TACOMA POWER
TACOMA PUBLIC UTILITIES

# 2010 Integrated Resource Plan

**August 2010**

Prepared by Power Management

Direct Comments/Questions to (253) 502-8025

# RESOLUTION NO. U-10411

A RESOLUTION relating to approval and adoption of the Tacoma Power 2010 Integrated Resource Plan.

WHEREAS Washington State law (Chapter 19.280 RCW) requires the Department of Public Utilities, Light Division (d.b.a. "Tacoma Power") to create and submit to the State, an integrated resource plan (" 2010 IRP") that identifies the resources that Tacoma Power will use to meet its customer's needs for at least the next ten years, and

WHEREAS RCW 19.280.050 requires the governing body of the electric utility to approve such plan, and

WHEREAS the 2010 IRP establishes the cost-effectiveness criteria Tacoma Power intends to use to meet the energy conservation requirements of Washington state's Energy Independence Act ("I-937"), and

WHEREAS Tacoma Power is required to file the plan with the State Department of Commerce by September 1, 2010

WHEREAS Tacoma Power has completed the 2010 IRP and requests approval and adoption by the Board; Now, Therefore,

BE IT RESOLVED BY THE PUBLIC UTILITY BOARD OF THE CITY OF TACOMA:

Tacoma Power's 2010 Integrated Resource Plan is approved and the appropriate officers of the City are directed to file such plan with the State of Washington in accordance with Chapter 19.280 RCW.

Approved as to form and legality:

Chief Deputy City Attorney

Clerk

Chair

Secretary

Adopted 8-25-10

# Tacoma Power

## 2010 Integrated Resource Plan

# Executive Summary

*Tacoma Power's 2010 Integrated Resource Plan recommends conservation as the sole addition to the utility's resource portfolio. Analysis indicates that an aggressive conservation acquisition program coupled with Tacoma Power's existing resources will be sufficient to meet projected retail load. This strategy should allow the utility to avoid a need to purchase expensive generating resources for over ten years.*

*Specifically, this IRP found that:*

- *Approximately 63 aMW of new conservation is cost-effective in Tacoma Power's service territory over the next ten years.*
- *This conservation, when combined with current utility resources should be sufficient to serve projected retail load beyond 2020.*
- *Tacoma Power is well positioned to comply with the 3 percent renewable resource mandate that begins in 2012. Tacoma Power's eligible renewable resource portfolio is comprised of nearly equal parts of utility owned incremental hydro and a contract for renewable energy credits.*

*The 2010 IRP also considered the potential effect of electric vehicles and climate change on utility operations:*

- *Electric vehicles are unlikely to impose a significant load on Tacoma Power until 2018 to 2025.*
- *The effects of climate change are likely to be small for Tacoma Power's loads and resources through the mid-2020s. This assessment is preliminary – the findings are likely to evolve as our understanding of the regional implications of climate change improves.*

The primary purpose of preparing an integrated resource plan (IRP) is to determine whether a utility has sufficient resources to satisfy projected retail loads. The second purpose is to determine the mix of new supply-side and demand-side resources that will meet any identified load-resource gap at the lowest cost and risk. For Tacoma Power, a third purpose is to identify a conservation acquisition goal for the utility. Tacoma Power's 2010 IRP addresses these tasks together.

## Tacoma Power's Resource Status

### *Retail Electric Loads*

Electric load forecasts are a fundamental component of any IRP. Tacoma Power's load projection was compiled from individual forecasts for each of the utility's seven customer classes. A variety of factors including population, economic conditions, energy prices, and business expectations (for large customers) influenced these individual forecasts. The red line on figure ES.1 represents the utility's projected annual retail customer load over time without any conservation savings.[1]

### *Conservation*

Conservation reduces retail load. The black line on Figure ES.1 shows the projected annual retail customer load with conservation. The difference between the red and black lines shows how much conservation is expected to reduce Tacoma Power's retail load.

Tacoma Power's conservation estimate is the sum of the energy saved by multiple individual conservation measures. To develop this estimate, the utility hired the Cadmus Consulting firm to assess the applicability of 306 individual conservation measures and more than 60,000 variations on those measures. Over 200 of the assessed measures were found to be "cost-effective" in Tacoma Power's service territory; that is, the energy saved costs less than had the utility acquired the same amount of electricity from the wholesale market. These cost-effective measures are projected to reduce Tacoma Power's retail load by about 63 aMW over the next decade. However, a small portion of the potential conservation is at federal facilities and outside of the utility's control. Excluding this energy savings reduces the utility's ten-year conservation potential to about 60 aMW.

