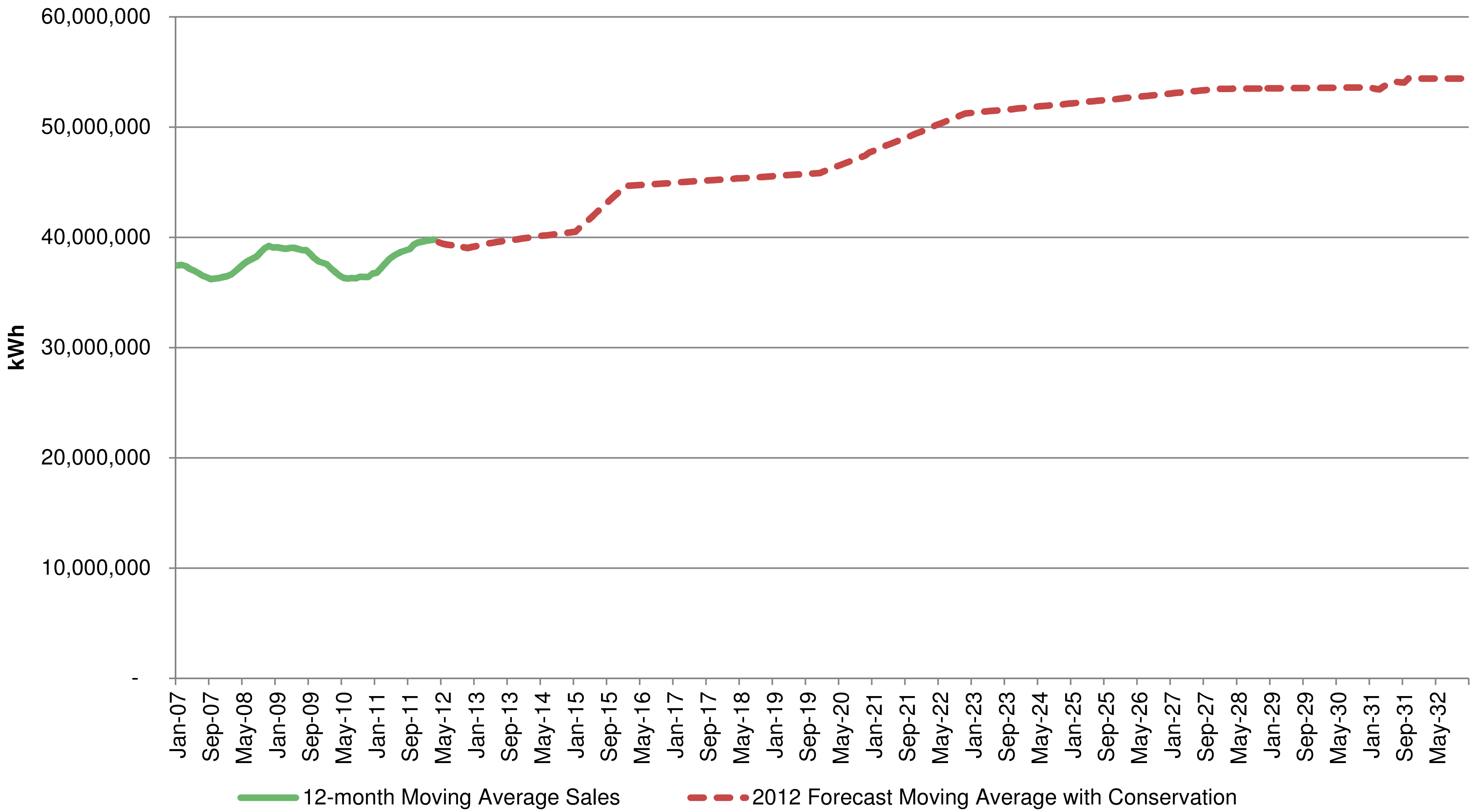
High Voltage General Sales (Directly Estimated)



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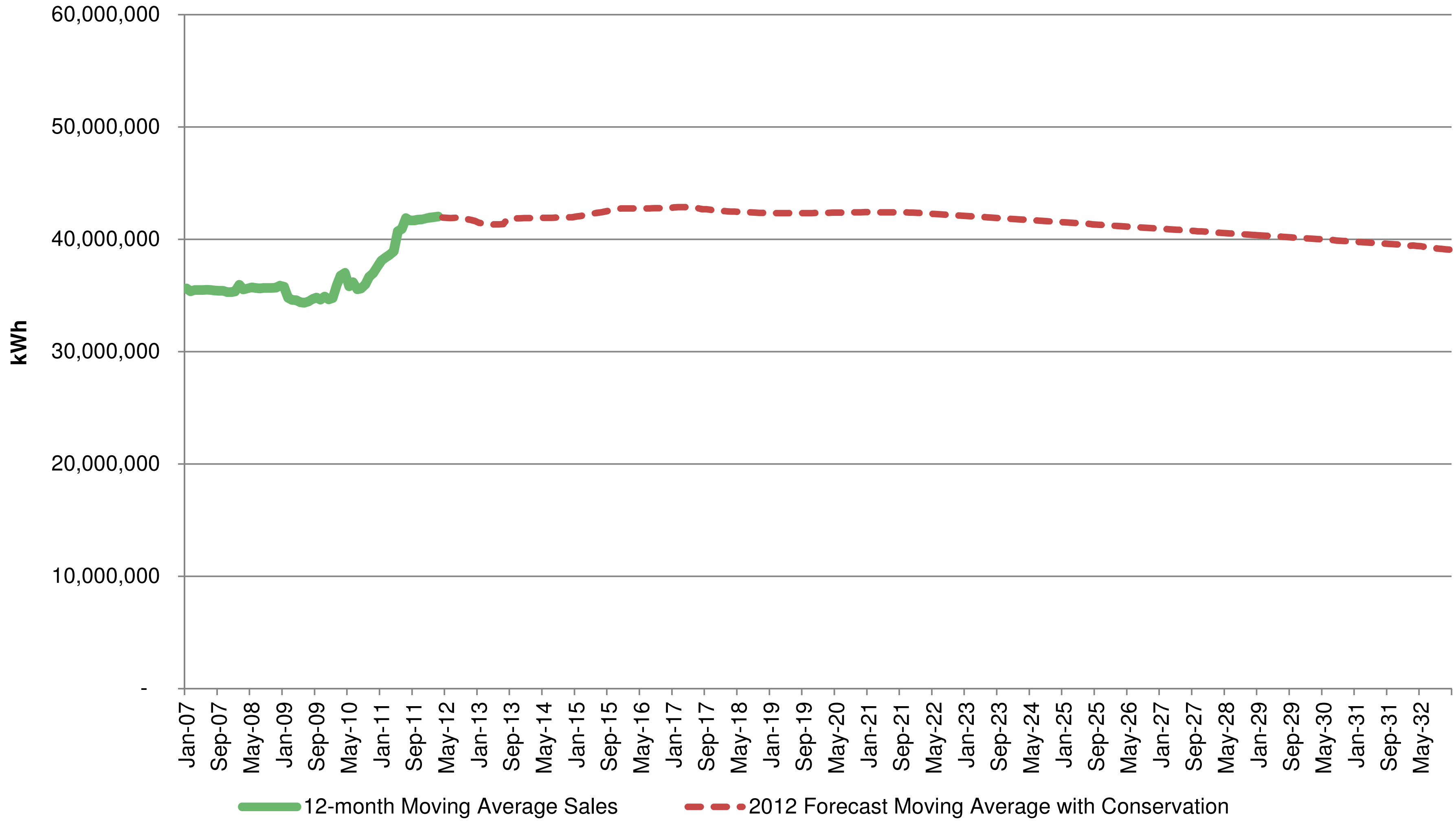
Contract Industrial Sales (Directly Estimated)



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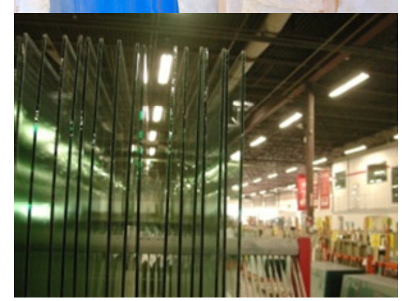
Conservation Resources

Steve Bicker, Manager

Commitment to Energy Conservation

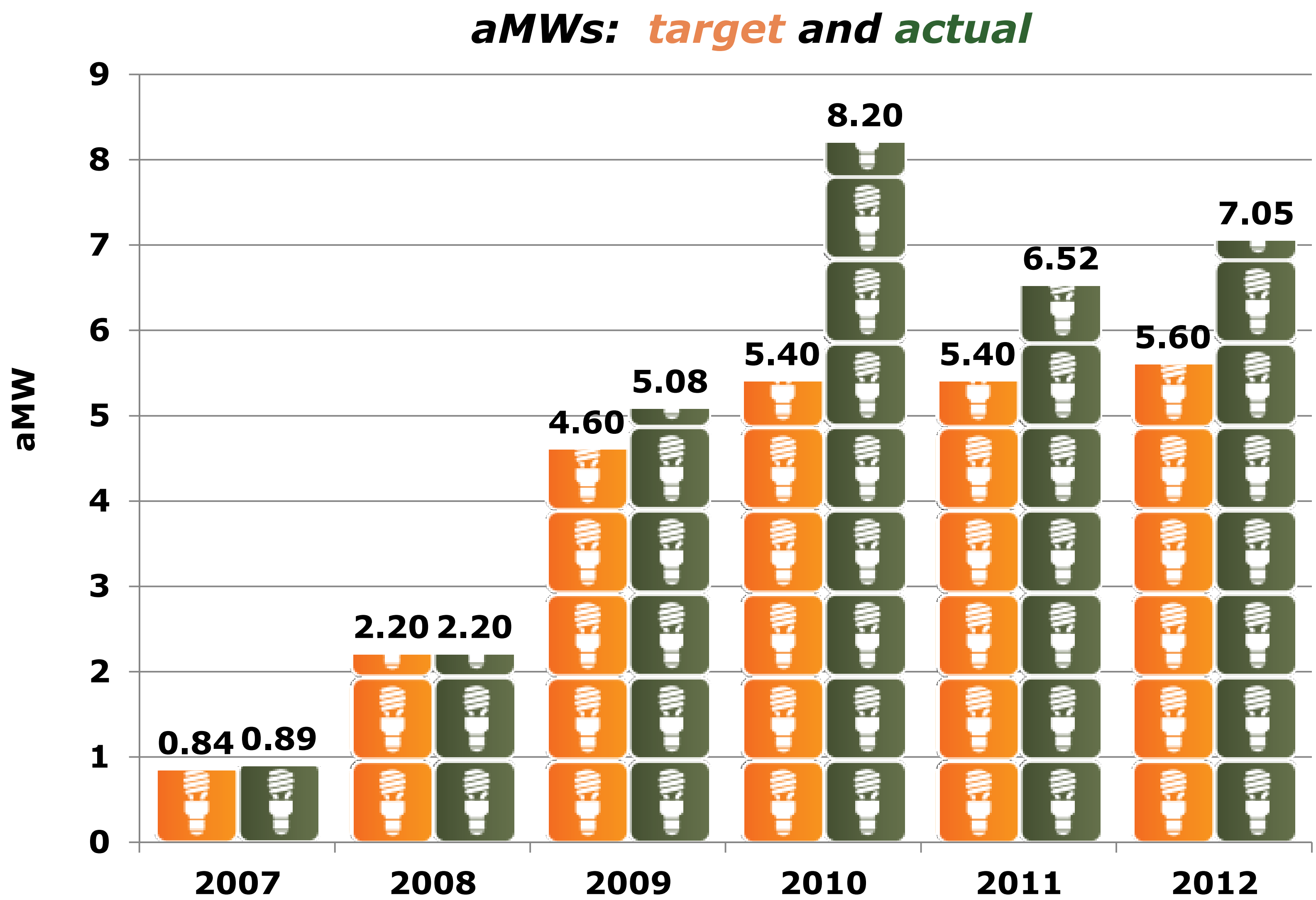


Committed:

- to conservation for 30 years
- to bear costs today for savings tomorrow
- to benefiting Tacoma ratepayer/owners
    - Helps families manage their budgets
    - Makes homes healthier and more comfortable
    - Local businesses save operating expense by reducing overhead and improving productivity and safety
- to providing local resources and jobs
- to an environmentally friendly supply portfolio

Exceeding Targets When We Can

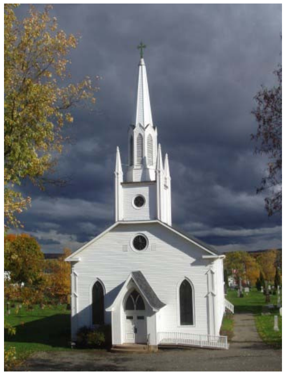


Constraint #1: TRC Cost Effectiveness

- Regional Act: "Defines cost-effective conservation as… estimated incremental system cost no greater than that of the least-cost similarly reliable and available alternative measure or resource…"

- The Total Resource Cost Test measures the net of costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.
  - *California Standard Practice Manual*

Constraint #2: Equity



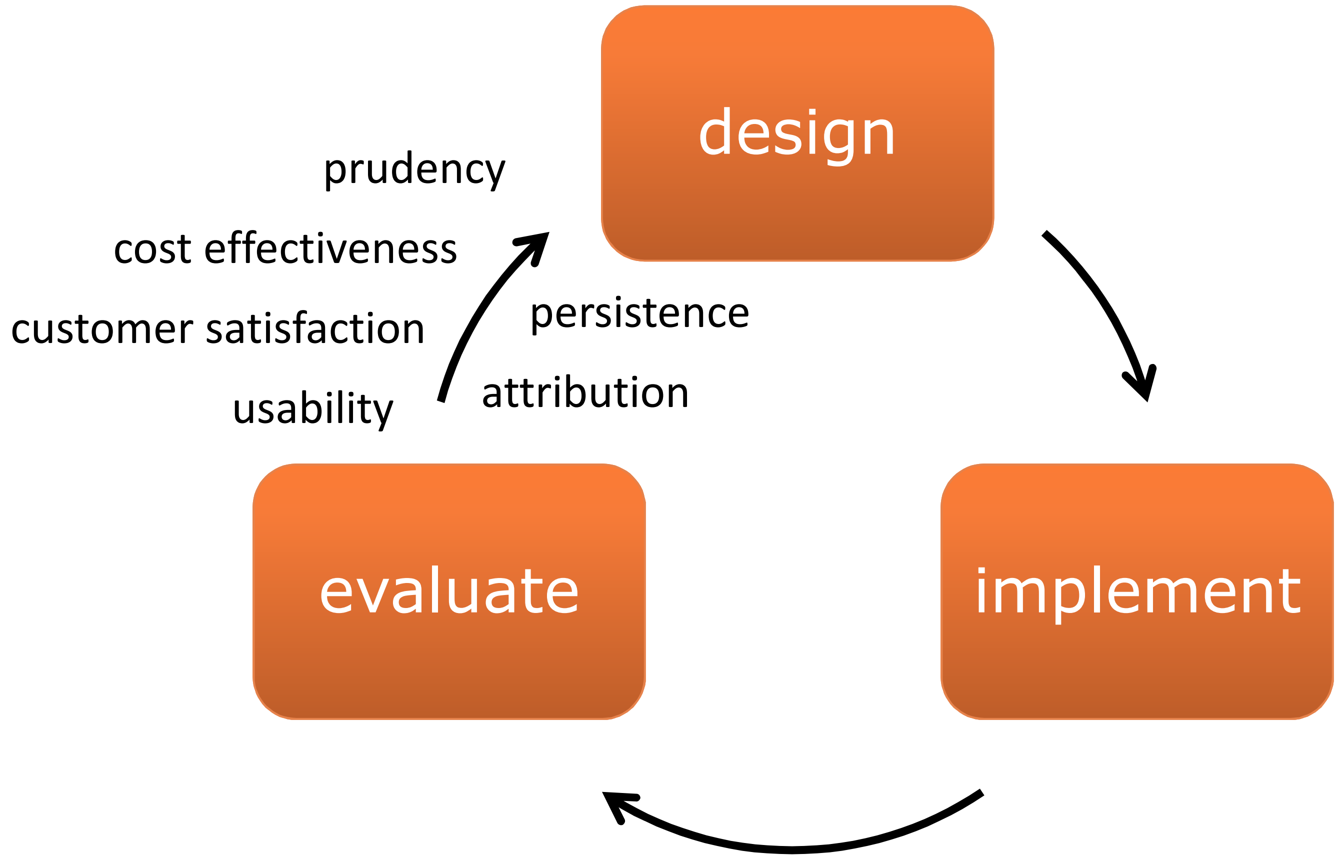
Constraint #3: Customer Satisfaction

- Customers remember products they didn't like for a long time, even after the products improve
  - Ghostly, flickering, slow to light CFLs
  - Smelly washing machines
  - Spitting showerheads that don't rinse well
- Future success tied to the past satisfaction

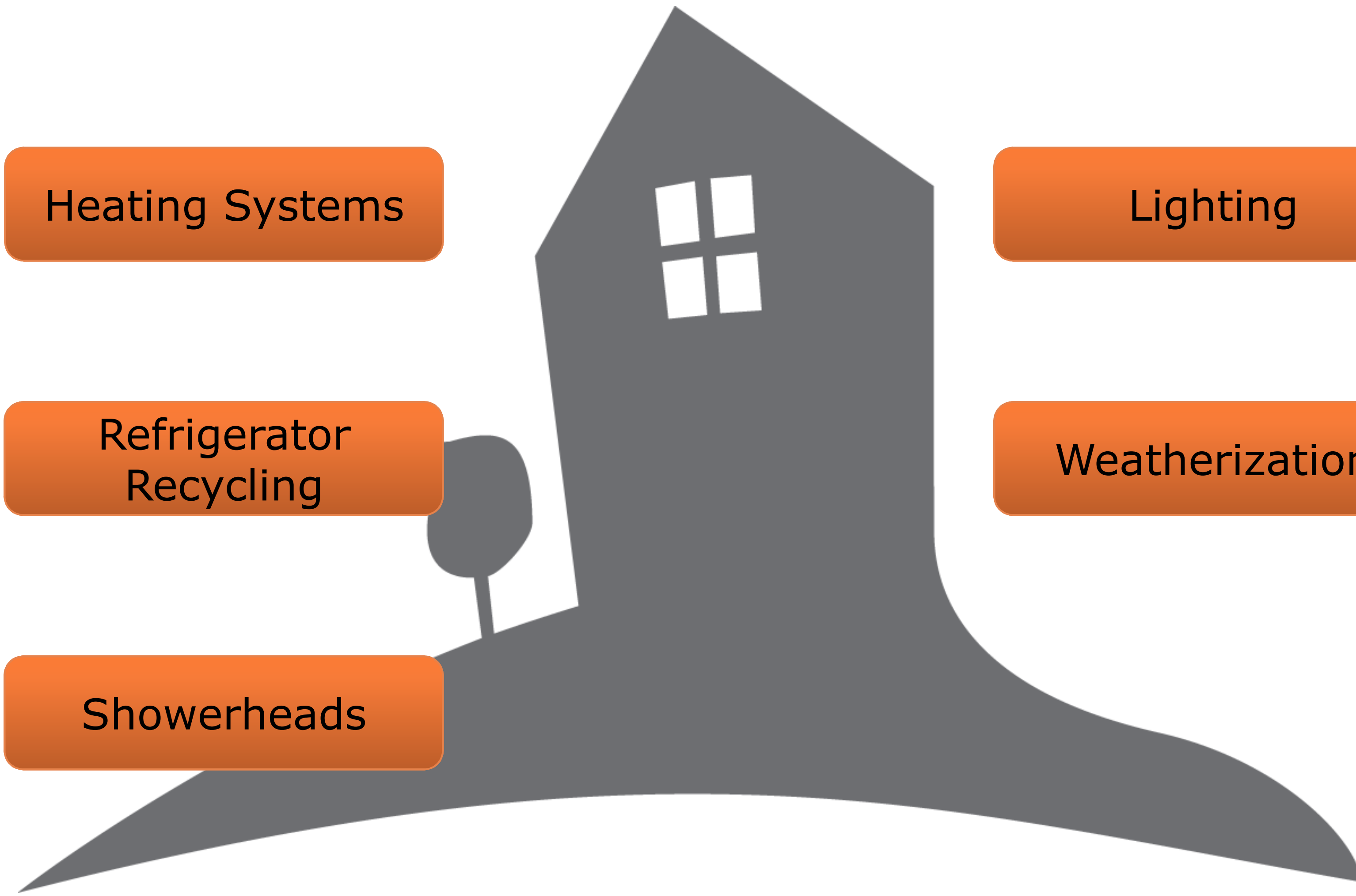
Constraint #4: Diversity

- Market variables …vary
  - 2009
    - Residential lighting program didn't meet goals
    - But commercial lighting over performed
  - 2010
    - Commercial lighting slowed down
    - Residential lighting far exceeded goals

Continuous Improvement



Residential Programs



- Heating Systems
- Refrigerator Recycling
- Showerheads
- Lighting
- Weatherization

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Key Benefits of Residential Programs

- Lighting
  - Instant discounts on CFLs - many available for less than $1 after rebate
  - Instant discounts up to $20 on Energy Star qualified fixtures
- Heating systems
  - Up to $1,200 to install and commission a ducted heat pump
  - $800 or zero-interest loan to install a ductless heat pump
- Weatherization
  - Up to $3,000 to install ceiling, floor and wall insulation
  - Up to $1,000 to replace inefficient windows
  - Up to $450 to seal leaky heating ducts
- Refrigerator recycling
  - $30 rebate and free recycling of qualifying refrigerators
- Showerheads
  - Instant discounts up to $6 on Water Sense showerheads

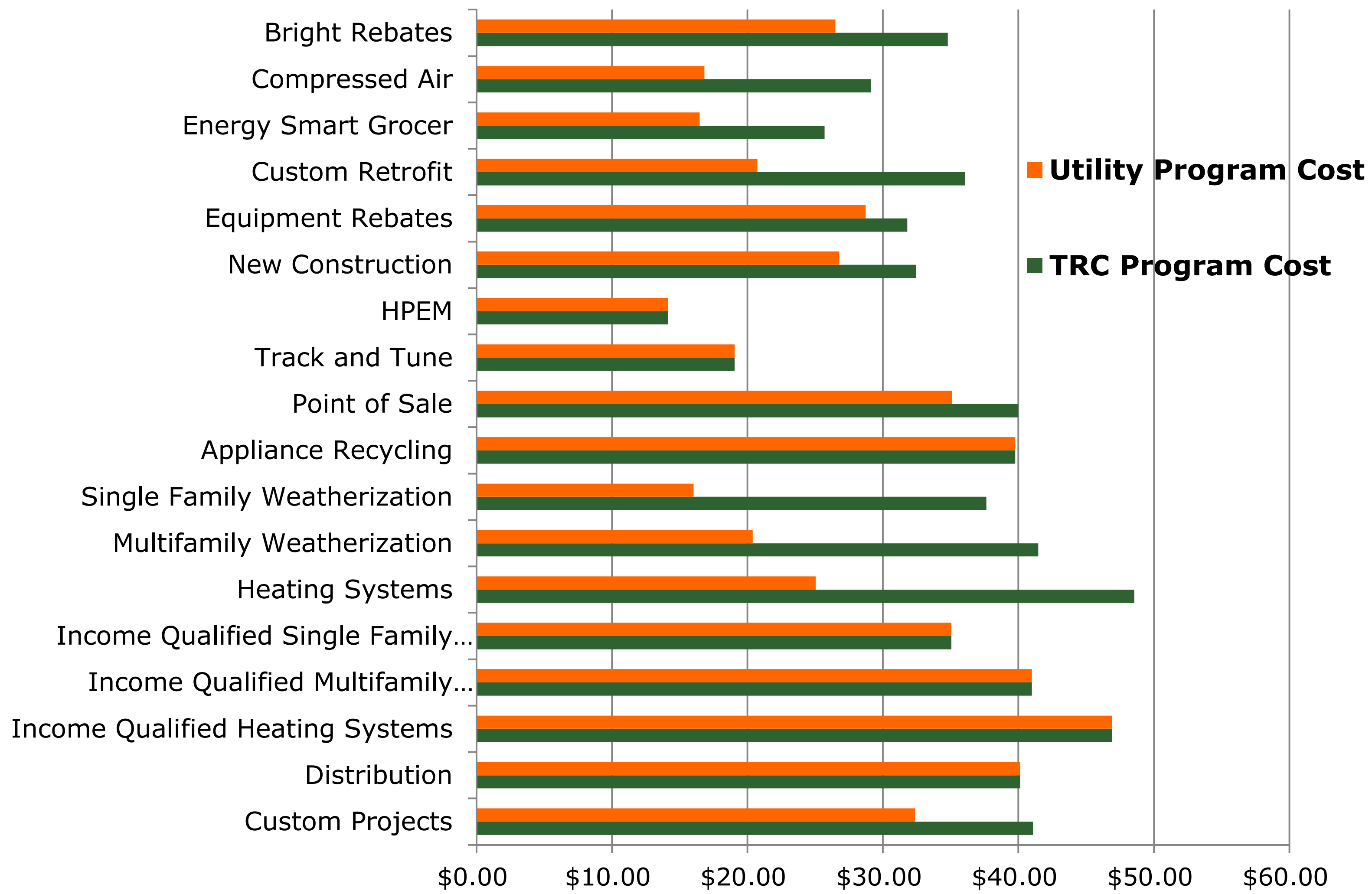
Commercial/Industrial Programs

- Efficient Equipment
- Multifamily
- New Construction
- Lighting
- Compressed Air
- Custom Retrofit
- EnergySmart Grocer

Key Benefits of Commercial/Industrial Programs

- Lighting
  - 17 cents per 1st year kilowatt hour saved, up to 70 percent of the approved project cost
- Efficient equipment
  - Varied incentives to install efficient food service, HVAC and office equipment (for example, up to $2,000 for dishwashers, up to $70 per ton for heat pumps)
- Compressed air
  - 20 cents per 1st year kilowatt hour saved, up to 70 percent of the approved project cost
- Custom retrofit
  - 23 cents per 1st year kilowatt hour saved, up to 70 percent of the approved project cost
- EnergySmart Grocer
  - Varied incentives to install efficient refrigeration, lighting, food service equipment
- New construction
  - Prescriptive: up to 50 cents per square foot for lighting, mechanical systems
  - Custom: 20 cents per 1st year kilowatt hour saved, up to 100 percent of incremental cost
- Multifamily
  - Varied incentives to install insulation and efficient lighting, replace windows and recycle refrigerators

Costs By Conservation Program



What our customers are saying

"These programs offer people the chance to save money, improve their home, and help the environment. What's not to love?"

"Working with Tacoma Power to get the rebate was a quick and easy process."

"The Weatherization program is amazing."

"…That we're saving energy and doing something for the environment – it means a lot to the people who work here."

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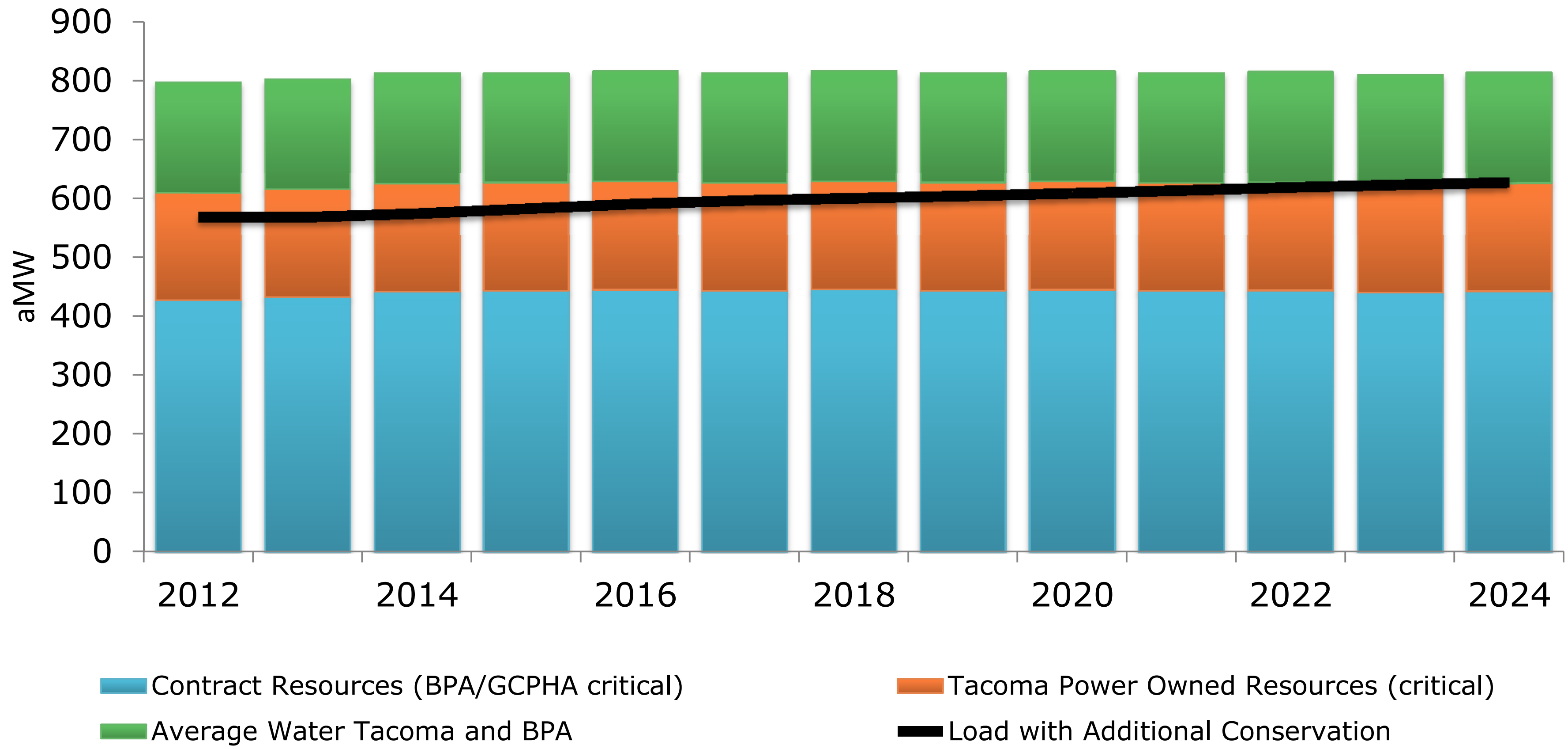
Load-Resource Balance & I-937 Requirements

Nicolas Garcia, Manager

Load-Resource Balance

- The 2012 IRP indicated that Tacoma Power has sufficient resources to meet long-term annual retail loads under critical water conditions for the next ten years



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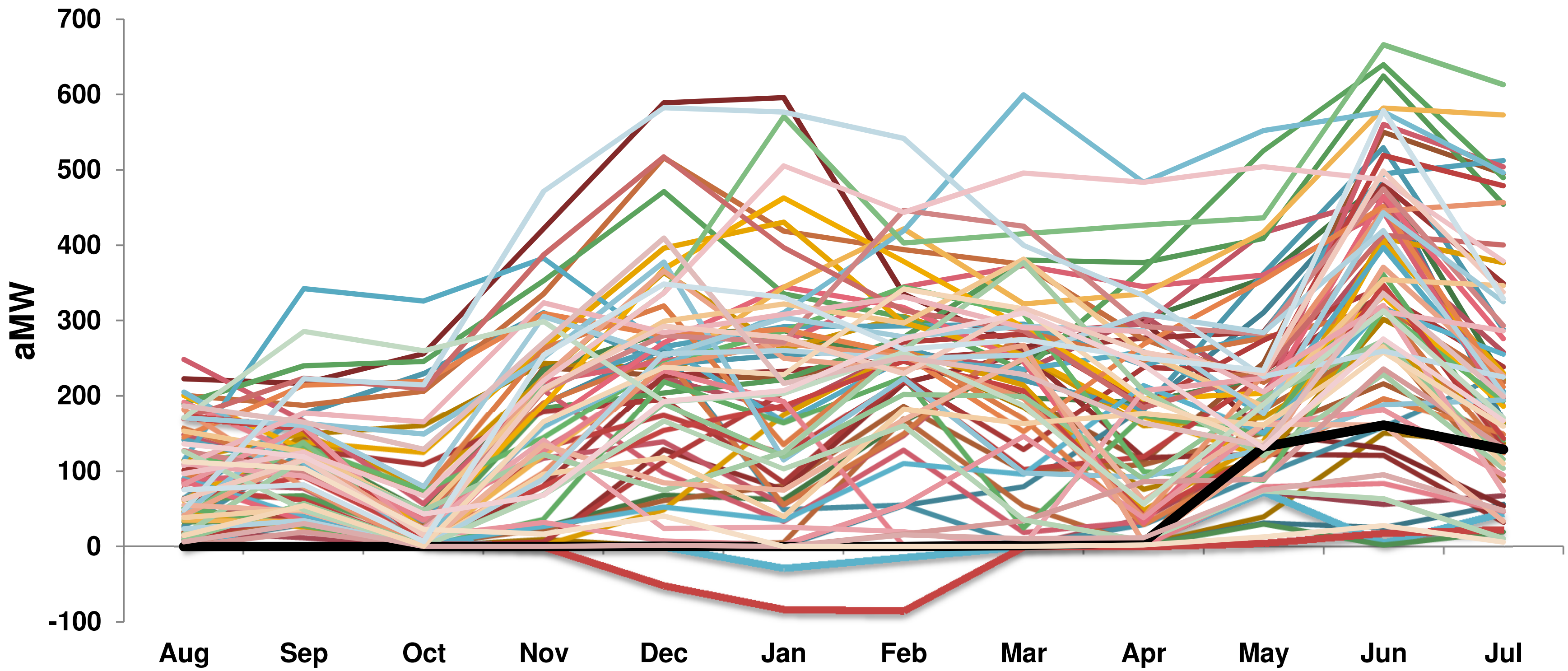
Load-Resource Balance Cont.

- The 2012 IRP indicated that Tacoma Power has sufficient resources to meet seasonal loads under nearly all historical river flow conditions



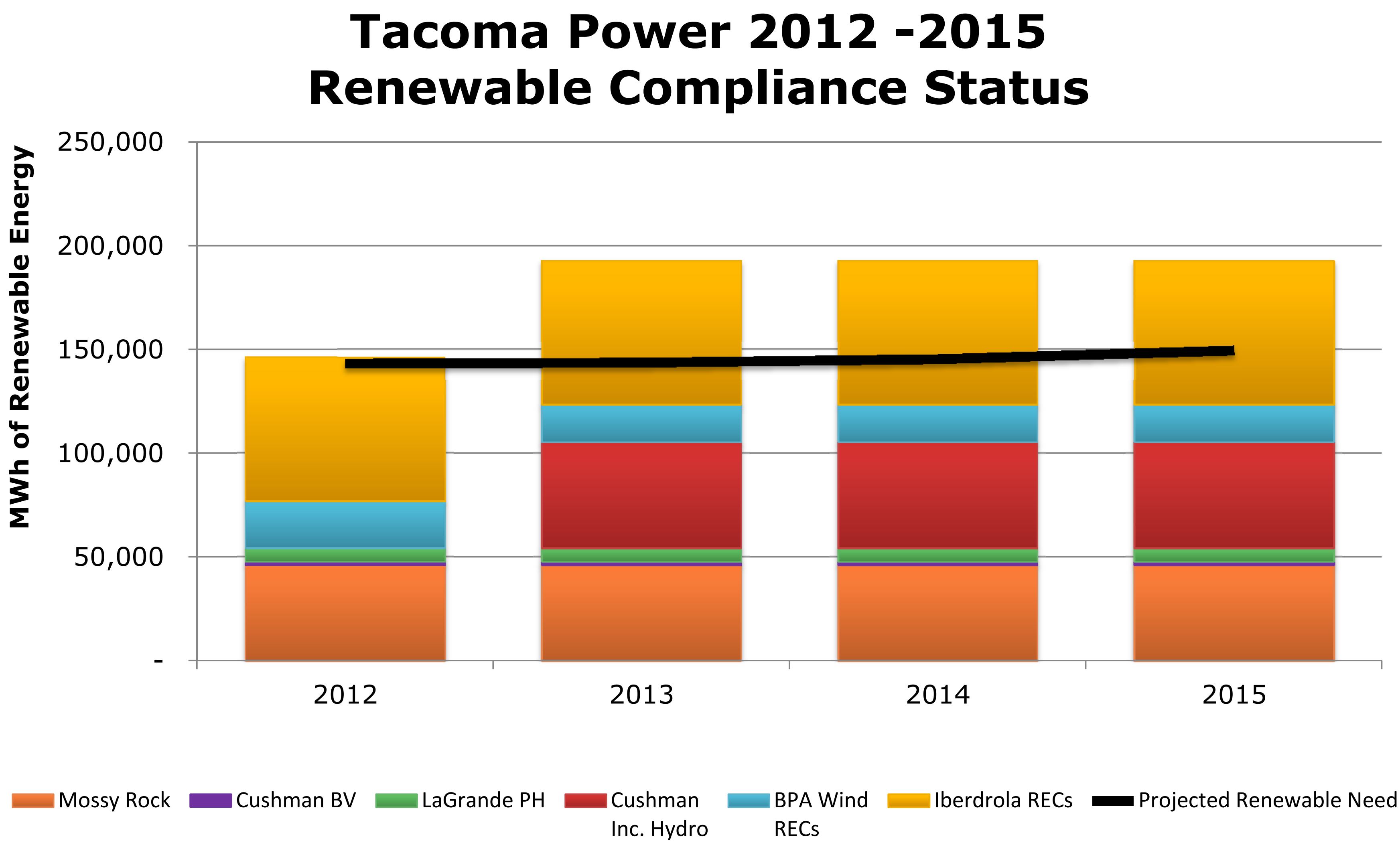
Washington's RPS

- Washington Renewable Portfolio Standard (I-937)
  - Must meet an annual renewable target based on the average amount of electricity delivered to retail customers over the previous two years
    - 3% by 2012
    - 9% by 2015
    - 15% by 2020
  - Tacoma Power's 2012 Target
    - 143,127 MWh's
  - Hydro, while renewable, is not an "Eligible" resource
  - $50/MWh penalty (plus inflation) for each MWh short of the goal
  - Cost Cap
    - 4% of Revenue Requirement
    - Tacoma Power 2012 cap was approximately $12 million

Eligible Renewable Resources

- Wind
- Solar
- Geothermal
- Incremental Hydro
- Biomass
- Landfill Gas
- Ocean (Wave/Tidal)
- Bio Diesel
- Renewable Energy Credits (REC's)

2012 -2015 RPS Compliance Status



Next Steps

- Next Meeting will take place in the beginning of May
  - Price Forecasts Overview
  - Uncertainty of Load, Price, and Hydro Conditions
  - Portfolio Modeling Methods
  - Conservation Resource Potential
  - Monthly Load Resource Balance
- Any Questions:

Travis Metcalfe

tmetcalfe@cityoftacoma.org

(253) 502-8149

- Thank you all for your time today and input into our process!

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2013 IRP

Stakeholder Presentation 2

May 13, 2013

Welcome & Introductions

- Manager of the 2013 IRP

  Travis Metcalfe

  tmetcalfe@cityoftacoma.org

  (253) 502-8149

- Welcome from Chris Robinson, Power Manager

- Stakeholder Introductions
  - Name
  - Whom you are representing

What we plan to cover today

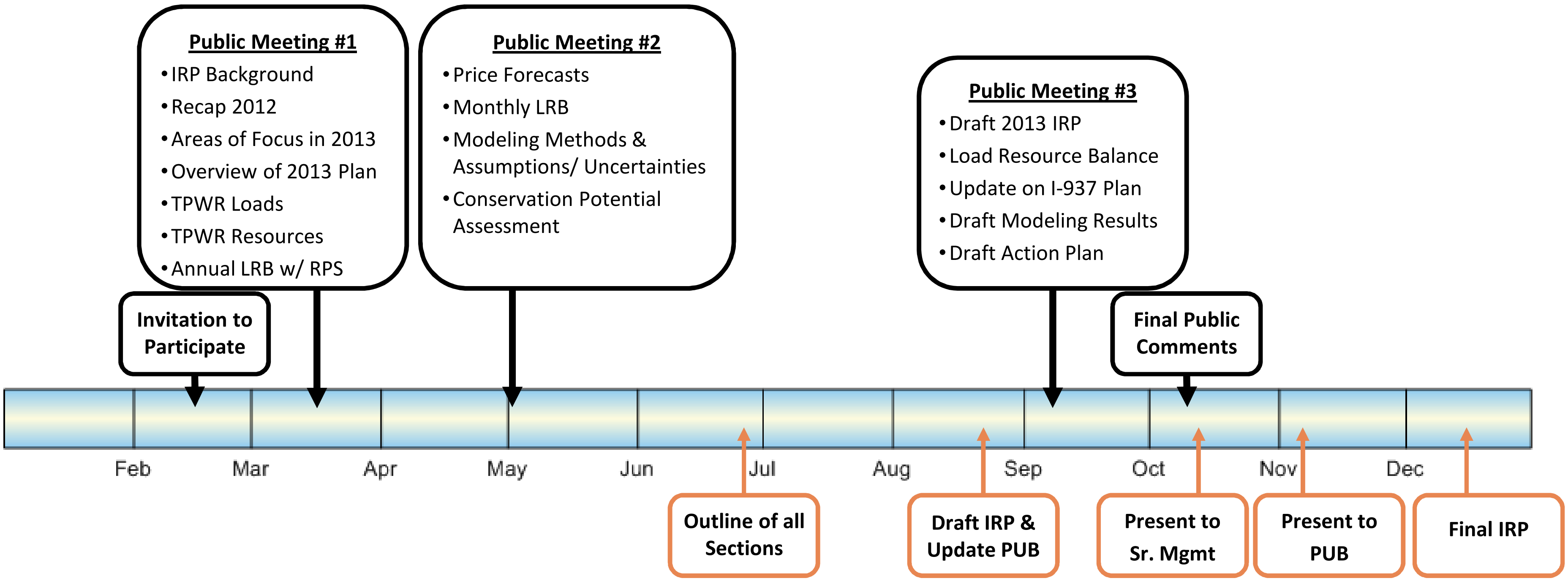
- What we covered in our first presentation
- Review of our Objective and Process for 2013
- 2013 Wholesale Electricity Price Forecast
- Conservation Potential and Planning
- Updated Load Resource Balance
- Modeling the Tacoma Power Portfolio in an Uncertain Future
- The focus of Meeting #3

2013 IRP Focus

- Questions to be addressed through analysis, discussion, and development of the 2013 IRP Action Plan
  - How much Conservation should Tacoma Power pursue in the 2014/2015 time period in order to:
    - Mitigate future risk and uncertainties
    - Delay the acquisition of unnecessary additional supply side resources
  - What is the recommended approach for complying with Tacoma Power's 2016 and 2020 I-937 - Renewable Portfolio Standard Requirements?
  - What future energy and capacity portfolio best conforms to the needs of the utility?

Public Involvement Timeline

Public Involvement Events



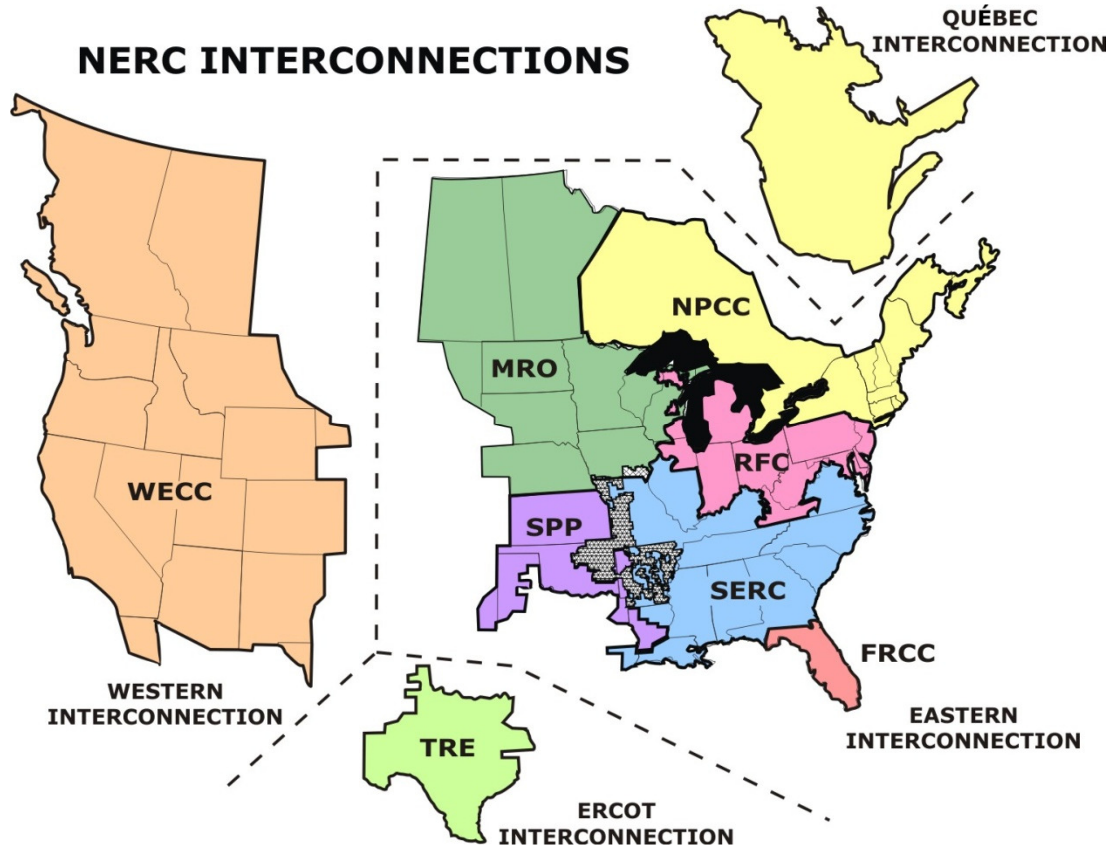
Internal Development Milestones

2013 Wholesale Electric Price Forecast

Cathy Carruthers

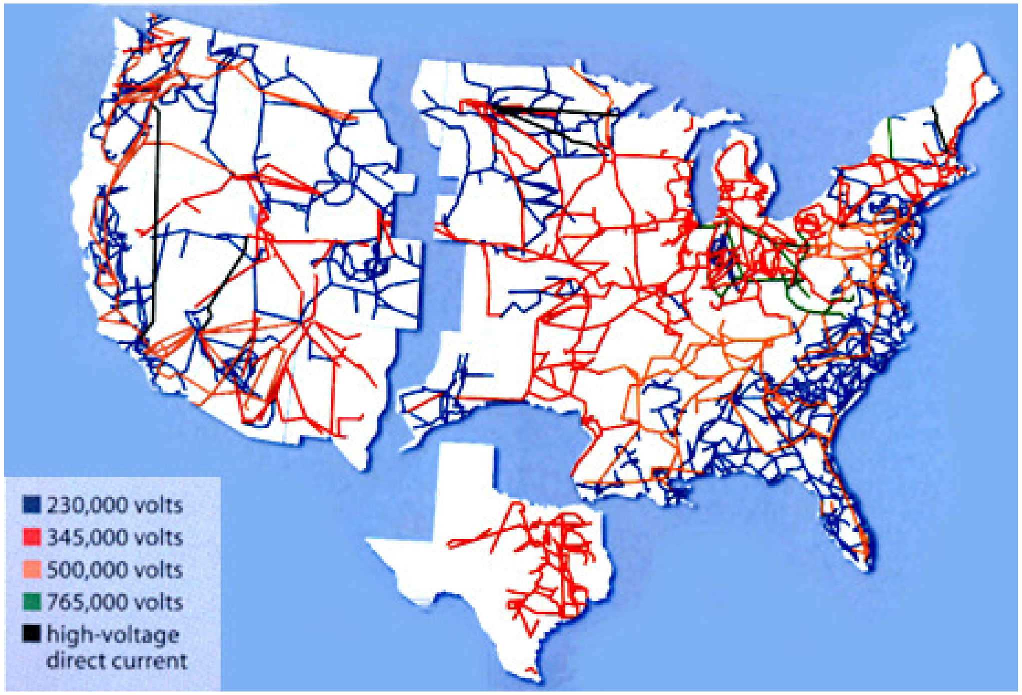
Price Forecast

- Wood Mackenzie
- Mid C Market - Wholesale
- WECC
  - Resources
  - Demand

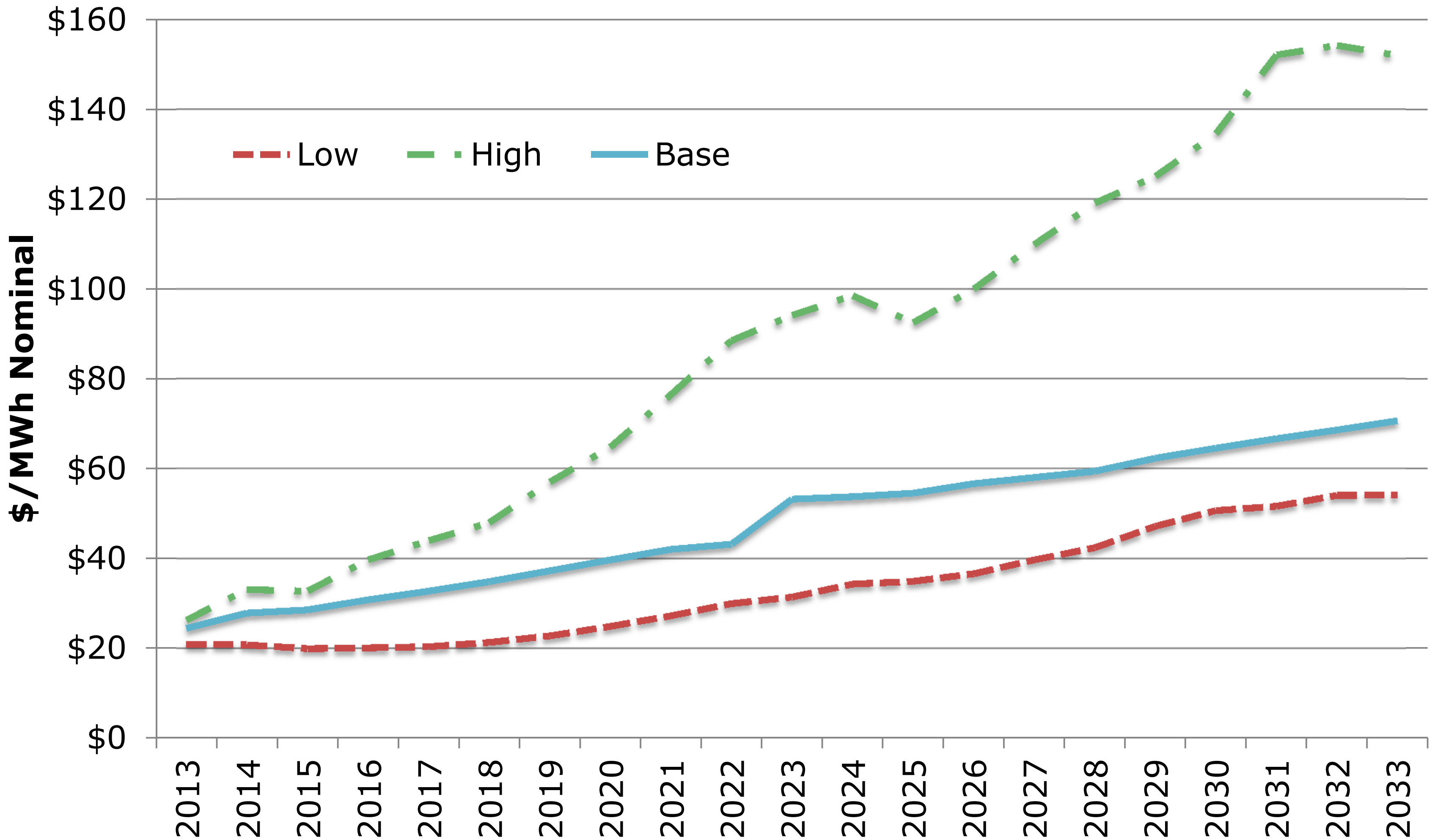


Wholesale Market

- WECC
- Large market
- Tacoma - Price Taker
- Large Impacts
  - Natural Gas Price
  - Hydro Supply
  - Demand
  - Transmission



2013 Recommended Forecast



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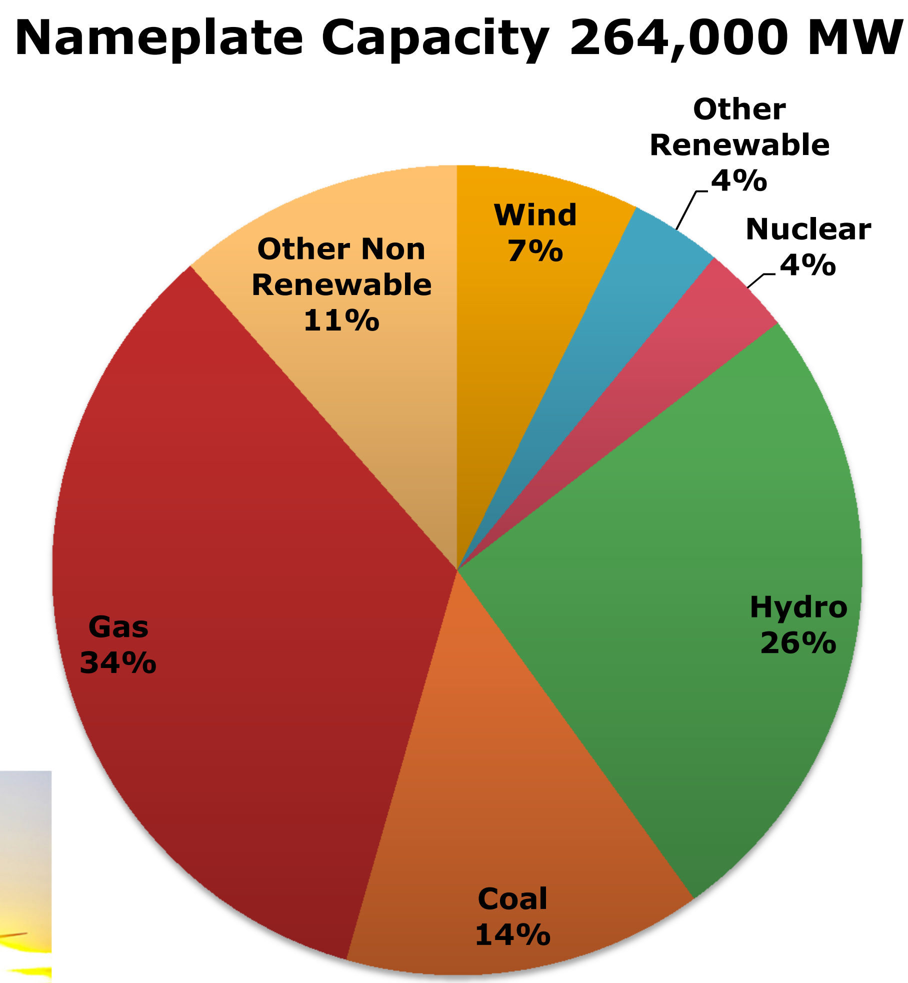
Drivers: Resource Supply in WECC

- The current combination of Resources in WECC



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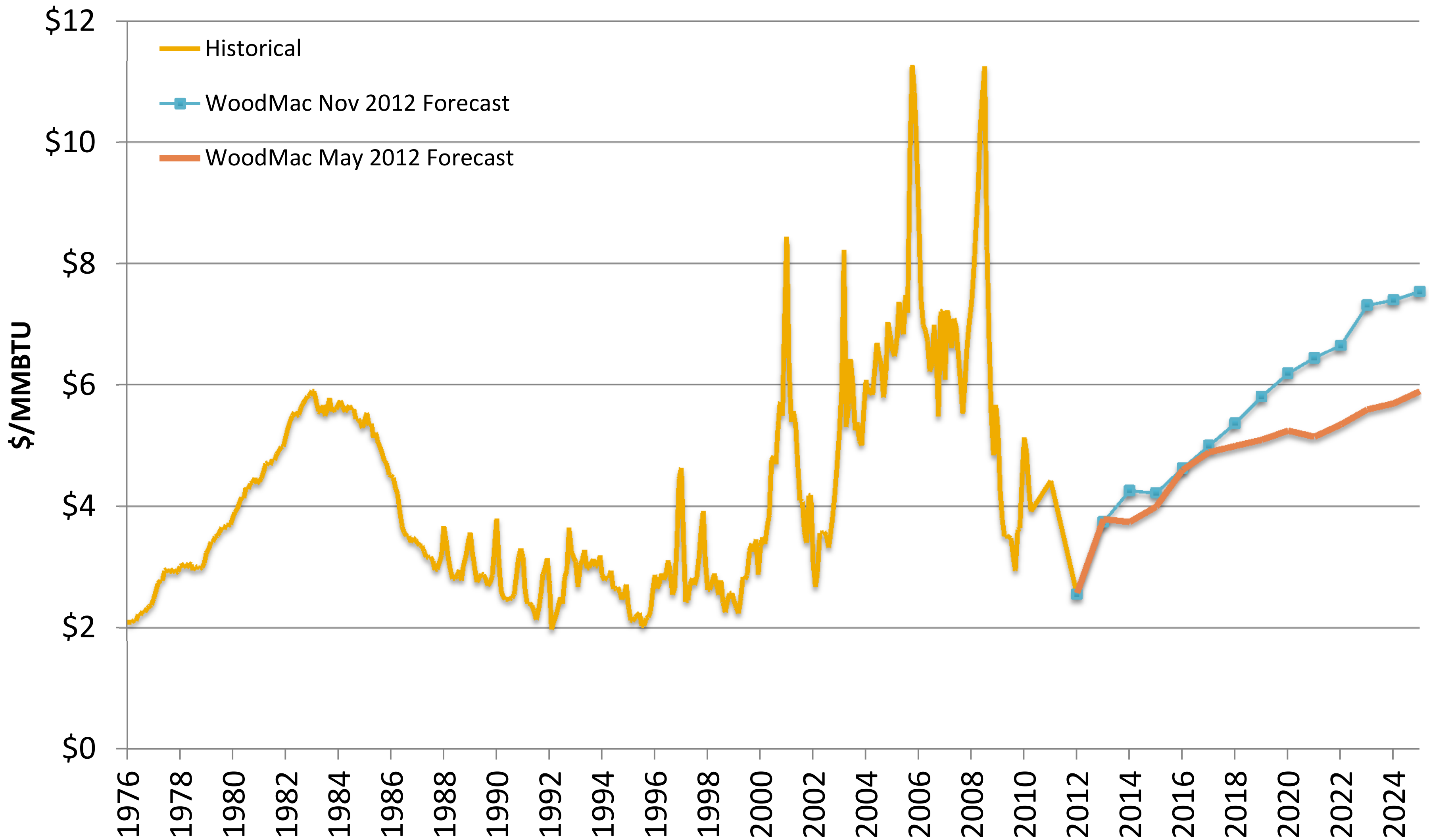
Drivers: Natural Gas Prices



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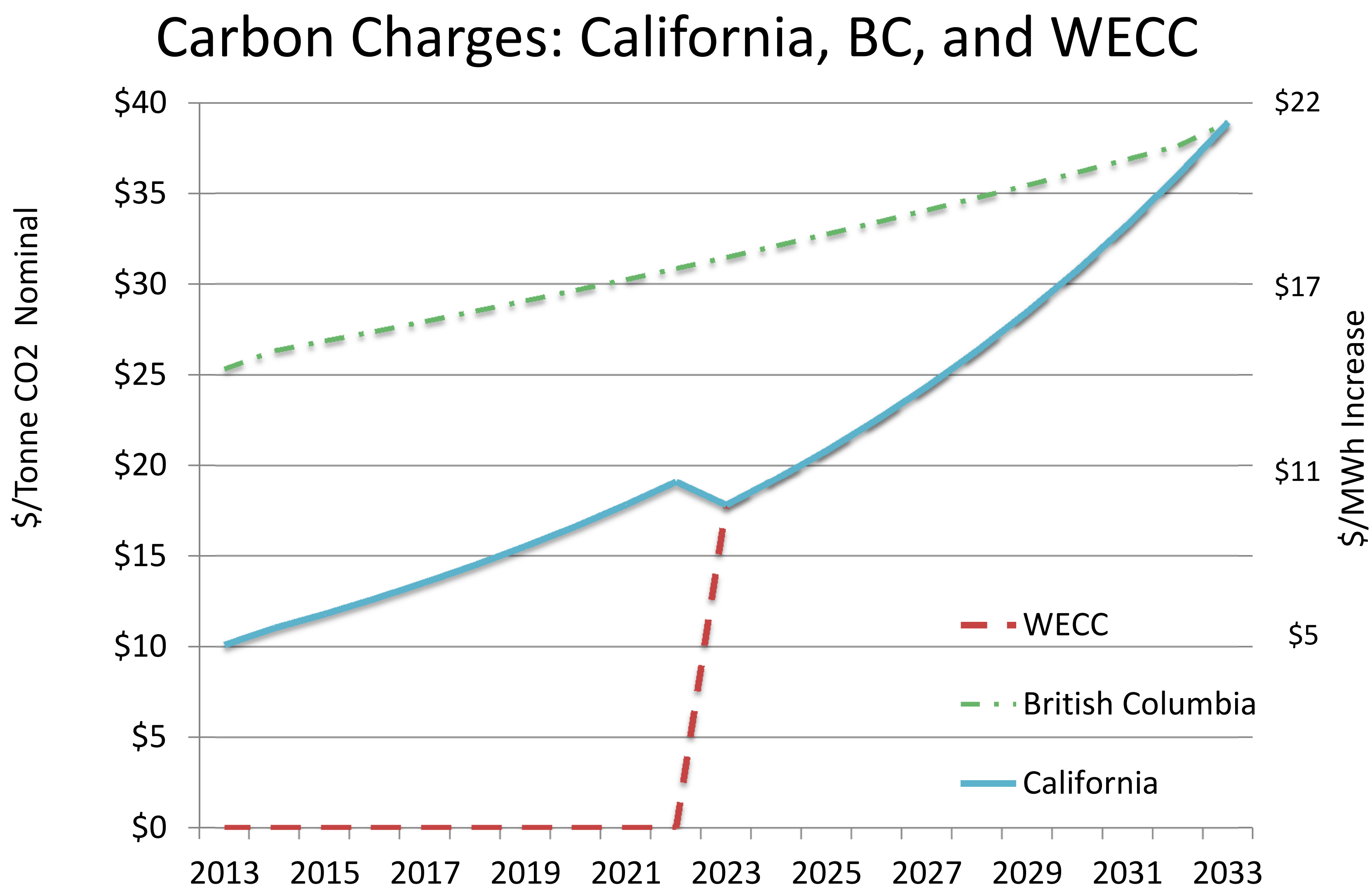
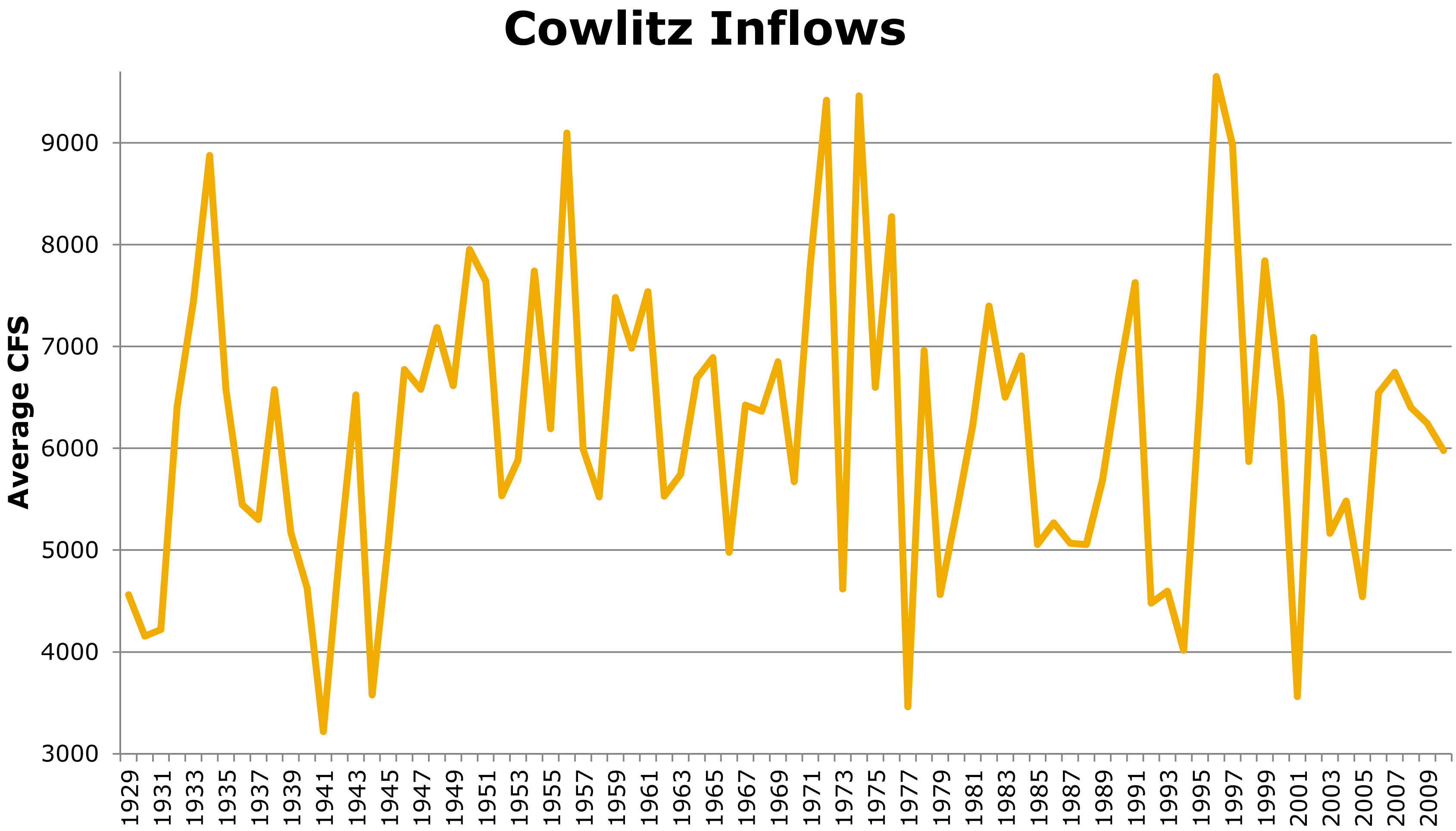
Drivers: Carbon Pricing



Drivers: Hydro Conditions

- Water supply varies each year



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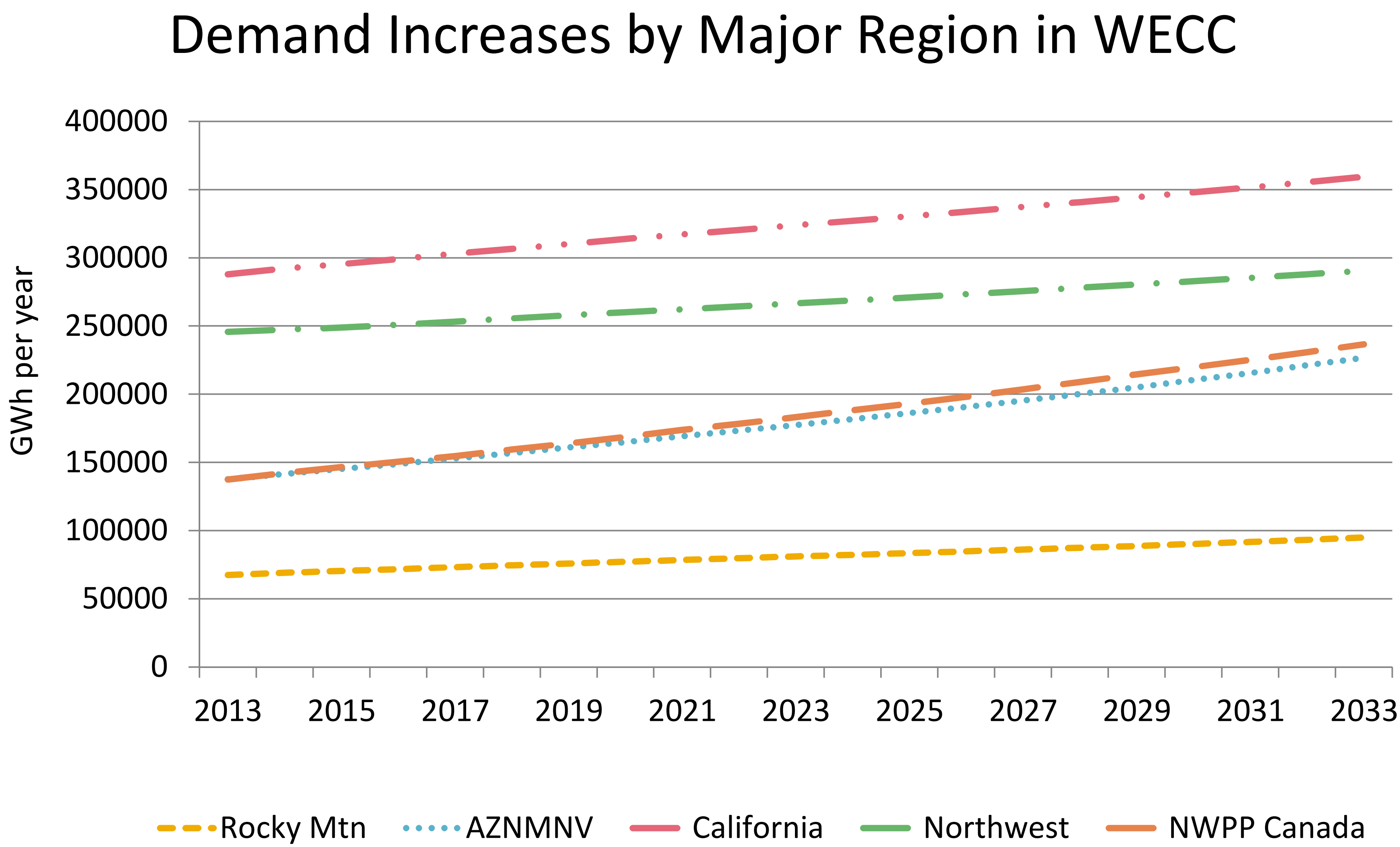
Drivers: Demand Increases



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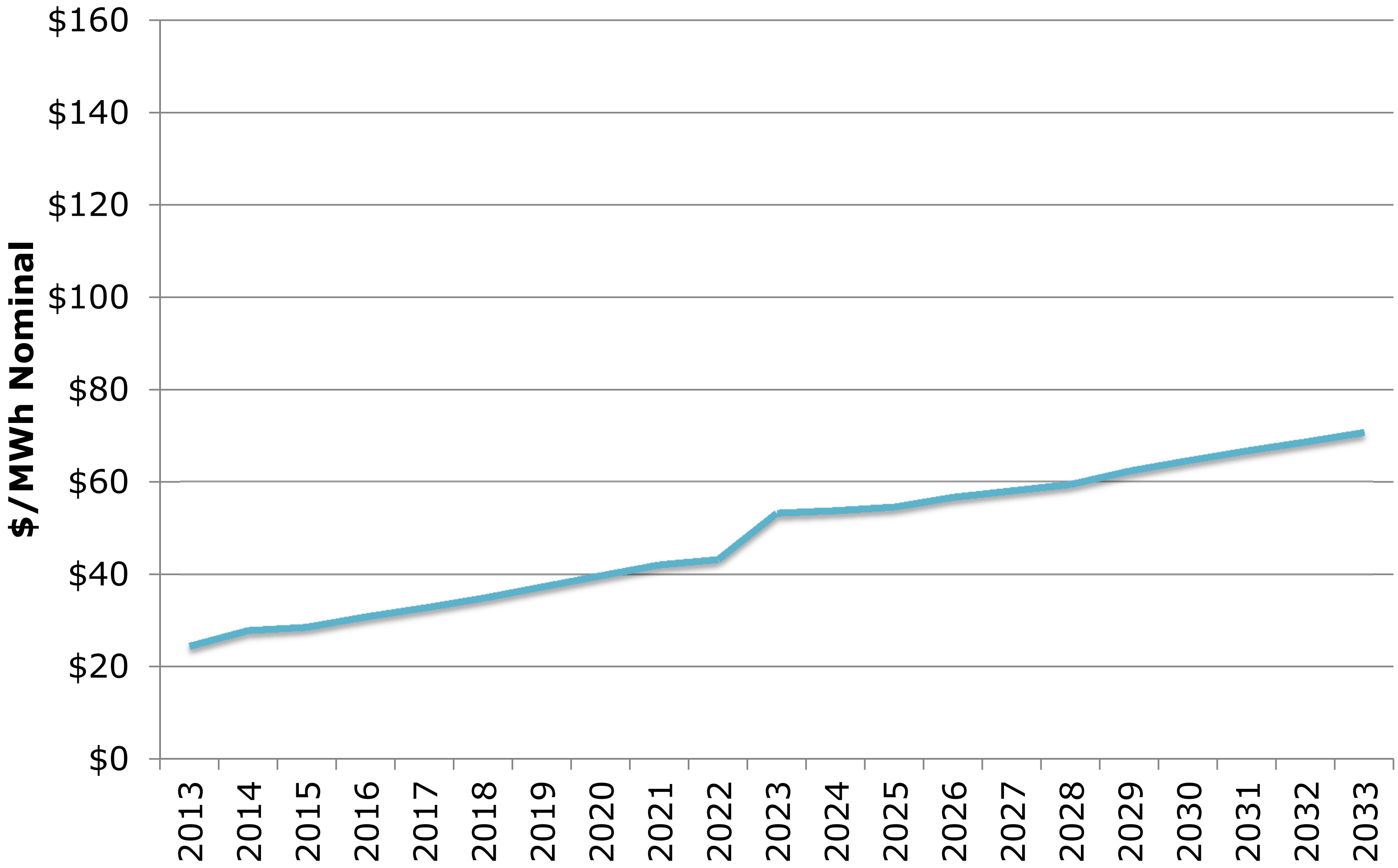
Base 2013 Forecast



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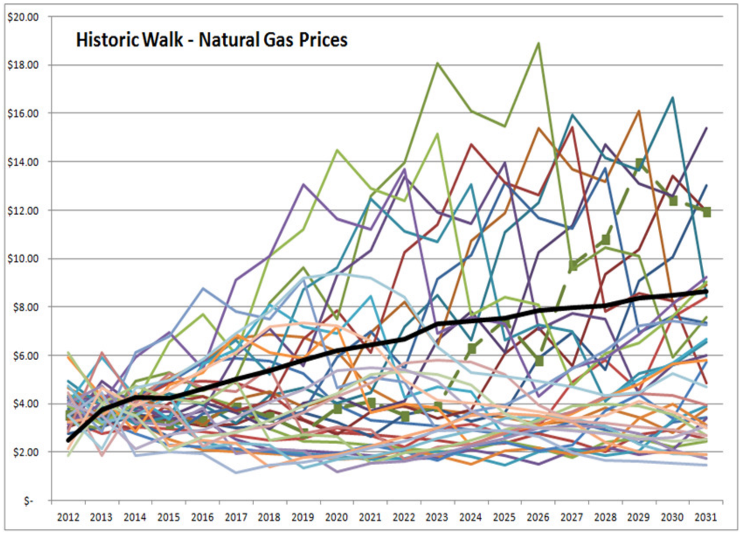
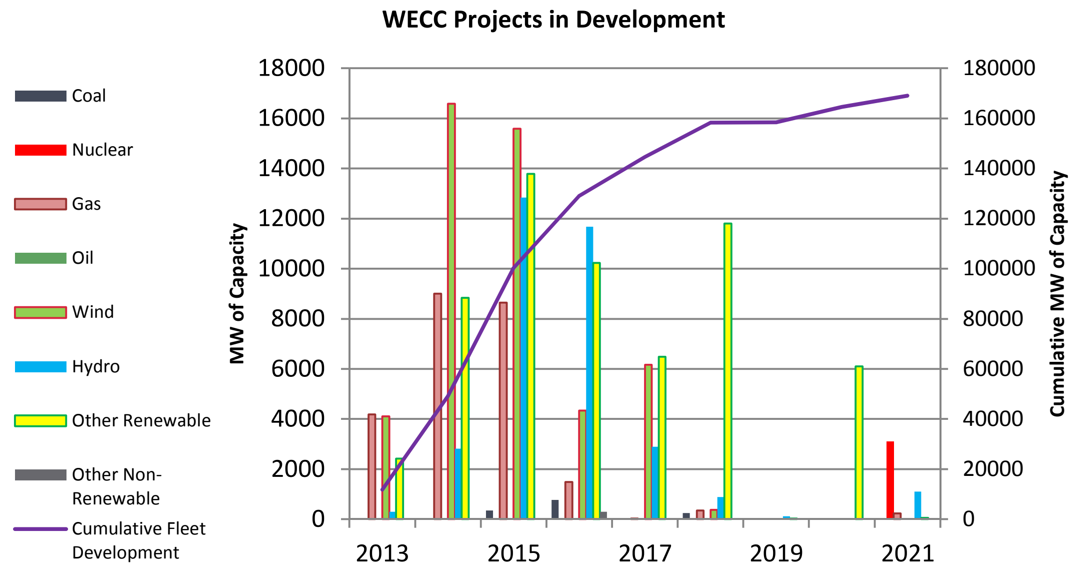
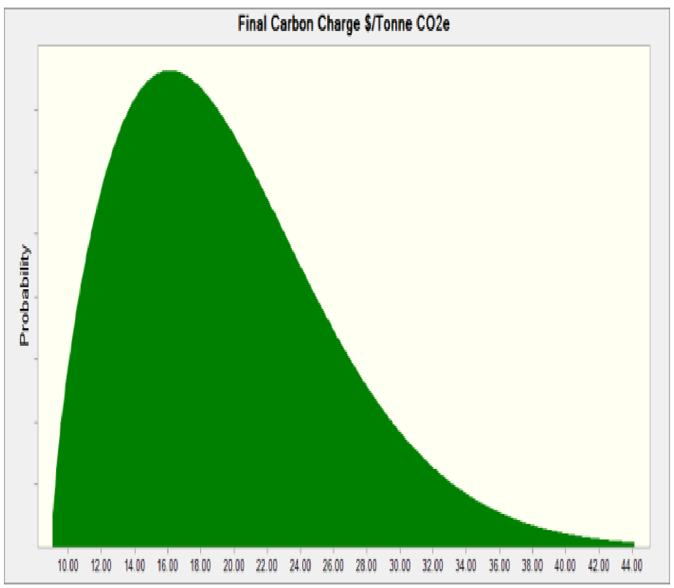
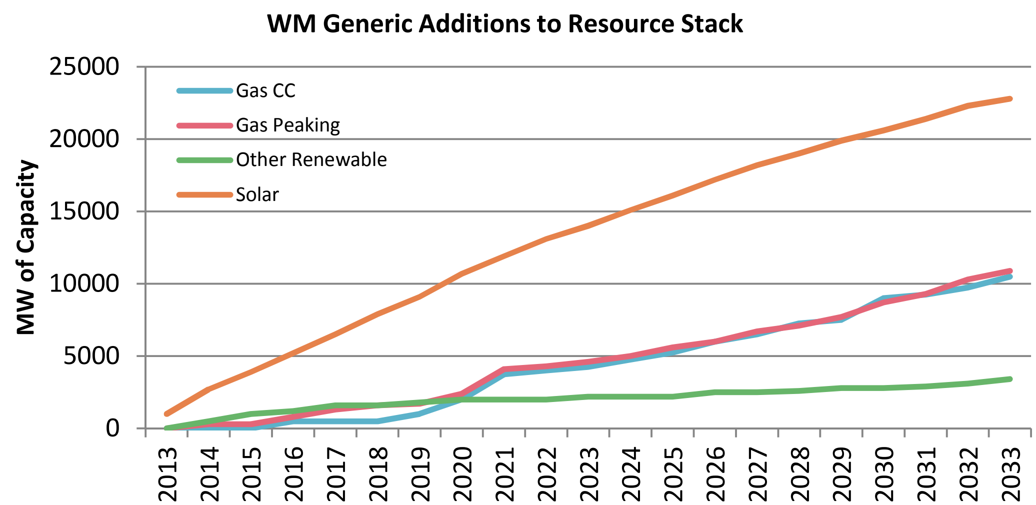
Adding Range to the Forecast – Crystal Ball

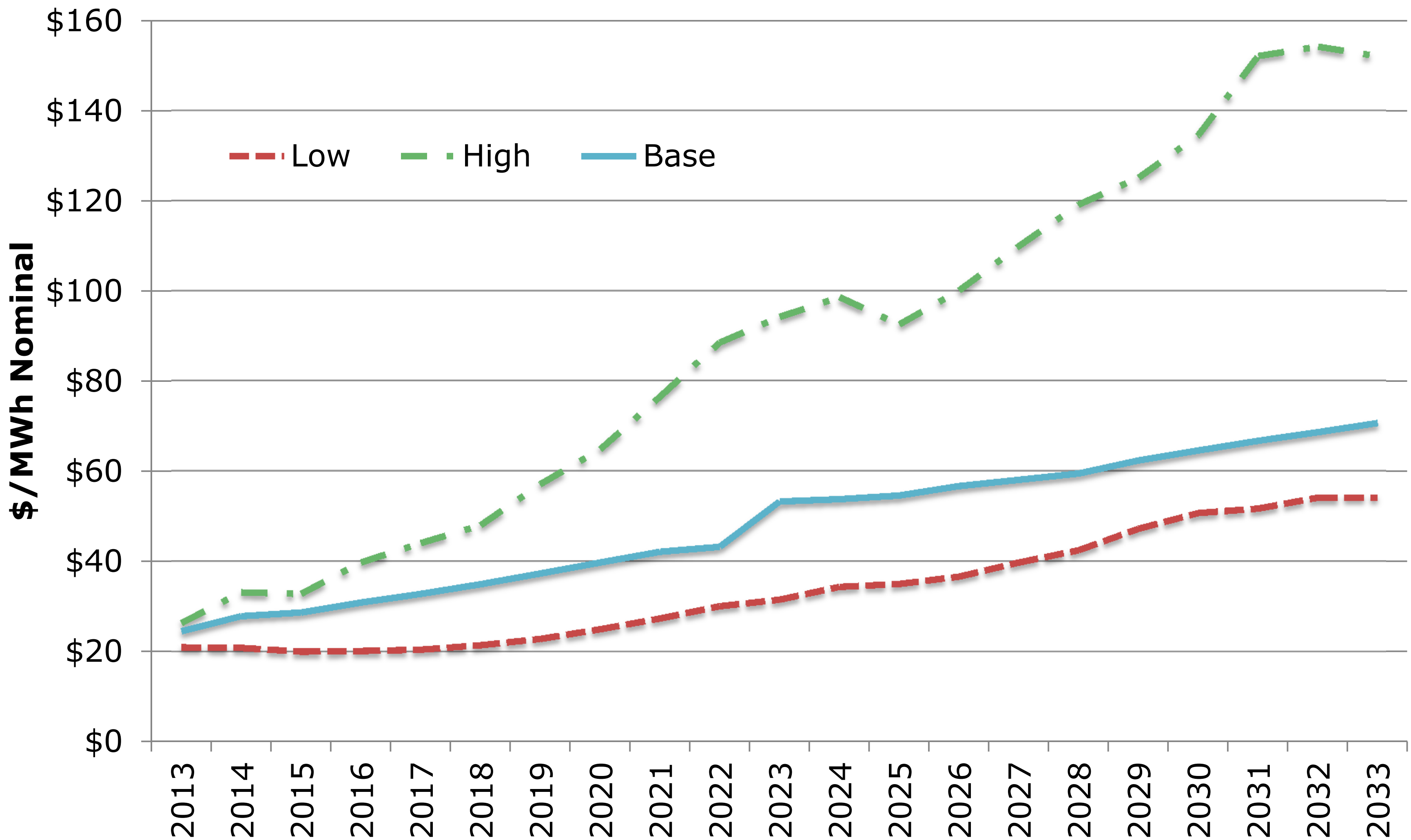








Forecast with Low and High



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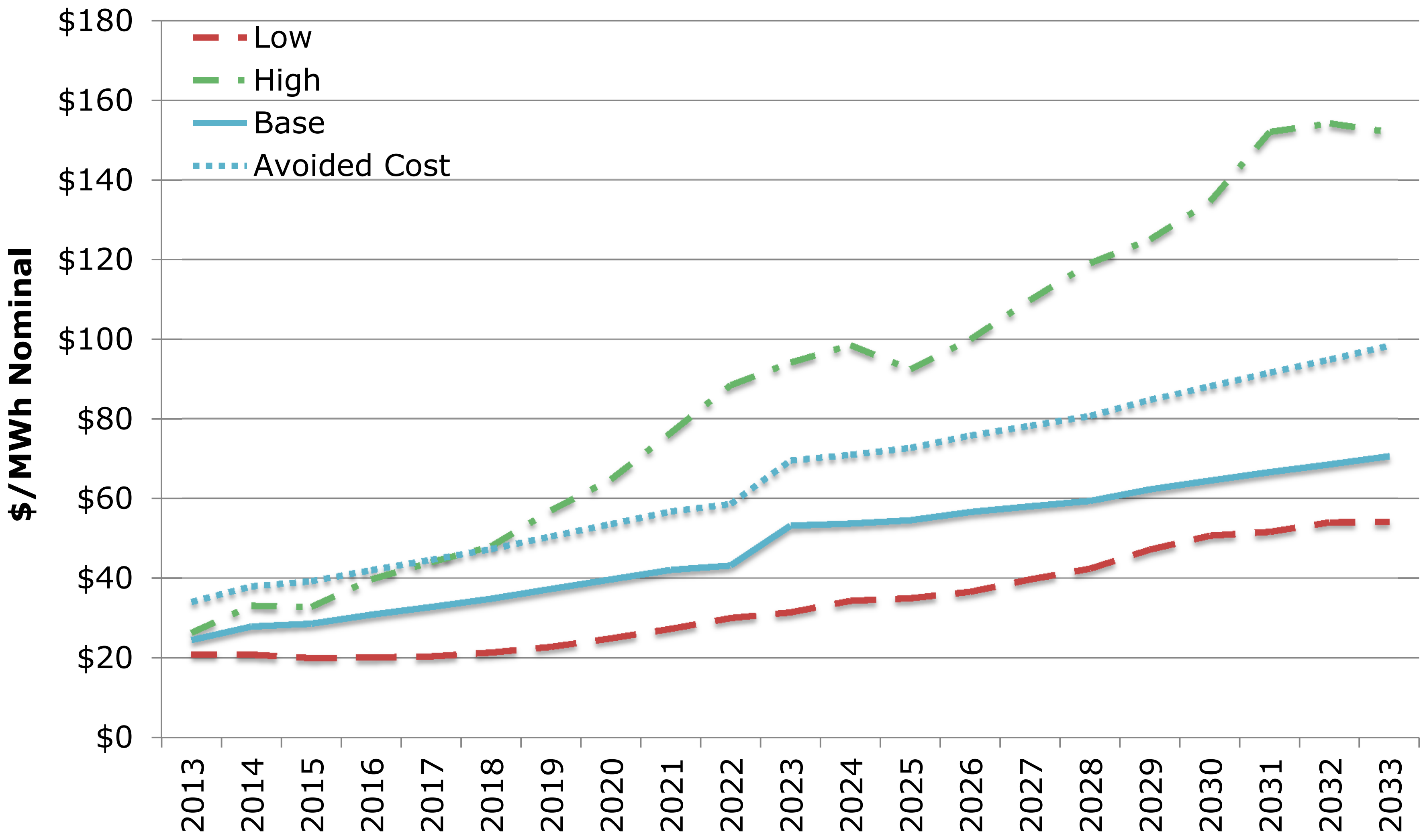
Avoided Cost Risk Adder

Calculation Basis - Frequency and Values

Additive Calculation of Risk	Basis	Odds	Value
Natural Gas	$12.97	15%	$1.95
Natural Gas + Water Year Risk	$17.27	5%	$0.87
Water Year Risk	$10.46	20%	$2.10
Demand with Water Variance	$7.71	54%	$4.63
			$9.55

Long-term Forecast with Risk Adder



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Conservation Potential & Planning

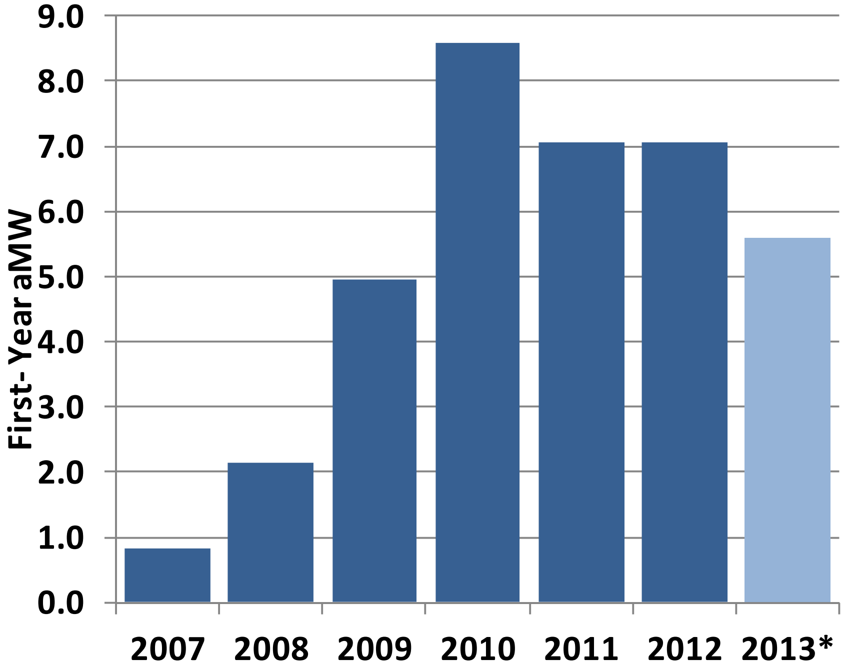
Rich Arneson

Conservation Potential and Planning Agenda

- Conservation History
- State Law
- Recent Conservation Plans and Accomplishments
- Role of Conservation Potential Assessment (CPA) in Planning
- Factors Impacting CPA Results
- Recent CPA Results
- 2014-2015 Planned Activity
- Forecast Conservation Acquisitions

Definitions of Potential

Recent Conservation Accomplishments



*The 2013 conservation accomplishments are planned.

- From 2007 to 2012, we have acquired 30.6 aMW of conservation
- 2010-2012, we have surpassed our targets by 7.7 aMW
- 2012 acquisitions by sector
  - 54% Residential
  - 46% C&I
- 2013 on track to acquire at least 5.67 aMW
- Programmatic levelized costs
  - Residential $15 to $46/MWh
  - Commercial-Industrial $4 to $34/MWh

Energy Conservation – State Law

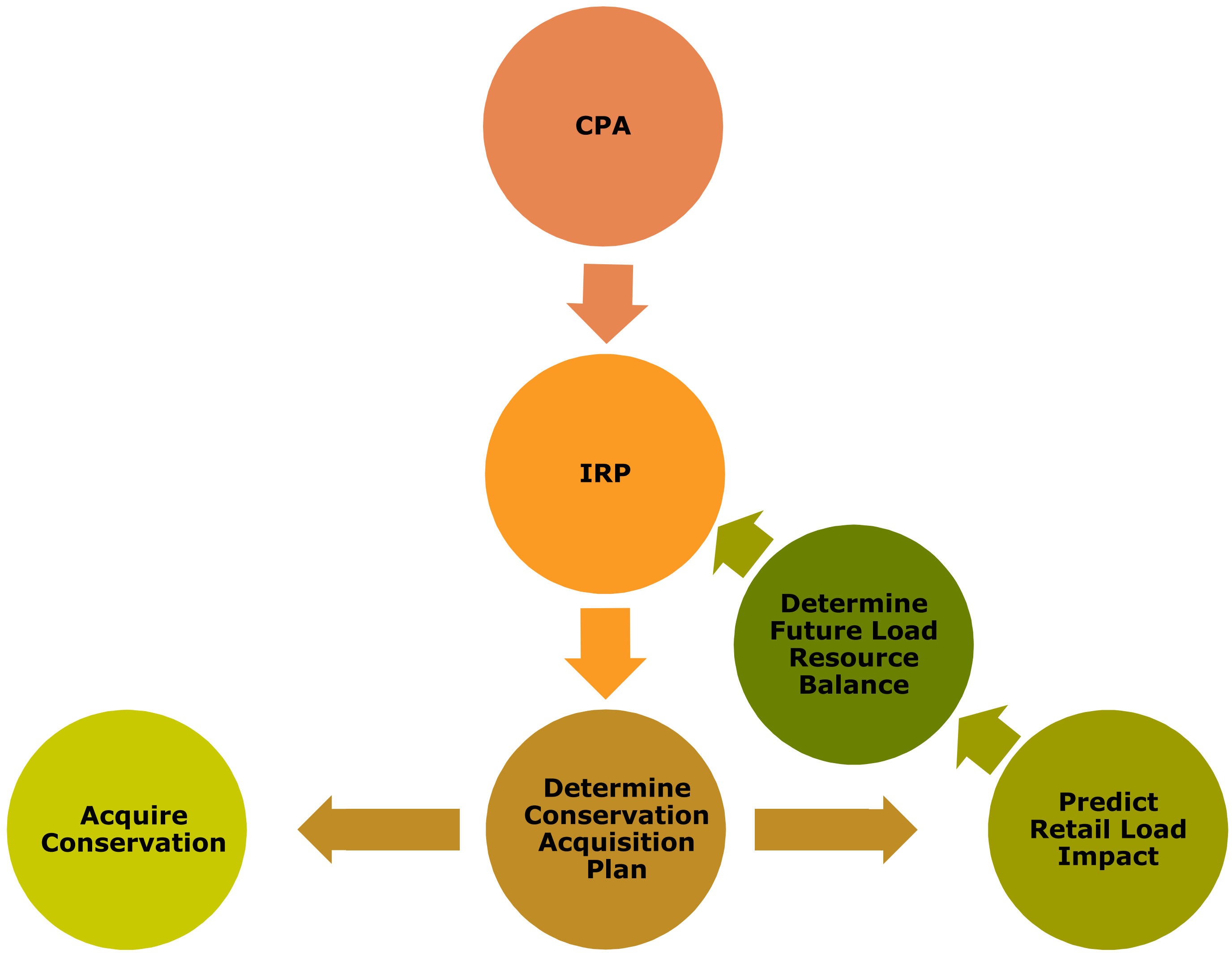
- The Energy Independence Act requires qualifying utilities to determine their conservation potential using "methodologies consistent with those used by the Pacific Northwest Electric Power and conservation planning council" (19.285.040(1)(a) RCW)

- The Energy Independence Act is codified in WAC 194-37 which requires qualifying utilities to establish a:
  - 10-year conservation resource potential every two-years
  - Biennial conservation target that is "no less than its pro rata share of its ten-year potential."

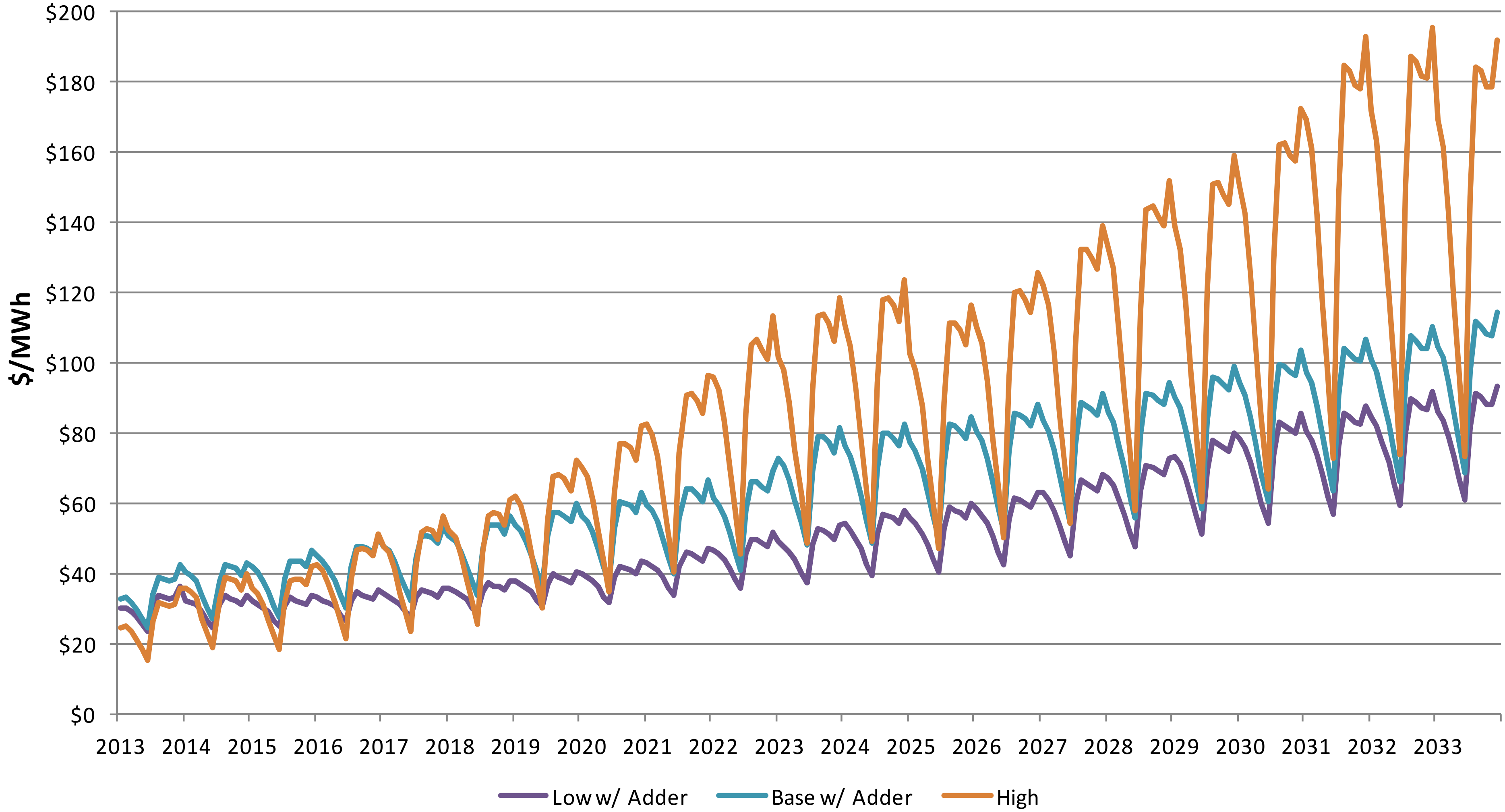
Role of CPAs in Utility Planning

- Used to:
  - determine near-term targets and long-term acquisitions
  - develop program plans and budgets
  - predict retail load impacts
  - determine future load-resource balance

Potential Assessment Life Cycle



Price Forecast with Adders



CPA Process

- Independent assessment conducted by Cadmus
- Among all sectors, 303 unique measures, and 3,186 permutations of those measures
- Data driven analysis using service area customer characteristics
- Incorporates the most up to date information about each conservation measure
- Incorporates the most up to date information about building and equipment requirements.
- Incorporates energy conservation acquired by the utility since the 2010 IRP

DRAFT 10-Year Achievable Potential

Sector	Achievable Technical (aMW)	Cost Effective Range (aMW)	
		Low	High
Residential	28.1	13.2	21.9
Commercial	11.3	6.8	7.6
Industrial	8.9	7.8	8.5
JBLM	N/A	2.7	2.7
Distribution Efficiency	1.5	1.5	1.5
Total	49.8	32.0	42.2

What Caused the Change in Potential?

Recent accomplishments impact remaining achievable potential

- From 2012 – 2013 (projected) we will acquire 12.6 aMW of conservation
- Recent new construction savings of 2.0 aMW does not decrease remaining achievable

Incorporates updated savings assumptions since the 6th Plan

Additions (aMW)	Subtractions (aMW)
Street Lighting (0.5)	Residential Lighting (1.5)
Ductless Heat Pump (2.2)	Heat Pump Water Heater (1.7)
Distribution Efficiency (1.6)	
Other Measures (1.6)	

How data is used

- Try different ramps
- Measure choices
- What is most cost effective and beneficial to the utility
- That work is underway right now
- Minimize risk, maximize value
- Input to modeling
- On of the objects of the entire IRP process will inform/recommend target to propose to the Public Utility Board

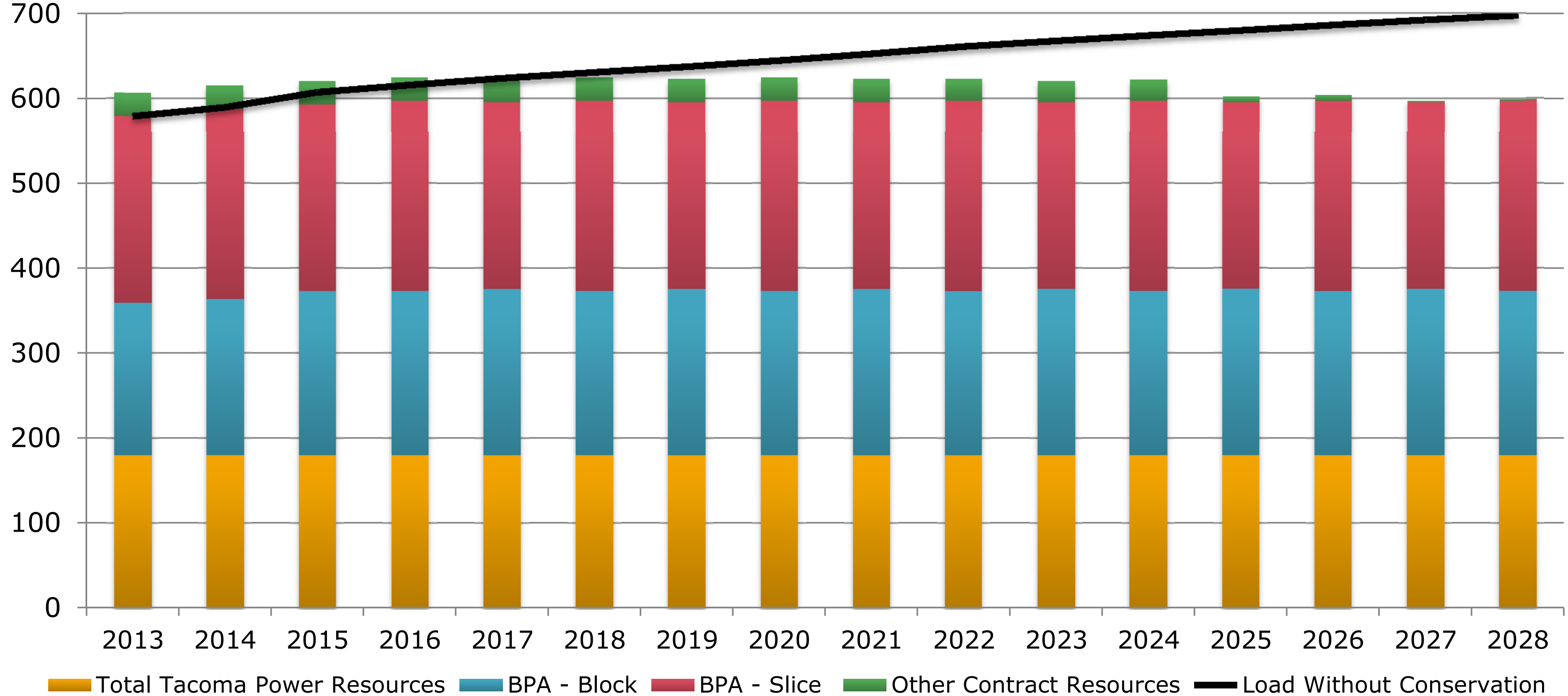
Next Steps

- IRP modeling conservation potential impacts
- IRP modeling load forecast
- IRP modeling unique characteristics of each resource
- Development of Conservation Acquisition Plan

Load-Resource Balance & Forecasting the Future

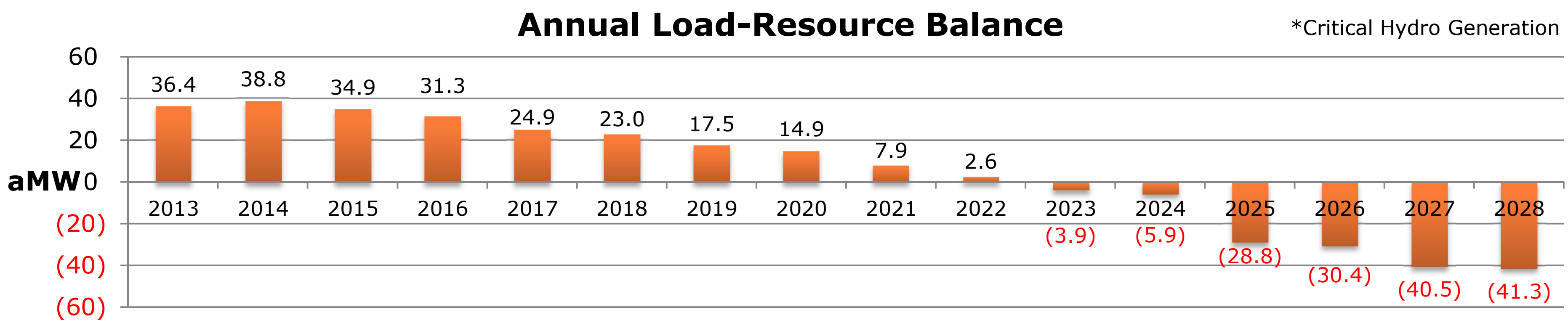
Travis Metcalfe

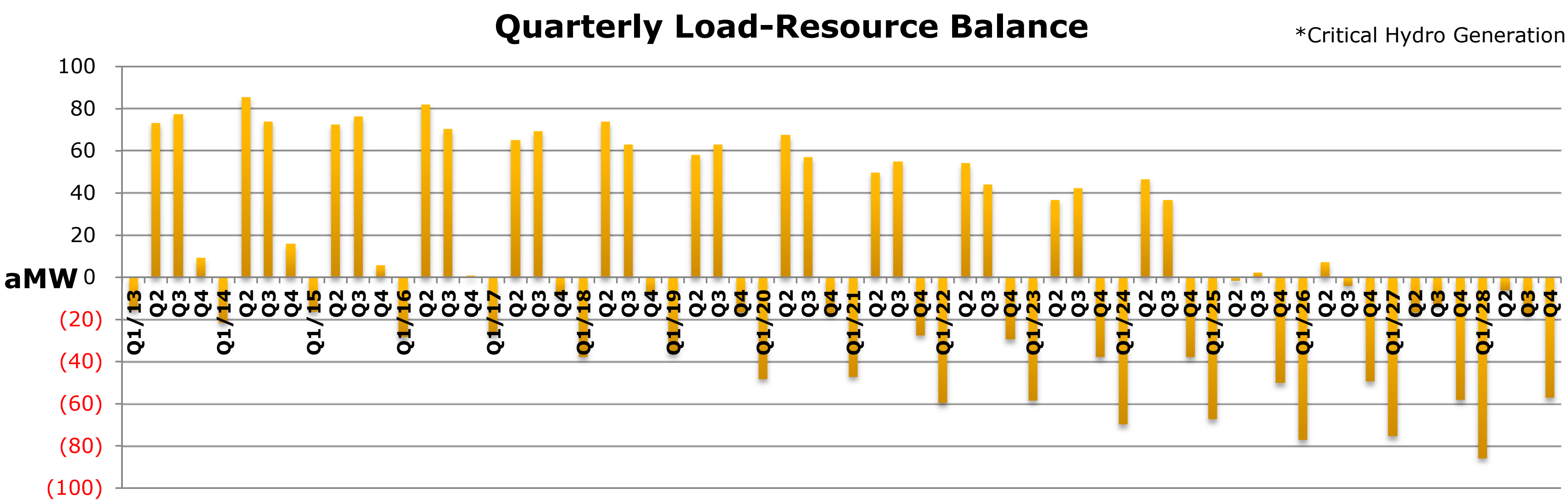
Annual Load-Resource Balance



- Latest Load Forecast and Generation Levels at Critical Water
- 2012 Load Forecast with previous conservation target implies Tacoma Power has annual resource generation sufficient to meet load until 2023

Annual Load-Resource Balance Cont.





* Loads represented with previous Conservation Target

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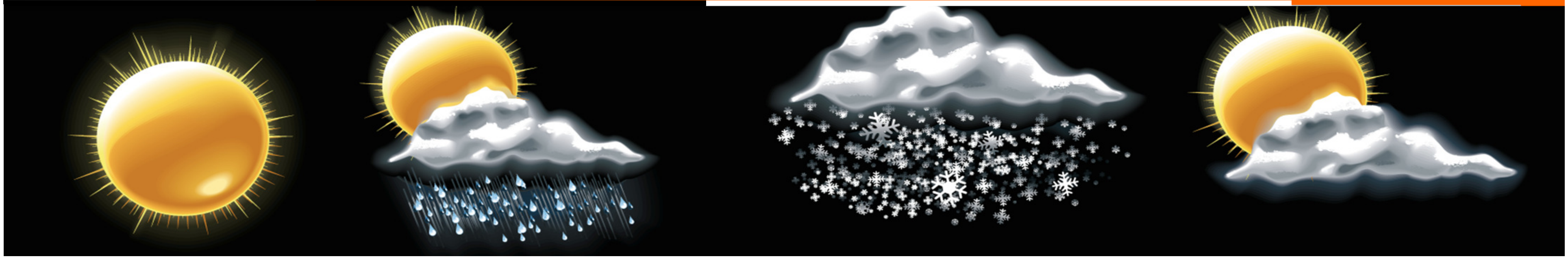
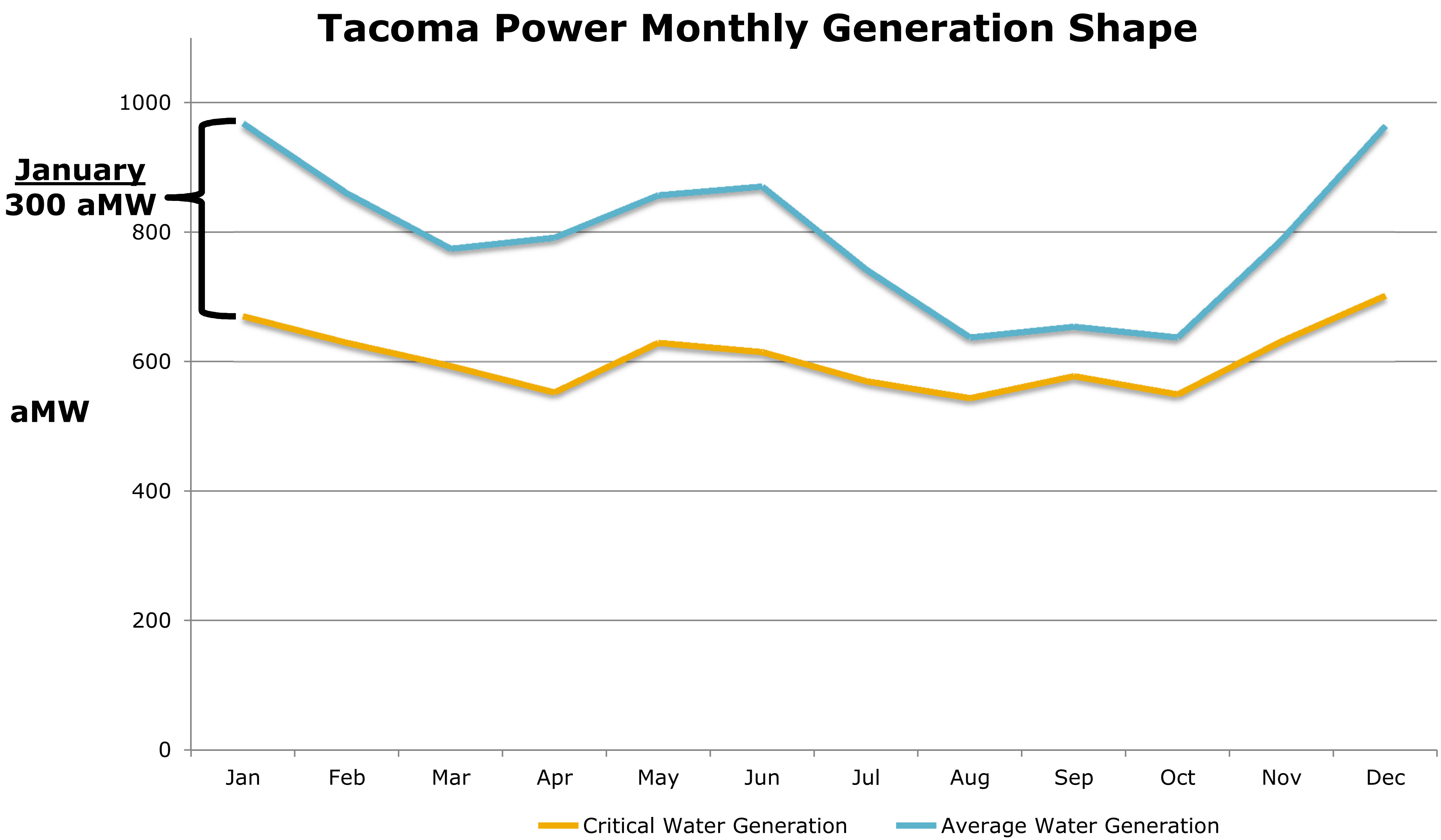
Water Conditions are Different Every Year



- Tacoma Power's generation portfolio is 93% hydro
- This generation capability is heavily influenced by snow pack in the mountains or water levels in reservoirs
- Predicting the weather next week is challenging
  - Predicting the weather in 10 – 15 years, near impossible
- Every day's weather is cataloged and recorded
  - Historical information dating back to 1929
- Historical weather provides a range of possibilities for the future

Generation Uncertainty



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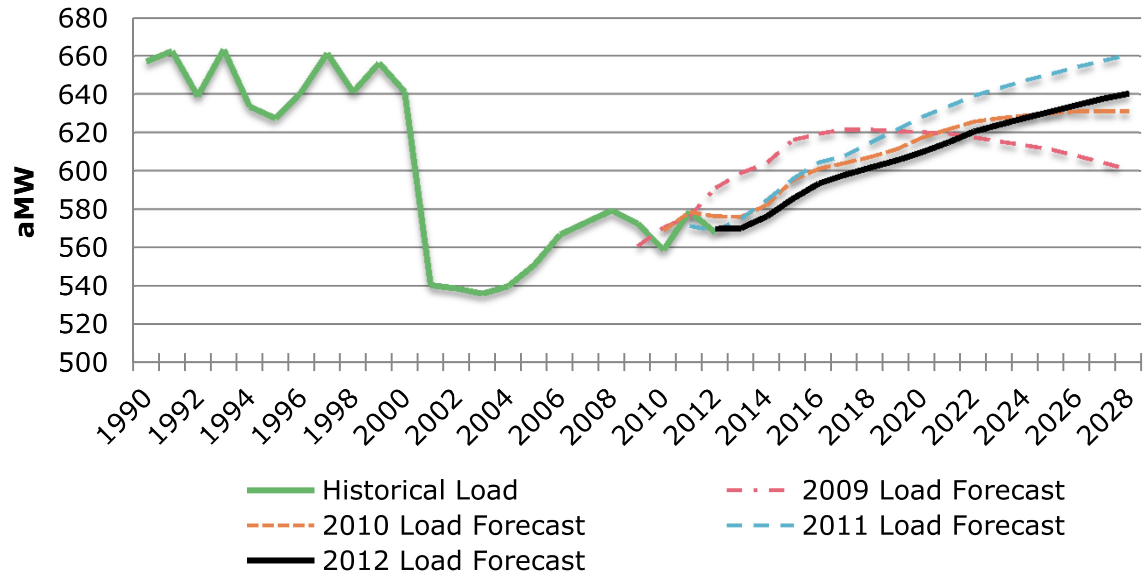
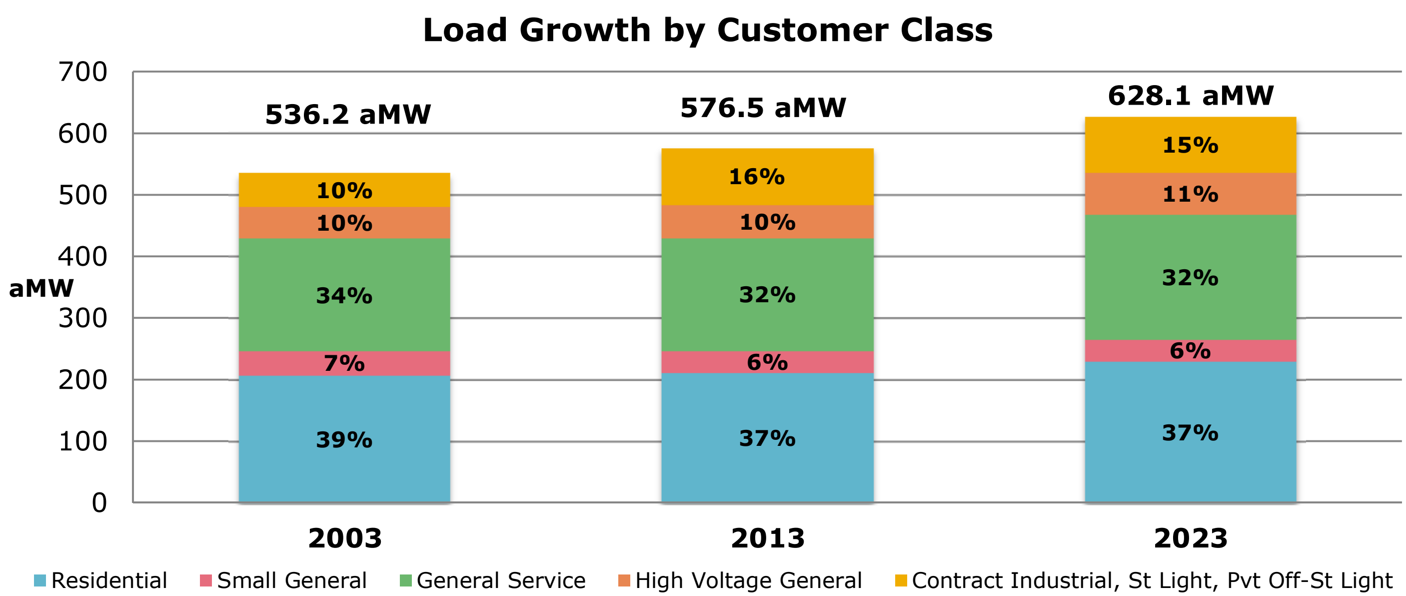
Load Uncertainties

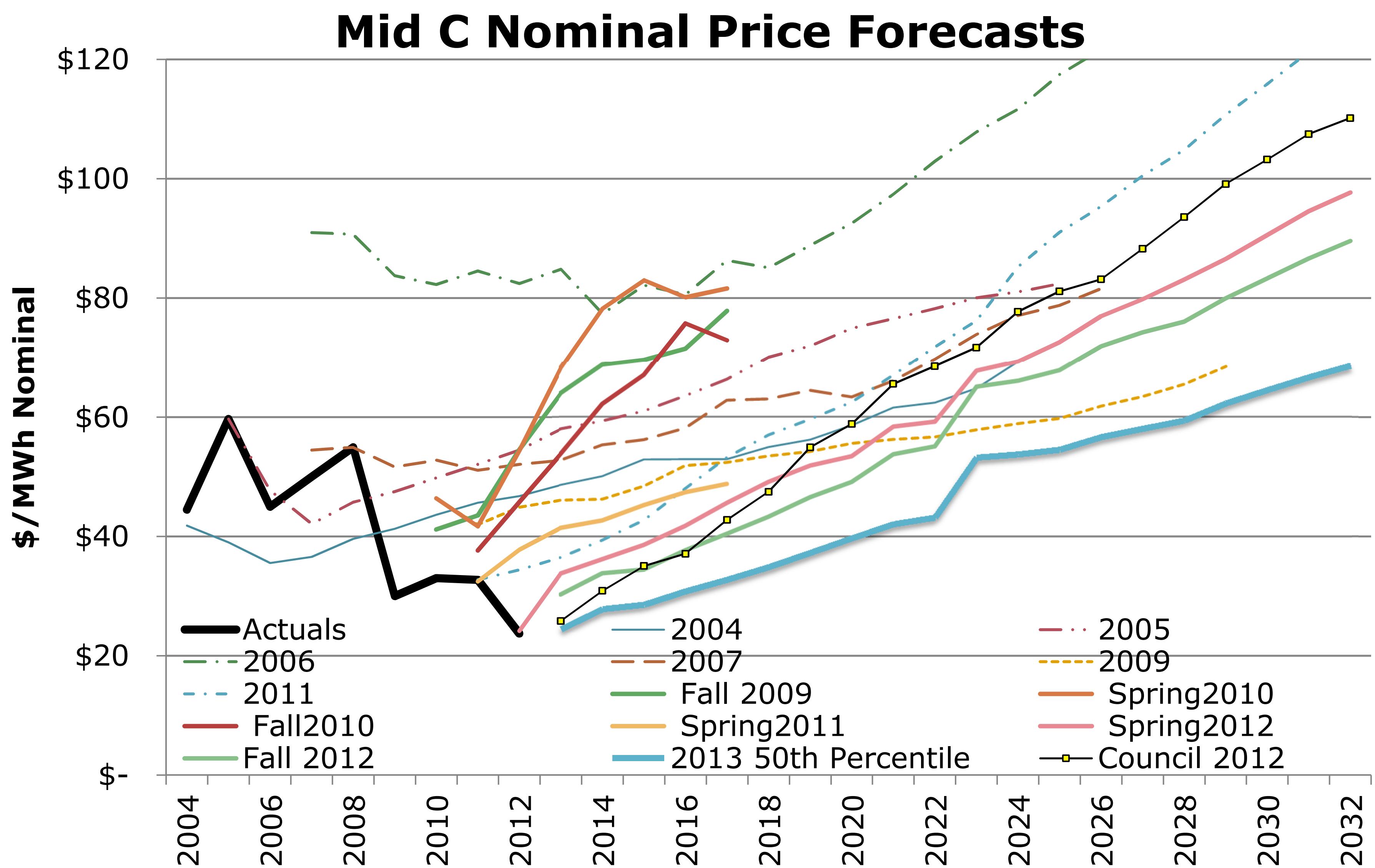
- Load Forecast is updated in June each year
- Hourly Load fluctuates:
  - 2012 – Minimum: 339 MW
  - 2012 - Maximum: 923 MW



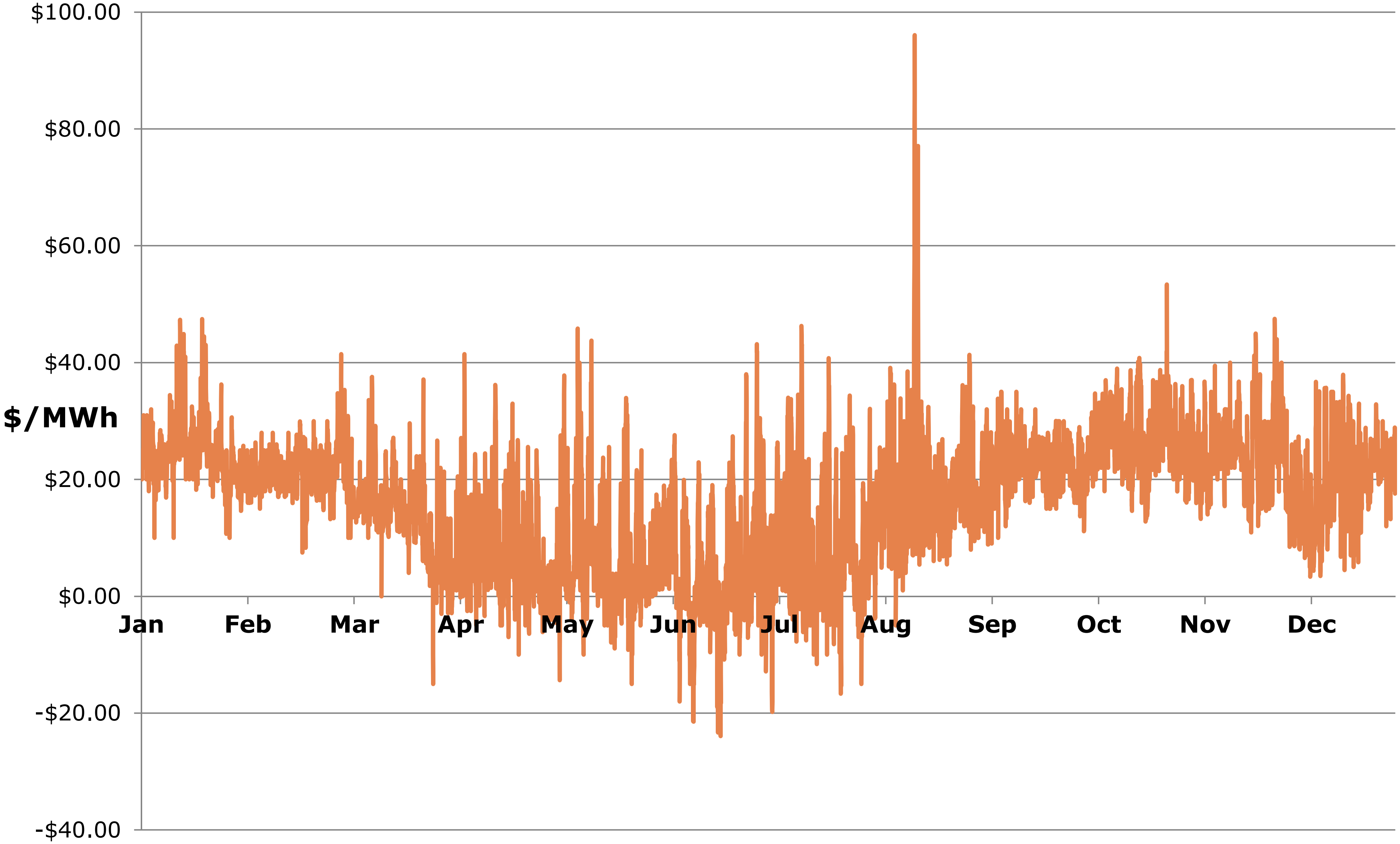


- Loads grow differently in different customer classes
- 2003 Load Forecast for 2013: 630 aMW

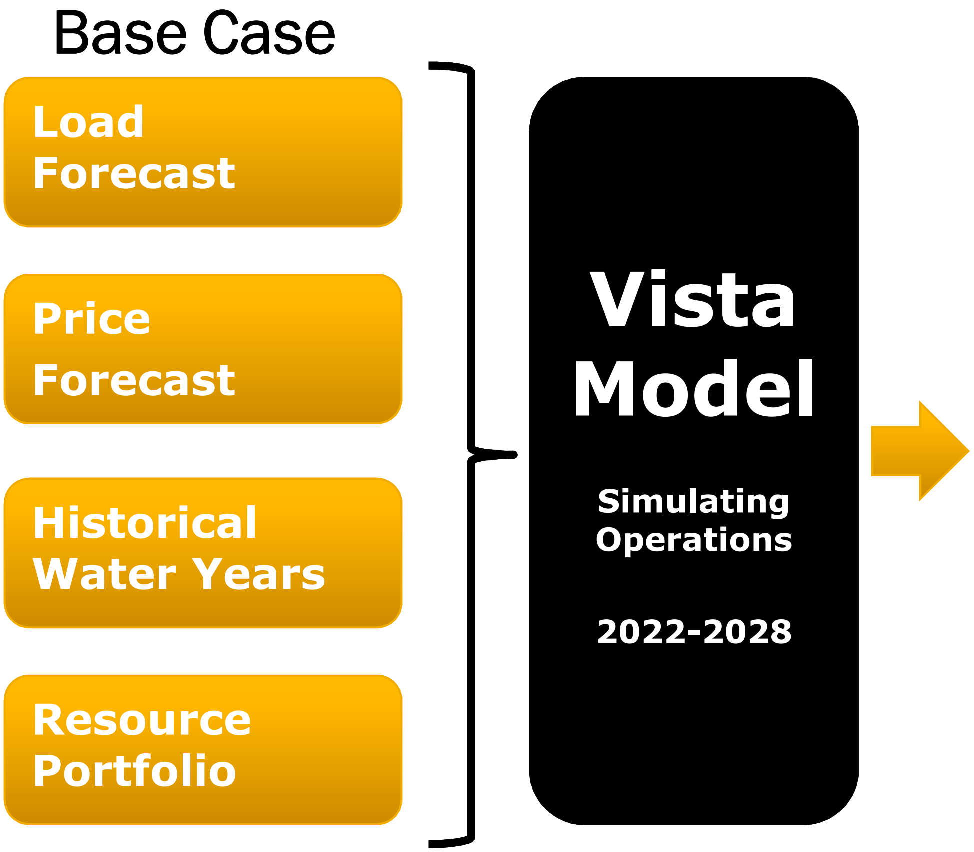
Forecasting Prices



2012 Hourly Mid-C Prices



Modeling Uncertainty in Portfolio Analysis



Model Output

- Simulated Portfolio Operations
  - historical water conditions from 1930-2008
  - forecast load in 2022-2028
  - Prices correlated to water conditions in historical year
- A distribution of Tacoma Power's resource portfolio operations in each of the historical water years
- The number of MWh's sold or purchased throughout the year to balance loads and resources

Modeling Uncertainty in Portfolio Analysis

Scenario Case

- **Higher Load Forecast**
- **Price Forecast**
- **Historical Water Years**
- **Resource Portfolio**

Vista Model

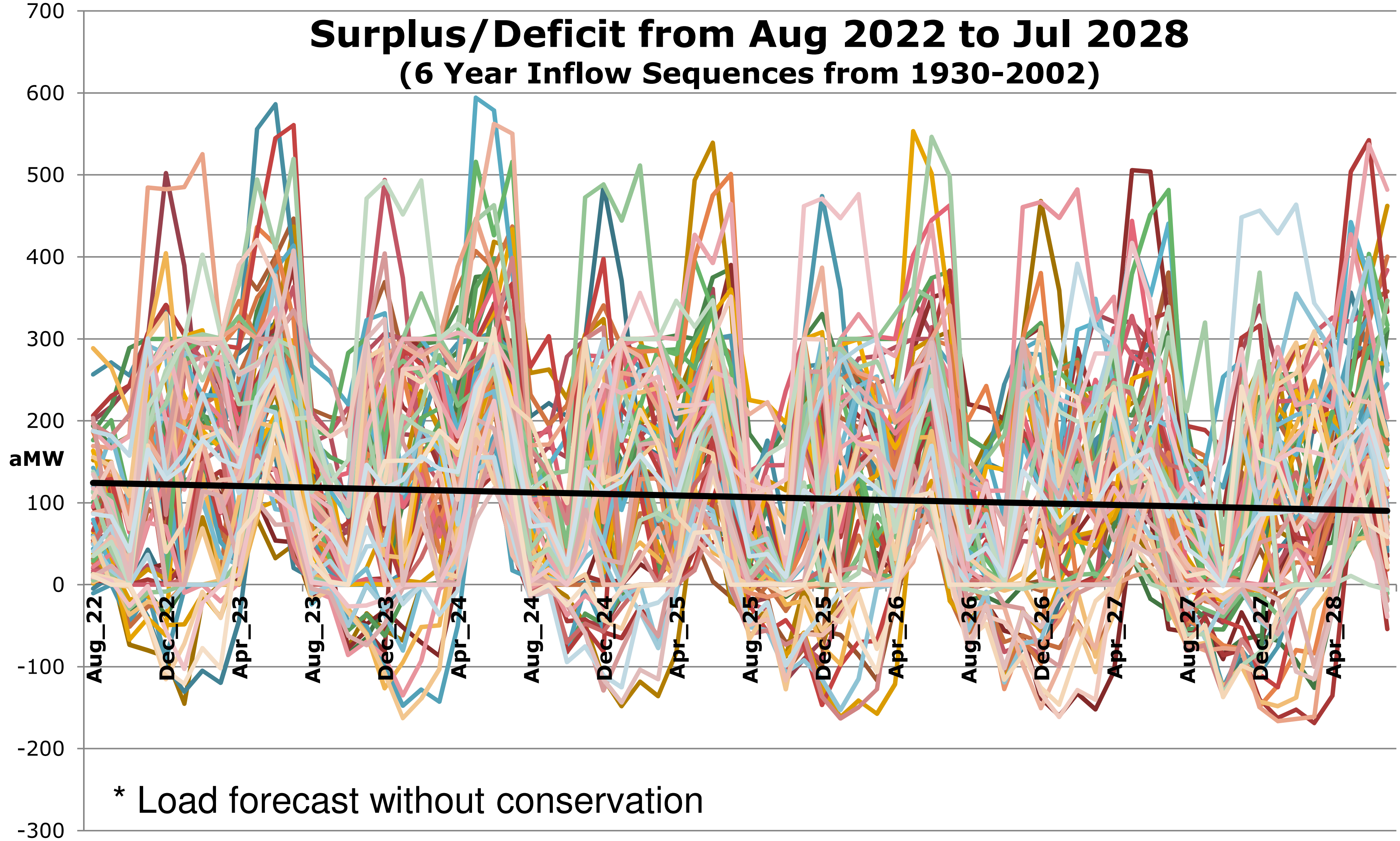
Simulating Operations

2022-2028

Model Output

- Simulated Portfolio Operations
  - historical water conditions from 1930-2008
  - forecast load in 2022-2028
  - Prices correlated to water conditions in historical year
- A new distribution of Tacoma Power's resource portfolio operations in each of the historical water years
- The number of MWh's sold or purchased throughout the year to balance loads and resources

Simulated Portfolio Operations



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Comparing the Costs and Risks

- Analyzing Risks and Reiterating Simulation Model
  - Determine the number of hours that we expect to purchase additional resource supply to serve load
  - Compare water years that result in months or seasons where we are expecting to purchase additional resource supply to serve load
  - Additional modeling for the variability of loads and electric power prices
  - Adjust the resource portfolio with additional resources and reiterate the simulation model
- Compare with the costs and resource options for best serving loads
- Determine the optimal portfolio resource mix that provides a least-cost/least-risk portfolio for Tacoma Power

Additional Resource Considerations

- Sample of Potential New Resources
  - Conservation
  - Demand Response
  - Pumped Storage
  - Biomass
  - Wind
  - Solar
  - Natural Gas Turbines
  - New Technologies
- Sample Risk Factors
  - Environmental Attributes
  - Dispatch ability
  - Availability
  - Resource Shape
  - Fuel Source
  - Capital and O&M Costs

Next Steps

- Next Meeting will take place in September
  - Final Load Resource Balance
  - Conservation Acquisition Plan
  - Results of Portfolio Modeling
  - Update on I-937 Compliance Strategy
  - Draft Action Plan
  - Draft of 2013 Integrated Resource Plan
- Any Questions:

Travis Metcalfe

tmetcalfe@cityoftacoma.org

(253) 502-8149

- Thank you all for your time today and your input into our process!

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2013 IRP

Stakeholder Presentation 3

October 14, 2013

Welcome & Introductions

- Manager of the 2013 IRP

  Travis Metcalfe

  tmetcalfe@cityoftacoma.org

  (253) 502-8149

- Welcome from Nicolas Garcia, Assistant Power Manager

- Stakeholder Introductions
  - Name
  - Whom you are representing

What we plan to cover today

- Overview of our Objective and Process for 2013
- Load Resource Balance
- Portfolio Modeling Process & Results
- Conservation Potential and Target
- I-937 Compliance Strategy
- Draft Action Plan for 2013 IRP

2013 IRP Focus

- Questions to be addressed through analysis, discussion, and development of the 2013 IRP Action Plan
  - How much Conservation should Tacoma Power pursue in the 2014/2015 time period in order to:
    - Mitigate future risk and uncertainties
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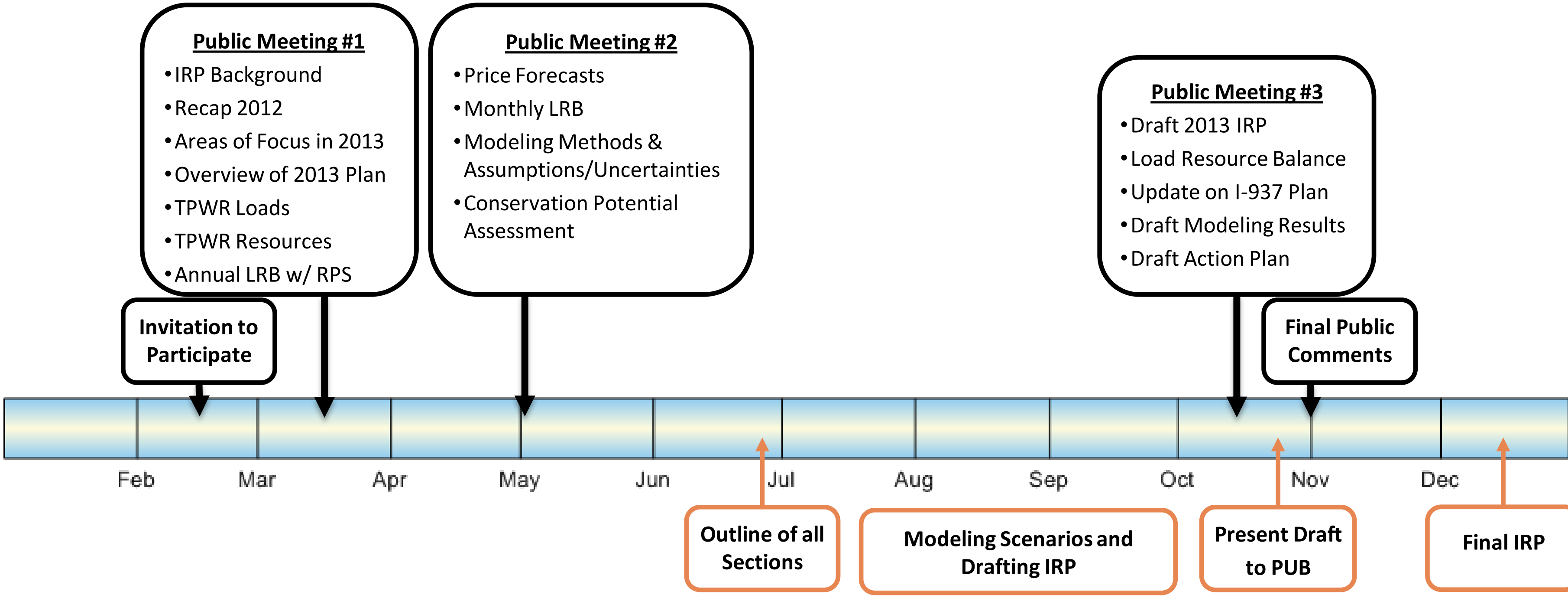
2013 Public Involvement Timeline

Public Involvement Events

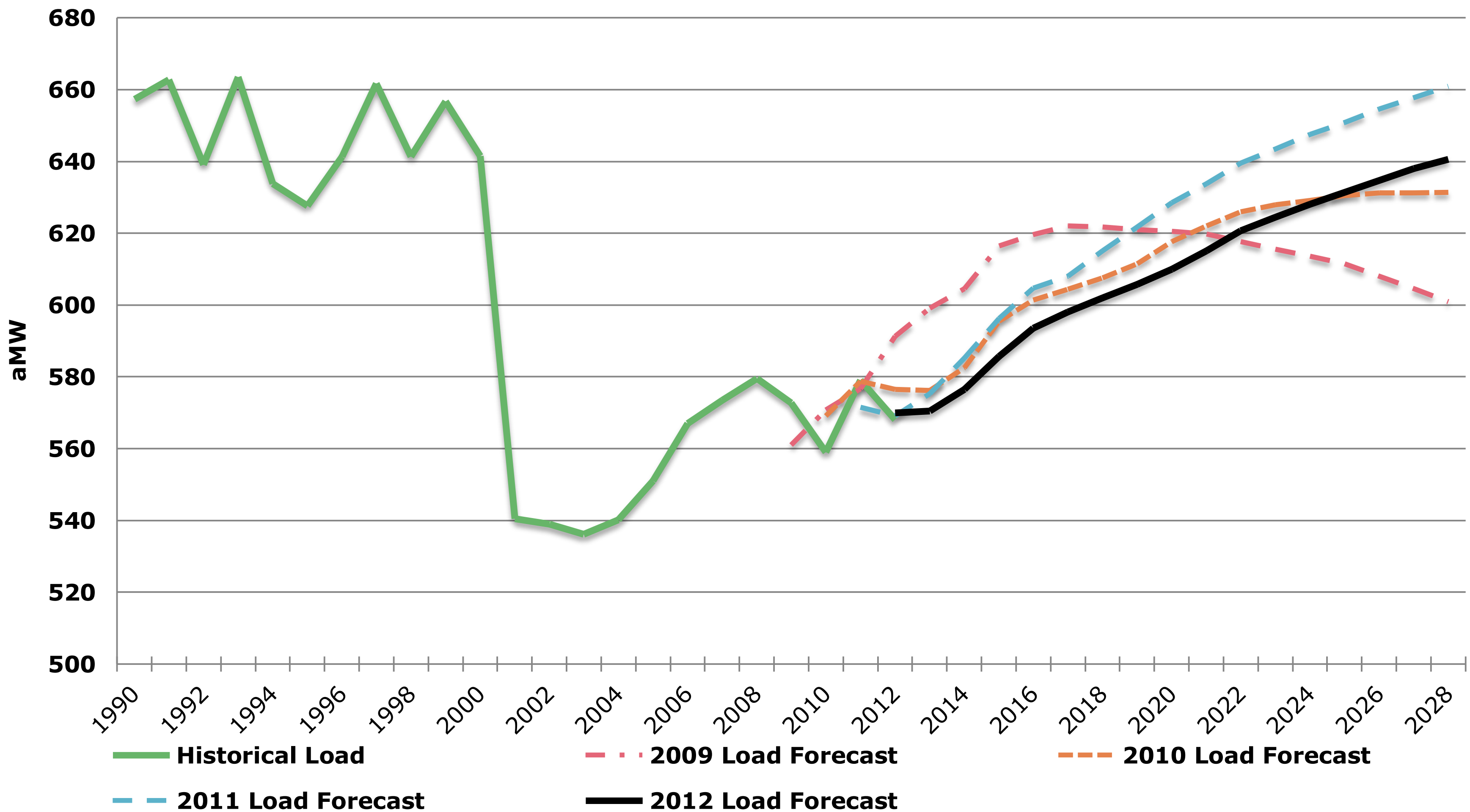


Internal Development Milestones

IRP Statutory Due Date: September 1, 2014

Load-Resource Balance & Portfolio Modeling

Annual Historical Load and Load Forecasts



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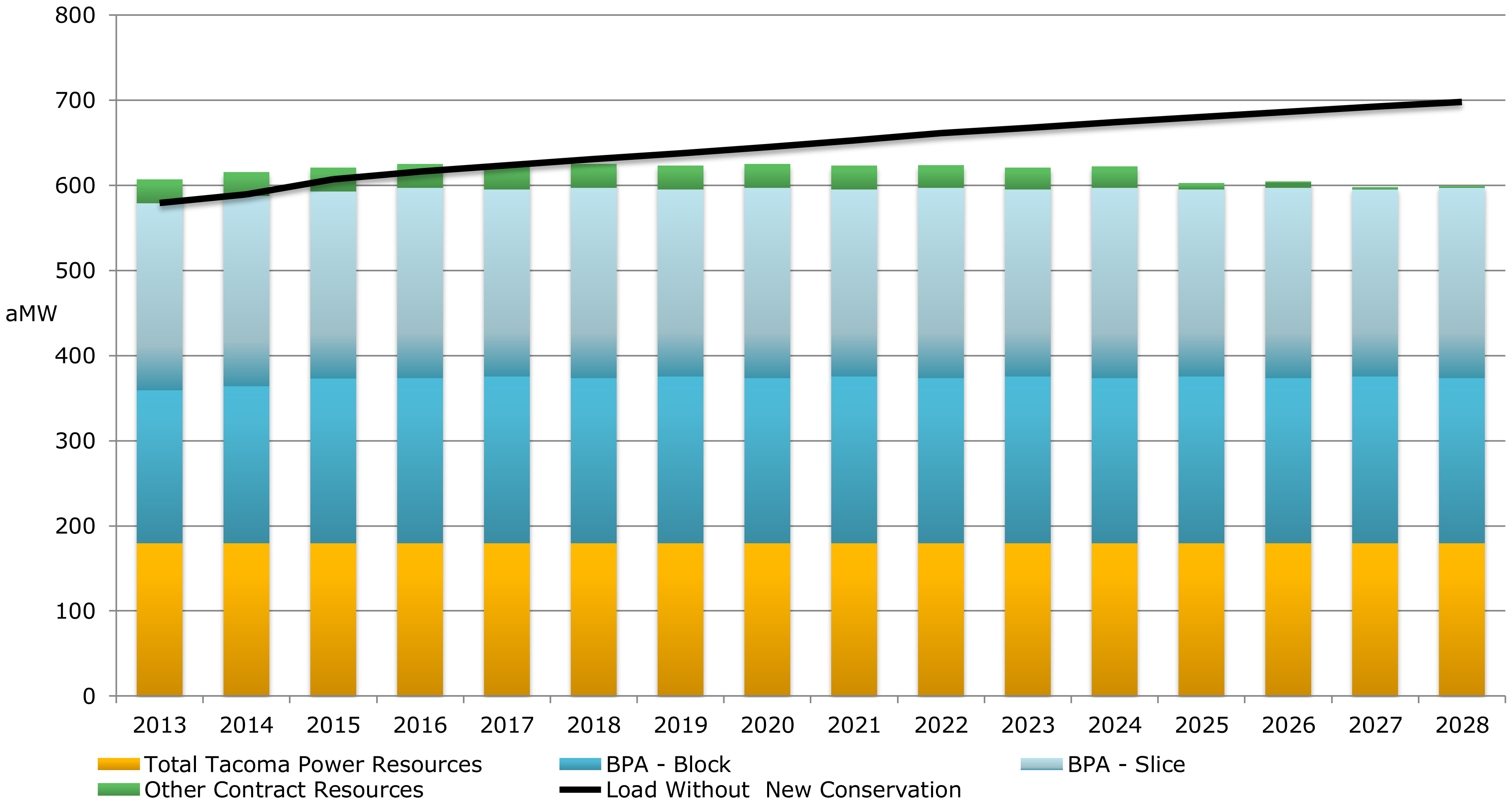
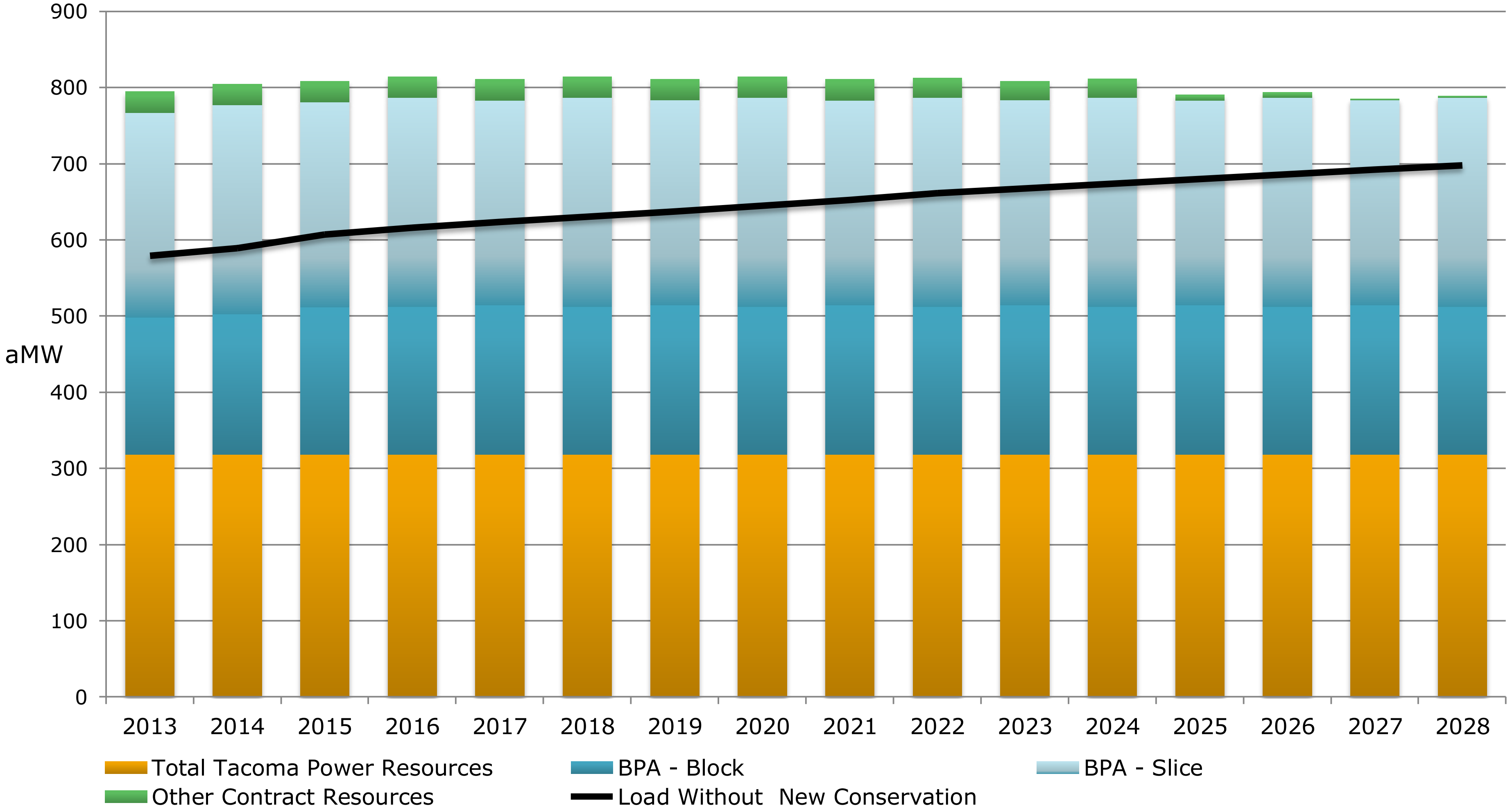
Annual Load-Resource Balance (Critical)



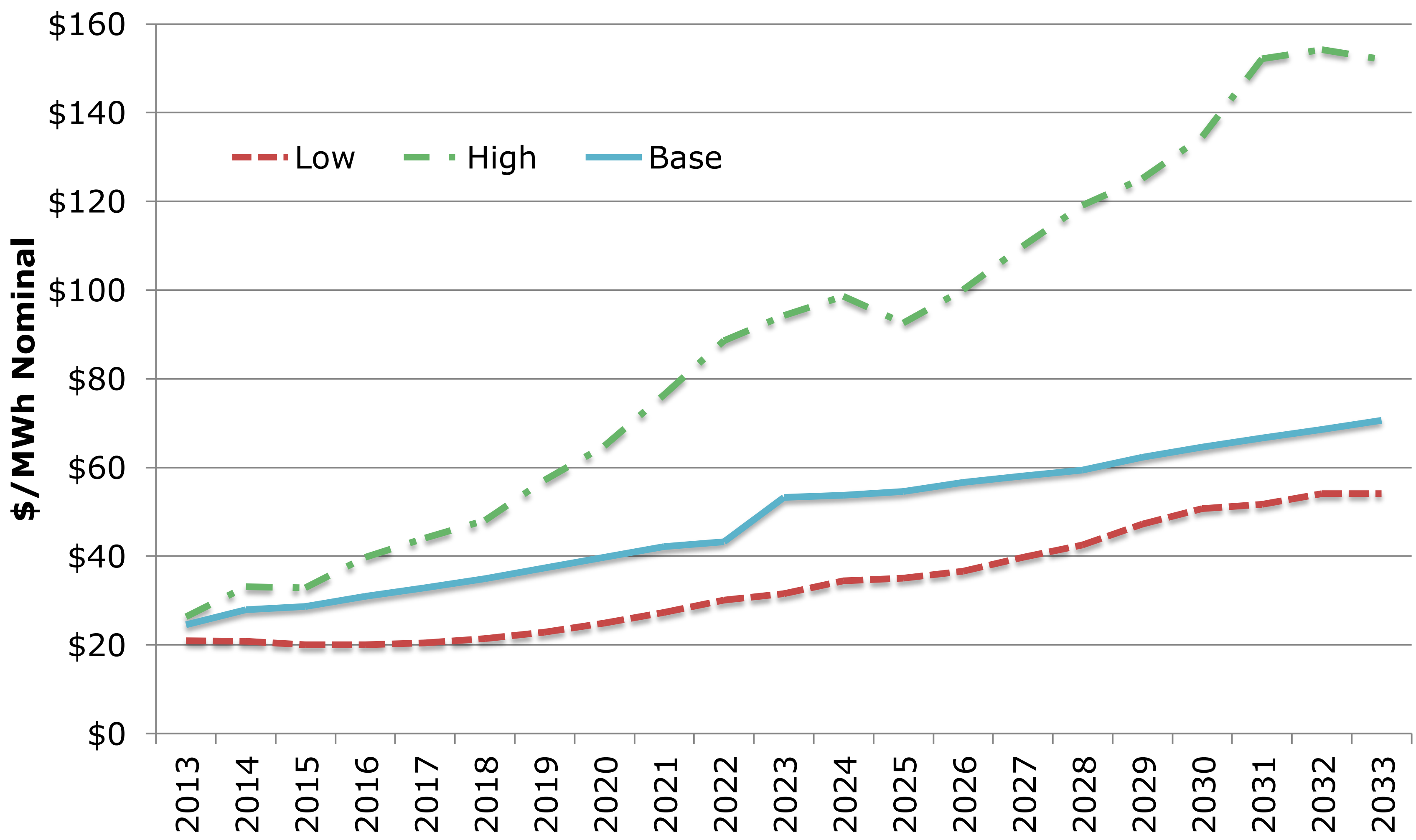
- Generation Levels at Critical Water

Annual Load-Resource Balance (Average)



- Generation Levels at Average Water

2013 Wholesale Price Forecast



Alternative Resource Selection Process

Alternative Resource Options

- Hydroelectric Generation
- Conservation
- Wind
- Solar/Photovoltaic
- Biomass
- Natural Gas SCCT & CCCT
- Geothermal
- Demand Response
- Distributed Generation
- Ocean Energy
- Bloom Energy
- Fuel Cells
- Nuclear
- Coal

Screening Criteria

- Statutory Mandates
- Compatibility with Portfolio
- Environmental Needs
- Cost
- Resource Flexibility
- Portfolio Diversity
- Reliability
- Control/ Ownership/ Location

Resulting Alternatives

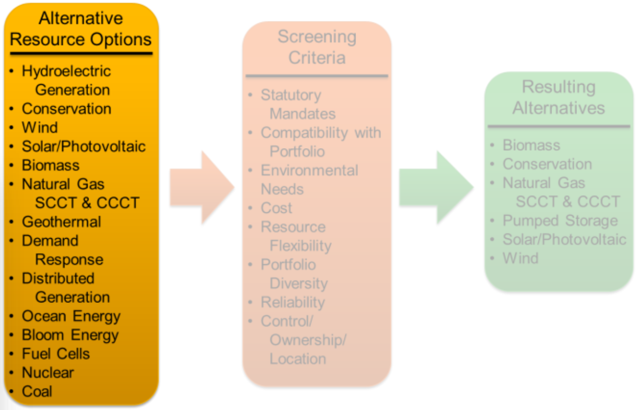
- Biomass
- Conservation
- Natural Gas SCCT & CCCT
- Pumped Storage
- Solar/Photovoltaic
- Wind

Alternative Resource Options

Conservation
(Ductless Heat Pump)

(Lighting)

Solar

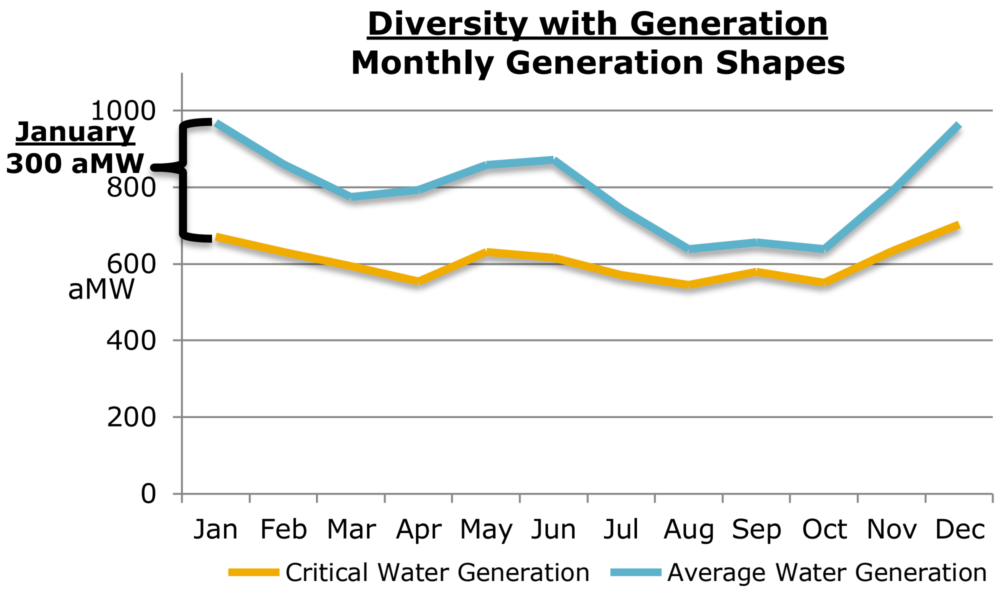


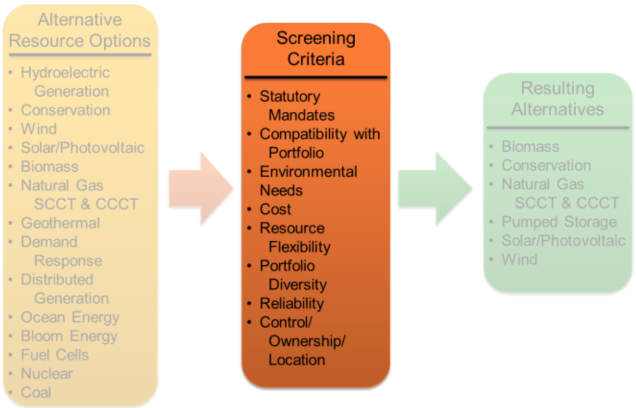
Pumped Storage

Wind

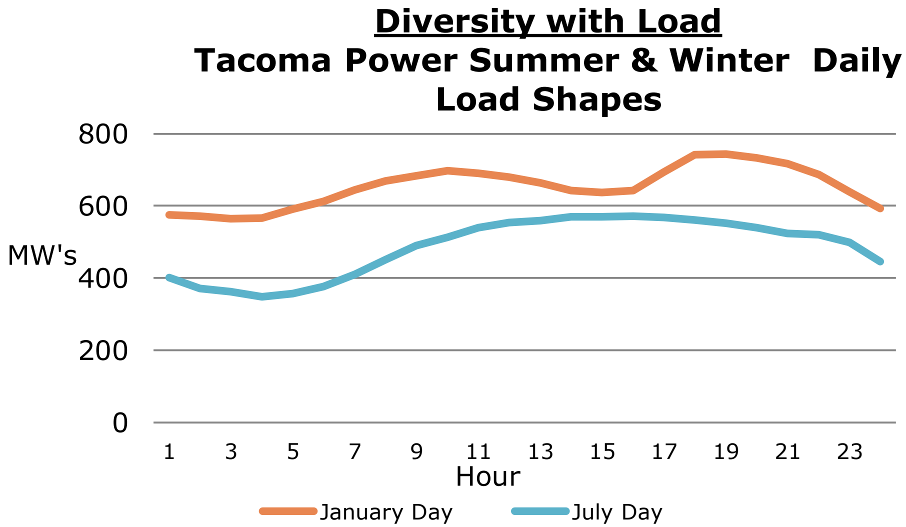
Bloomenergy

Screening Criteria



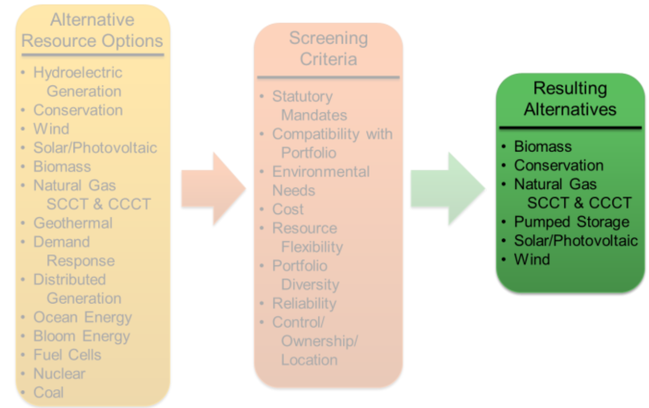


- Mitigate Risks
- Limit Costs

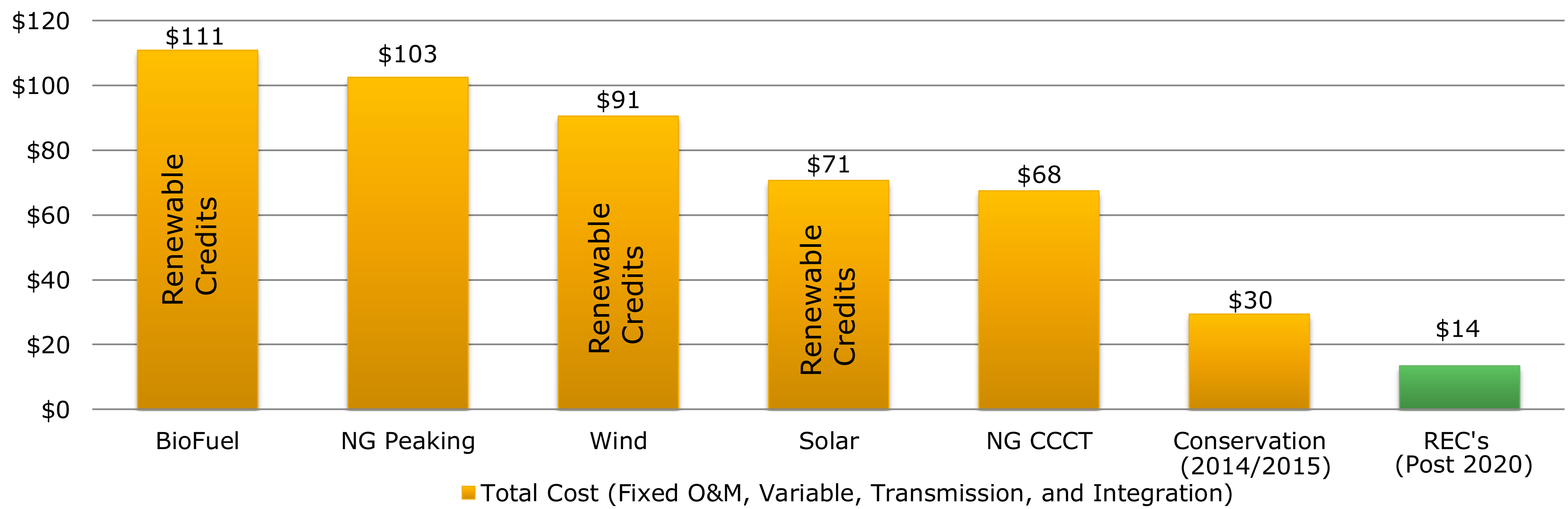


Resulting Alternative Resources for Analysis

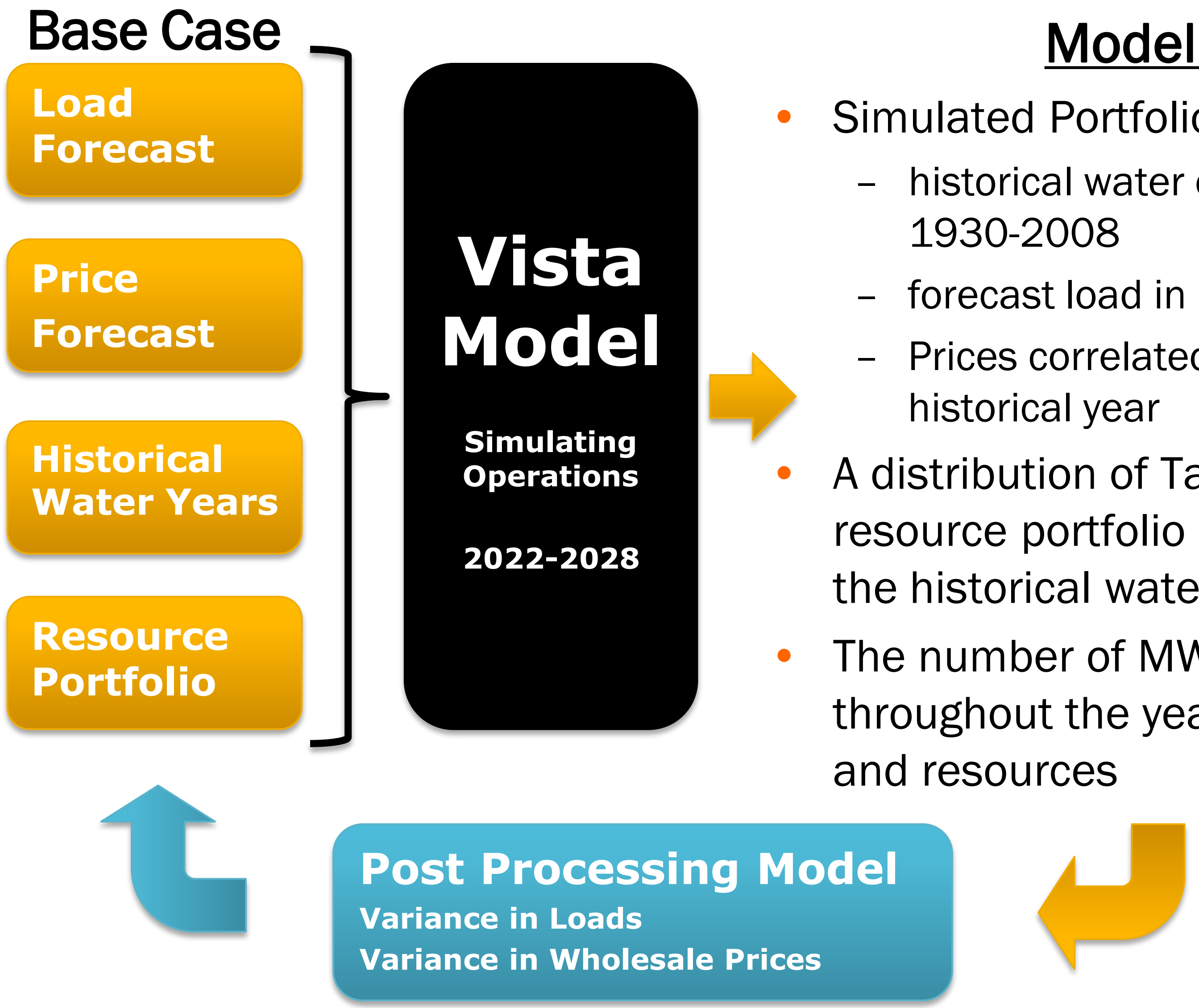
- 2012 Notable Price Point Comparisons
  - Tacoma Power Production Cost of Portfolio: $20.18/MWh
  - Average Mid-Columbia Market Price: $19.24/MWh



Levelized Cost of Resource Alternatives ($2013)



Modeling Uncertainty in Portfolio Analysis



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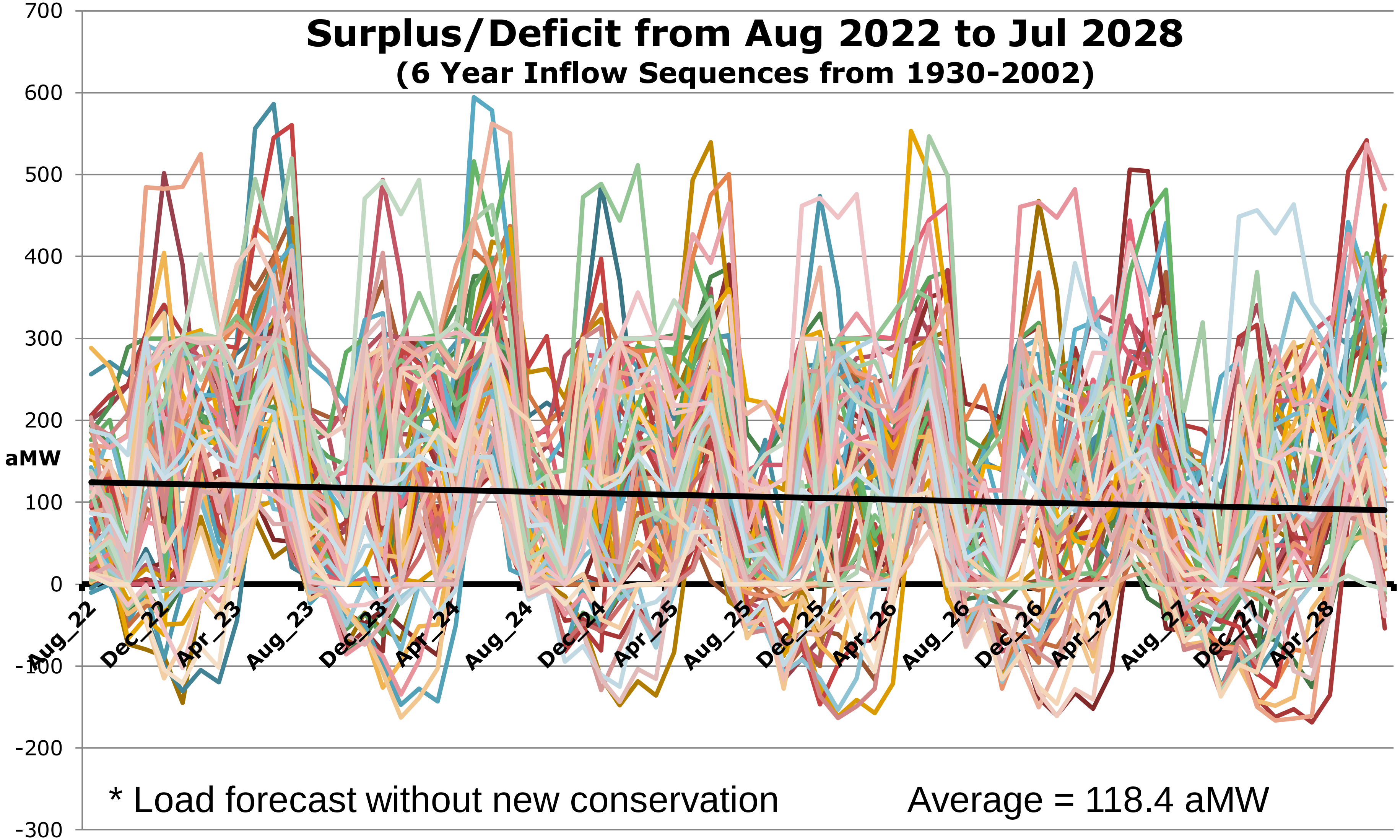
- The number of MWh's sold or purchased throughout the year to balance loads and resources

Simulated Portfolio Operations



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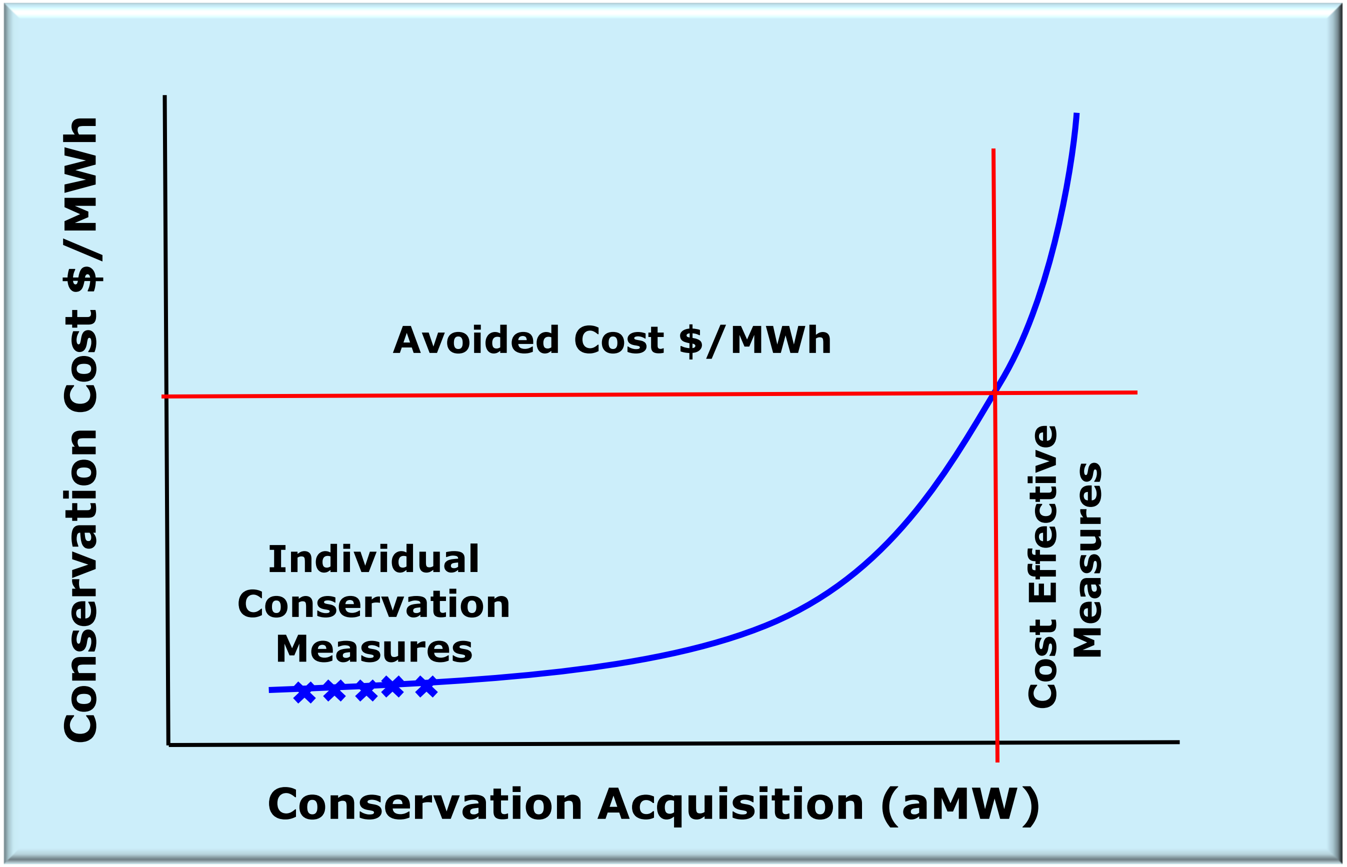
Conservation Potential and the 2014-2015 Target

Rich Arneson

Conservation Potential Assessment

- Study done as part of the Integrated Resource Plan
- Determined Tacoma's 10-year, 15-year conservation potential, and 2-year conservation target
  - Utility Service area specific customer data
  - Economic activity and building types
  - Current technology assumptions
  - Enables useful, relevant, detailed conservation planning
  - Consistent with NWPCC methodologies

Conservation Supply Curve Illustration



2013 Conservation Potential Assessment

- A 10-year total cost effective and achievable conservation potential of **40.5 aMW**
- A 15-year total cost effective and achievable conservation potential of **59.5 aMW**

- Most Significant Measures
  - Residential Ductless Heat Pumps
  - Commercial Lighting
  - Industrial Energy Management
  - Residential Windows
  - Residential Insulation
  - Residential Plug Loads
  - Industrial Pumps
  - Industrial Fans and Blowers
  - Industrial Compressed Air
  - Commercial Plug Load

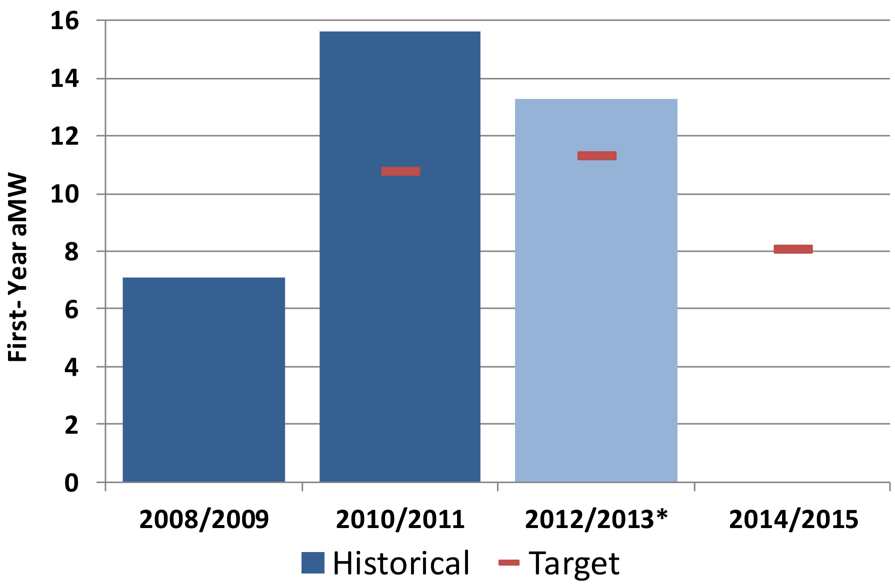
Changes Since 2010

- 2010 CPA 10-Year economic achievable potential: 56.7 aMW

Major Additions +12.4 aMW	Major Subtractions -29.3 aMW
Ductless Heat Pump +8.6	Conservation Acquired -18.0
Distribution Efficiency +1.5	Federal Standards -7.0
Street Lighting +0.7	Heat Pump Water Heater -1.8
Other Measures +1.6	Residential Lighting -1.5
	Washington Codes -1.0

- Conservation Acquisition is the biggest reason for a lower target
- 2013 CPA 10-Year economic achievable potential: 40.5 aMW
  - 2014/2015 Biennial Target: 8.1 aMW

Recent Conservation Accomplishments



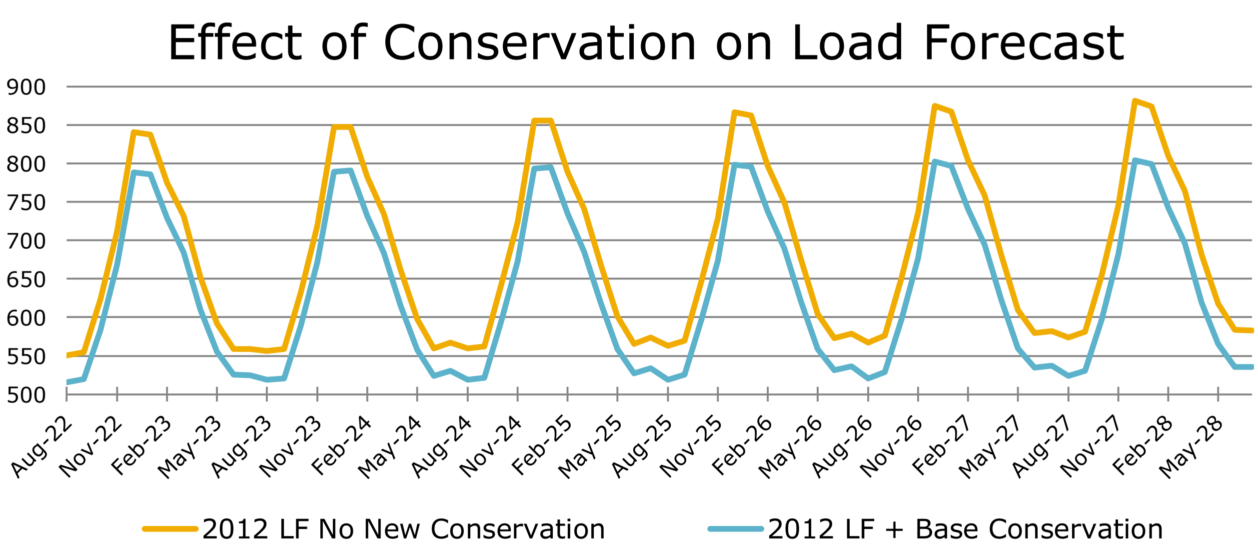
*Expected acquisition for 2012/2013.

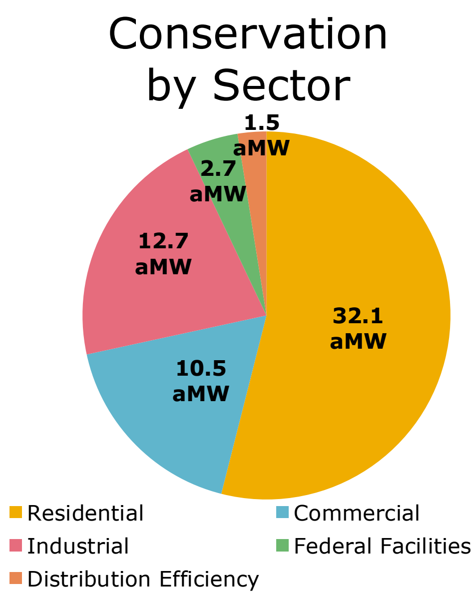
- From 2007 to date, we acquired nearly 34 aMW
- Exceeded targets in 2010/2011 and 2012/2013 bienniums
- 2014/2015 target = 8.1 aMW

Portfolio Analysis

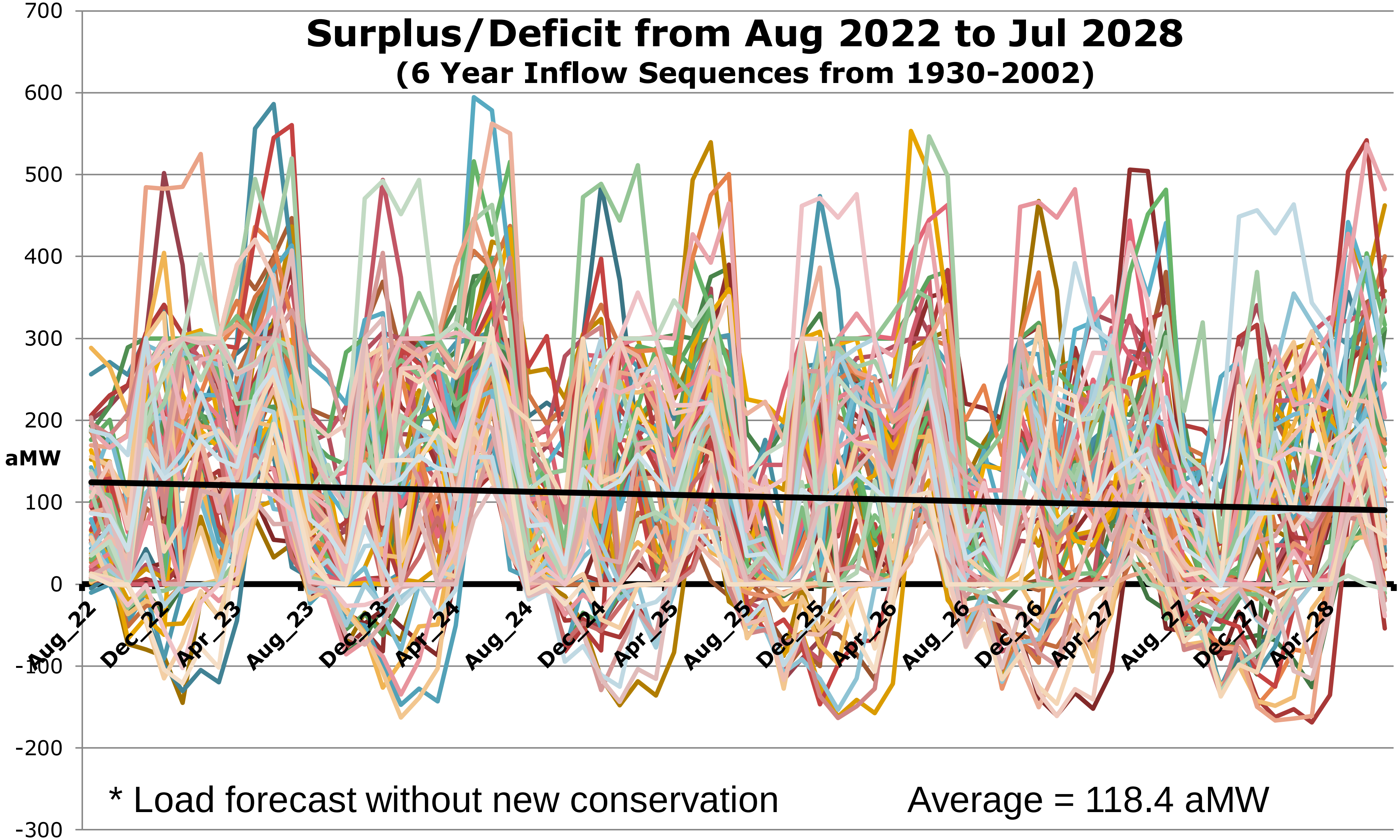
Establishing the Base Case

- Resource Portfolio with changes between now and 2028
- Adjusting Load Forecast to reflect the addition of 15-year cost effective Conservation: 59.5 aMW





Simulated Portfolio Operations



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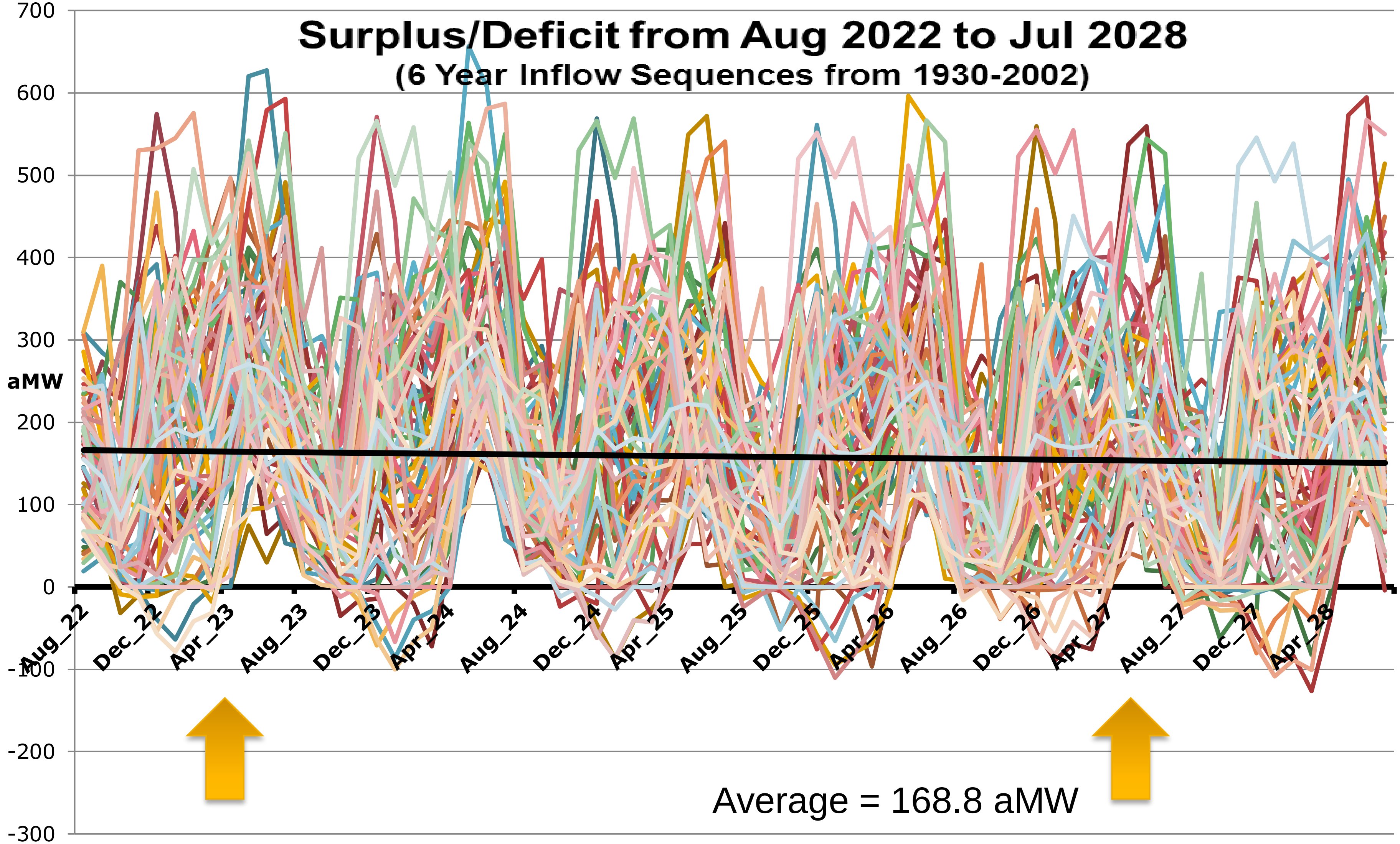
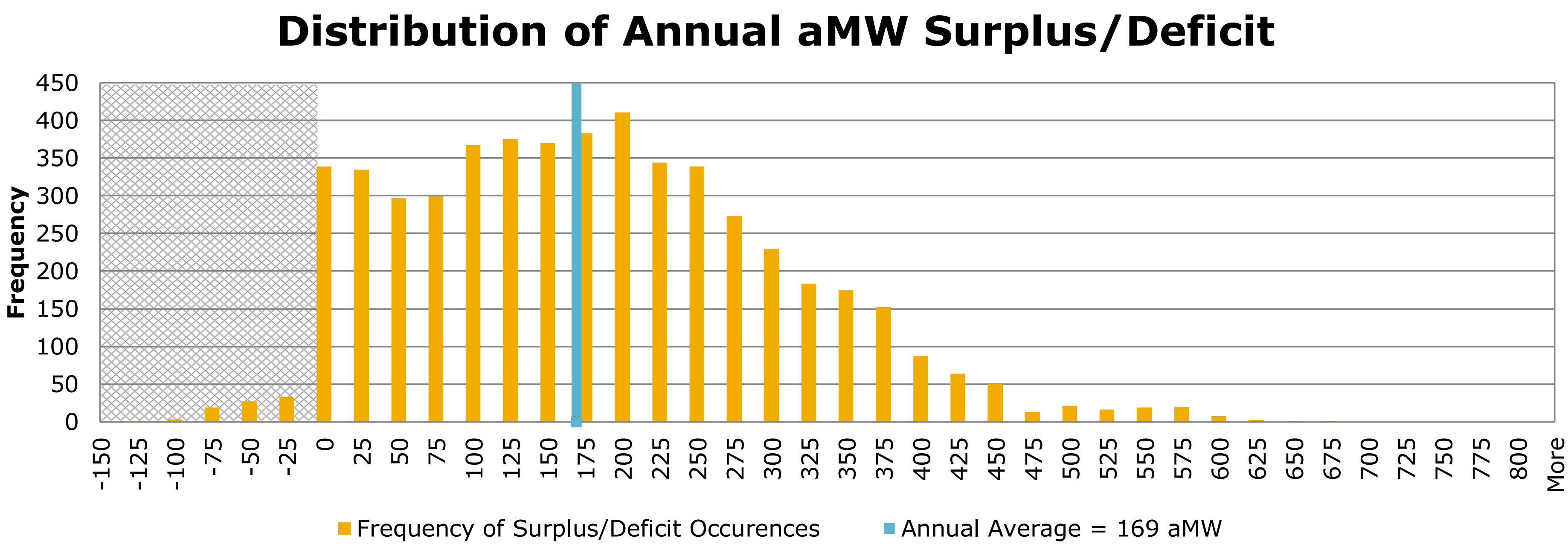
Base Case Portfolio Simulation

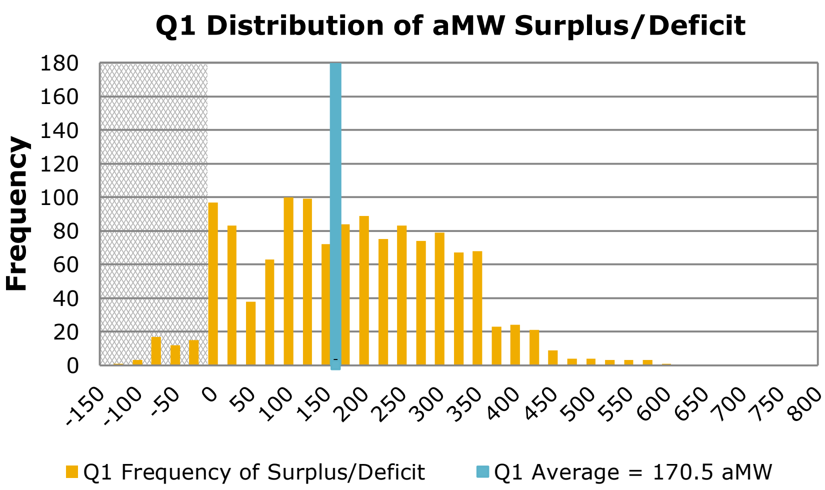


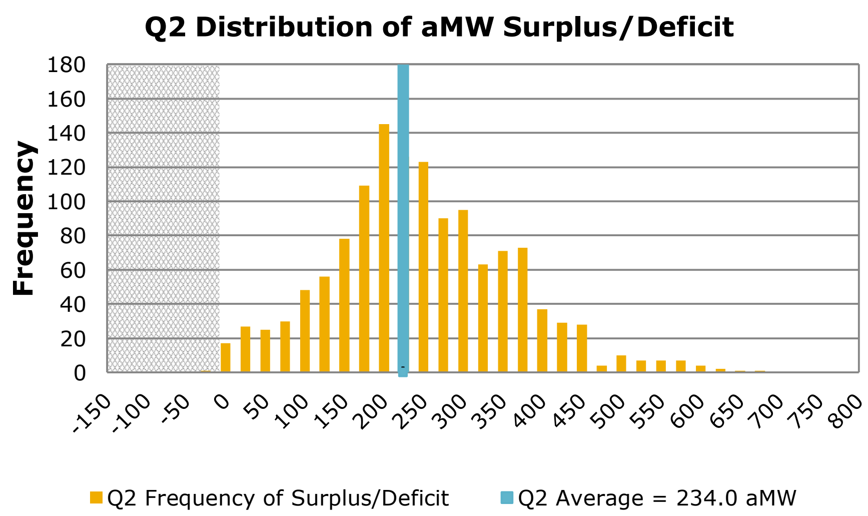
Base Case Annual Analysis

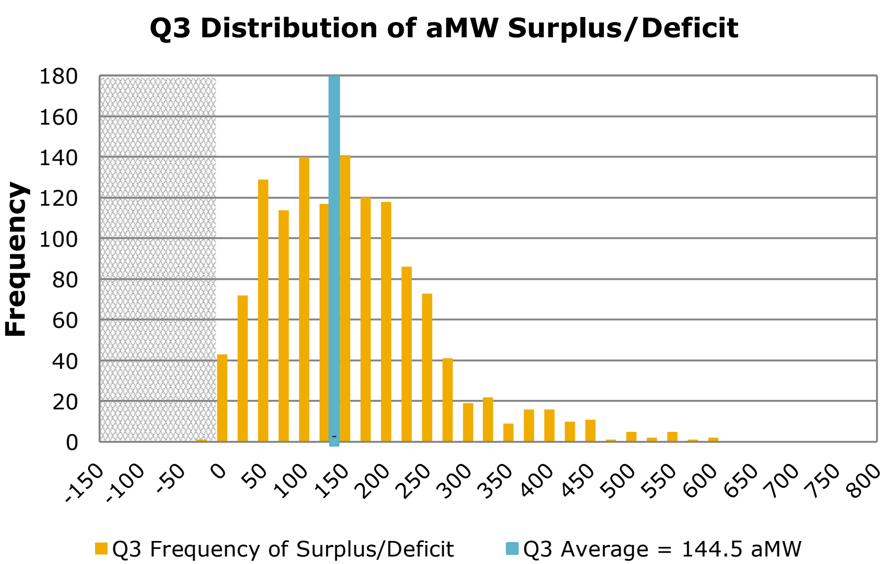


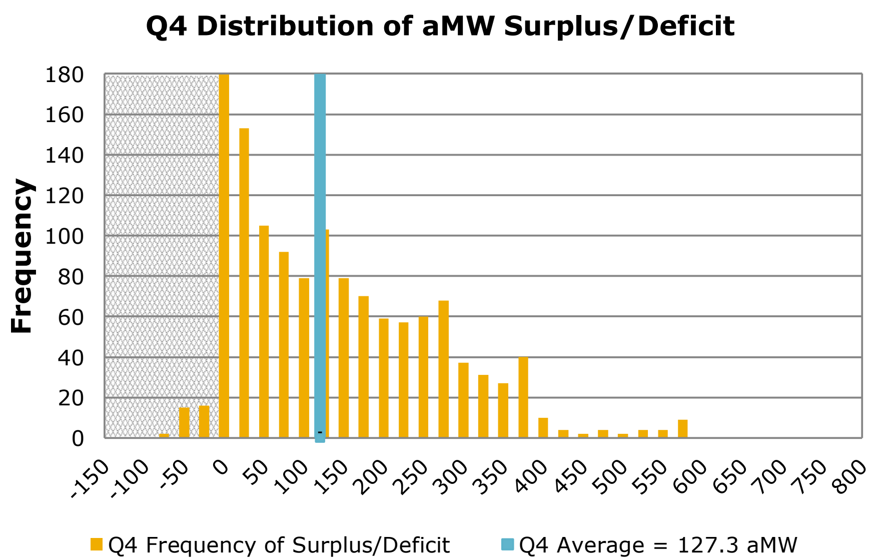
- Average of 169 MW's surplus between 2022-2028
- Very low probability of being deficit
  - Surplus in 96% of historical water conditions
  - Quantity and magnitude of the deficits are small
- Ability to purchase from Wholesale Power Market for shortages
- Manage surplus through Wholesale Energy Risk Management Program

Base Case Quarterly Analysis

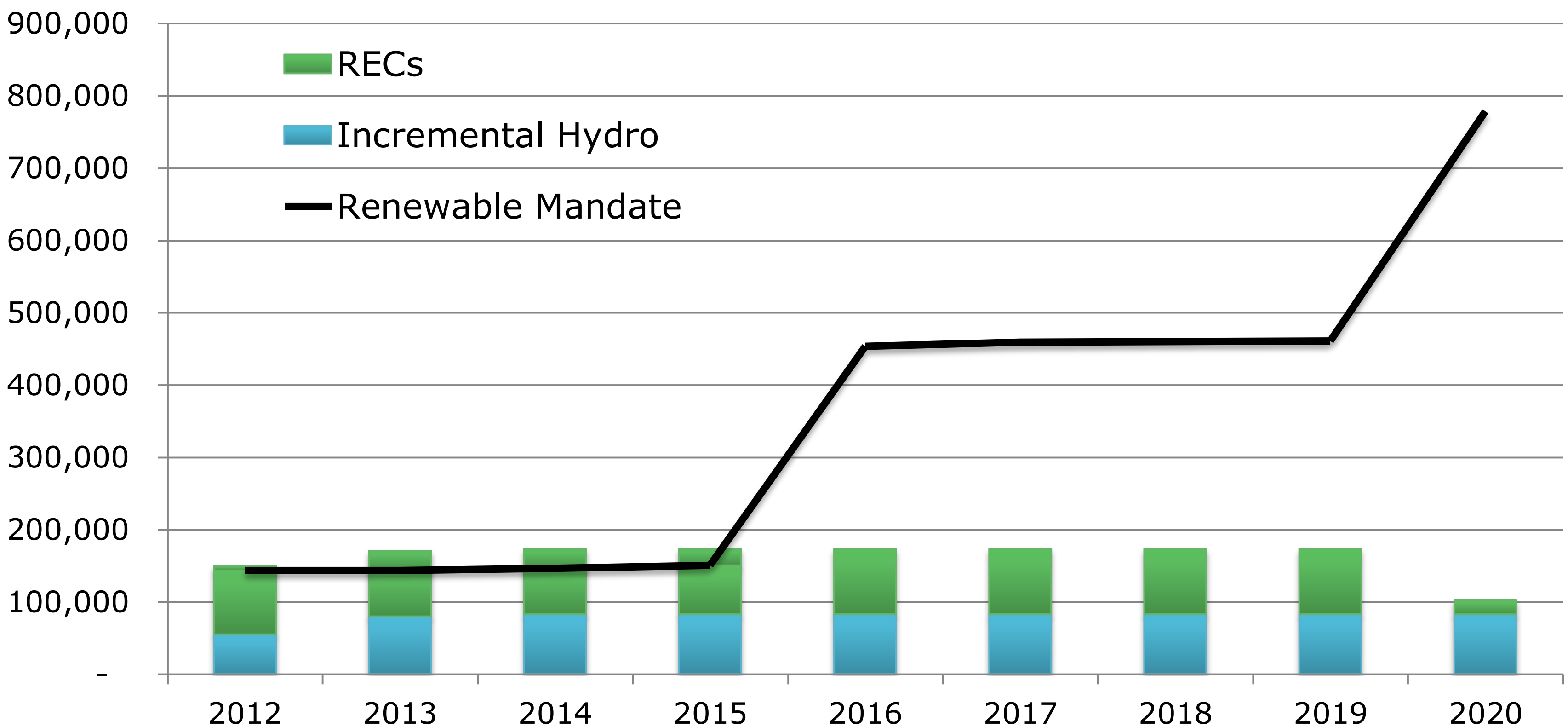








Current RPS Compliance Status



- Tacoma has a slight surplus of RECs/MWhs through 2015
- Through banking this surplus can be carried over to 2016
- From 2016 to 2019 Tacoma's annual compliance deficit averages about 265,000 RECs/MWhs
- Tacoma's principle current REC contract sunsets in 2019

I-937 Compliance Options

Renewable Resources

- Solar
  - Cost $70/MWh
  - Energy value $40/MWh
  - Effective REC price $30/MWh
    - Maximum output in Q2/Q3 when Tacoma least needs it
- Wind
  - Cost $90/MWh
  - Energy value $40/MWh
  - Effective REC price $50/MWh
    - Significant output in Q2 – same time as river runoff

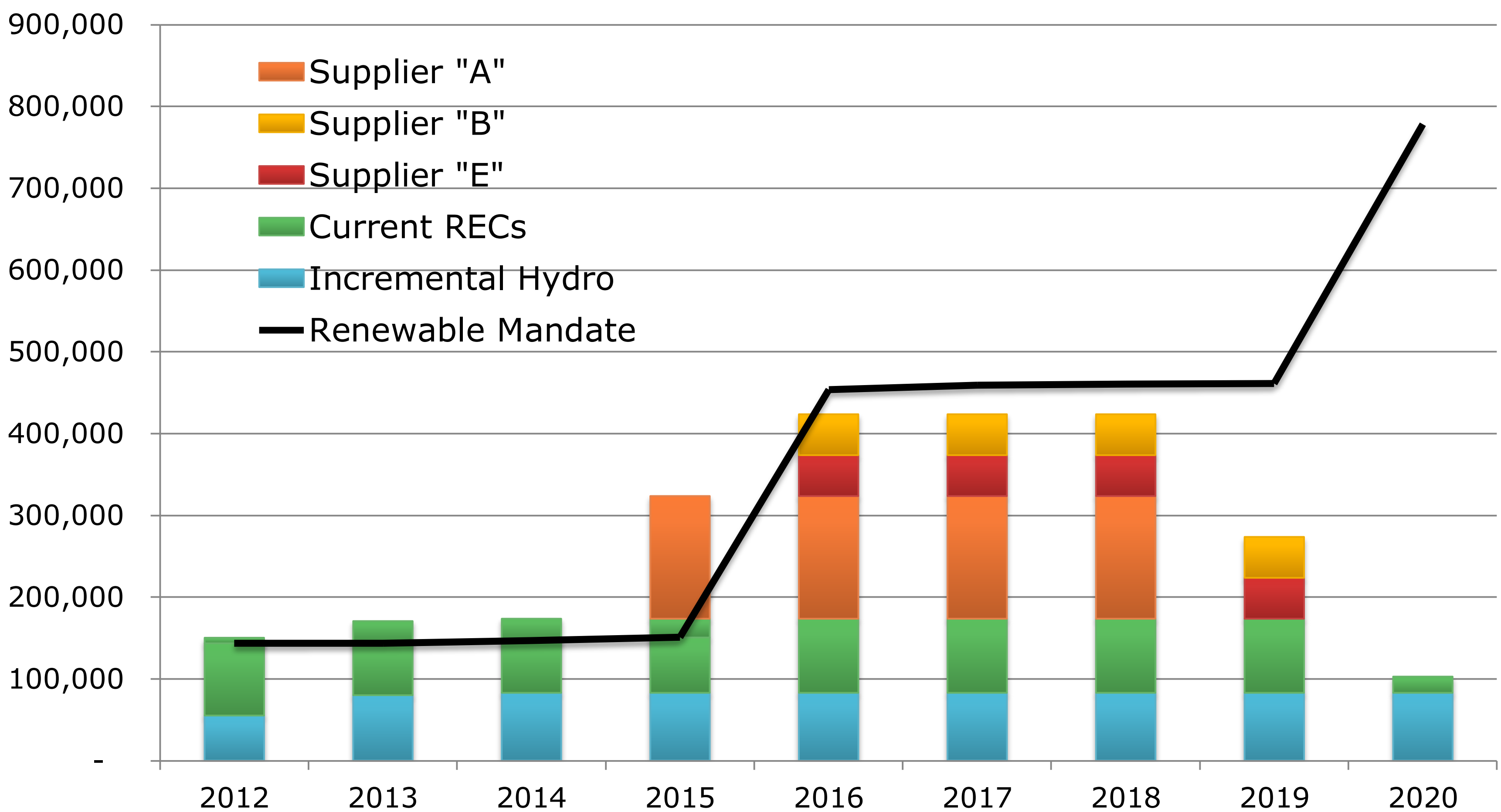
RECs

- Assessment indicates renewable resources exceed WA/OR RPS
- Expect oversupply would lead to low REC prices

REC Offers (2016-2019 Compliance Period)

REC Supplier	Start Date	Annual Volume	Price per REC
A	2015	149,700	*less than* $10
B	2016	50,000	
C	2016	200,000	
D	2016	51,000	
E	2015	50,000	
F	2016	43,800 (Dist Gen)	
G	2016	281,000	

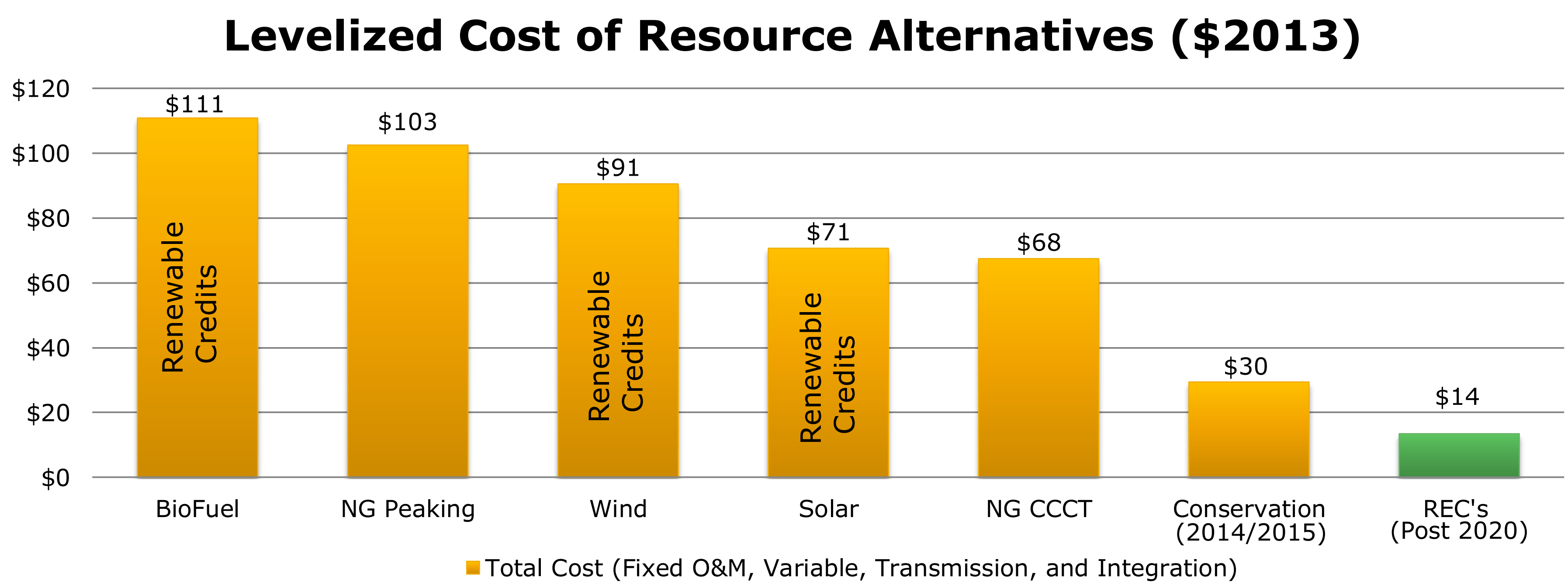
Expected RPS Compliance Status



- Expect to execute additional contract as we get closer to 2016 – 2019 and actual loads are more certain

Summary and Conclusion

- Things can change:
  - Loads
  - Resources
  - Regulatory Mandates
- Model the portfolio to account for uncertainties and analyze results of adding alternative resources
- With Cost Effective Conservation Tacoma Power is surplus in 96% of the historical water conditions on record since 1930
- The best alternative is cost effective conservation and REC purchases



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Draft IRP Action Plan

Draft Action Plan

- Actions from 2013 IRP
  - Acquire approximately 8.1 aMW of conservation in the 2014-2015 biennium
  - Purchase REC's to meet 2016 – 2019 renewable target
  - Consider opportunities to purchase REC's to fill part of post 2020 renewable target
- Actions between now and 2015 IRP
  - Develop strategy for Post 2020 REC Acquisition
  - Enhance utility modeling and assessment capabilities
  - Continue to monitor and model developing impacts of increasing solar generation capabilities in WECC
  - Continue monitoring developing climate legislation

Formal Commenting Opportunity

- Always open to comments and feedback
- Draft Version IRP Available
- Formal Commenting Period
  - October 14, 2013 – October 31, 2013
- Any Questions/Comments:

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- Thank you all for your time today and your input into our process this year!