Three schedules for acquiring conservation are considered in this IRP. Each schedule would achieve the same amount of conservation by the end of the ten-year period:

1. A roughly uniform amount each year (pro rata).

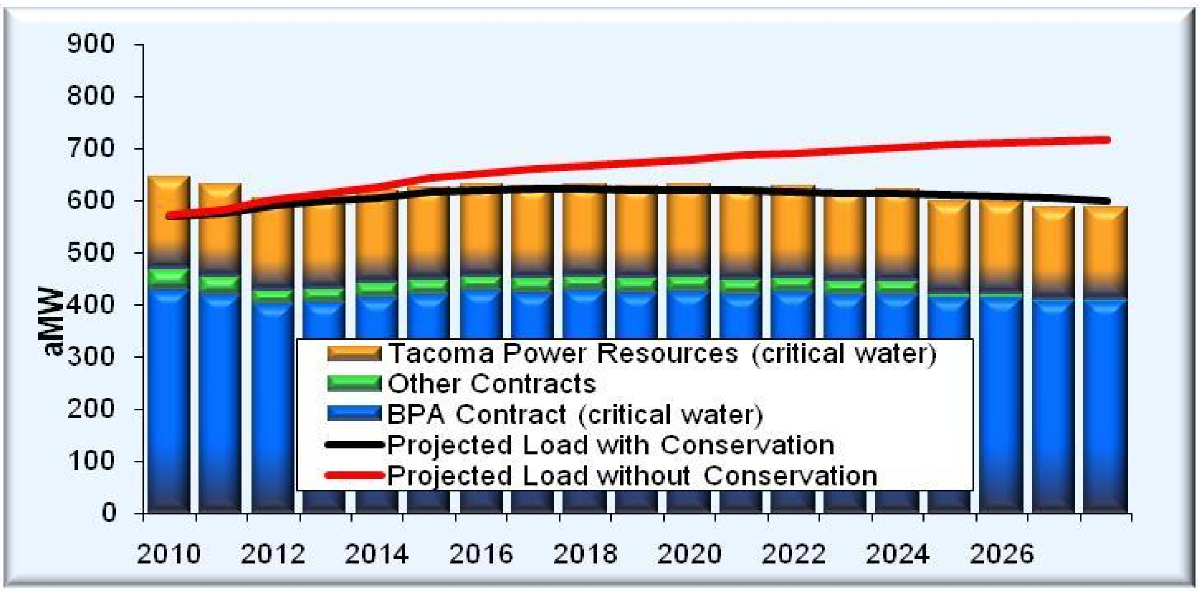
[1] This analysis used an 18-year planning horizon to coincide with the conclusion of the utility's new contract with BPA which expires on September 30, 2028.

2. Accelerated conservation in the early years (front-loaded).
3. Reduced conservation in the early years (back-loaded).

The *pro rata* conservation acquisition schedule was found to be best for Tacoma Power's customers. The Energy Independence Act (a.k.a. I-937) prohibits back-loaded acquisition schedules and a front-loaded schedule is estimated to have a life-cycle cost of $2.0 million more than the *pro rata* schedule. Tacoma Power's two-year, 2012 to 2013, conservation target under a *pro rata* acquisition schedule is 12 to 13 aMW.

The black line on Figure ES.1 shows the utility's projected annual retail load with conservation. This black line indicates the minimum amount of electricity Tacoma Power needs to serve load.

**Figure ES.1**
**Tacoma Power's Annual Load-Resource Balance: Critical Water**




## *Utility Resources*

For planning purposes, Tacoma Power assesses its electricity supply assuming that its owned and contracted resources face critical water conditions. Critical water is defined as the river flows that occurred over the 1940-41 operating year[2] – the year with the lowest combined river flows into Tacoma Power and Bonneville Power Administration (BPA) resources.

The bars in Figure ES.1 indicate the amount of electricity that Tacoma Power expects to be available each year from its generation and contract resources under critical water conditions:

- The blue portion represents electricity from BPA through the Regional Power Sales Contract.

[2] A utility operating year begins on August 1, and ends on July 31.

- The green portion represents electricity from other electricity supply contracts.
- The orange portion is electricity from Tacoma Power's own generation resources.

### *Annual Load Resource Balance*

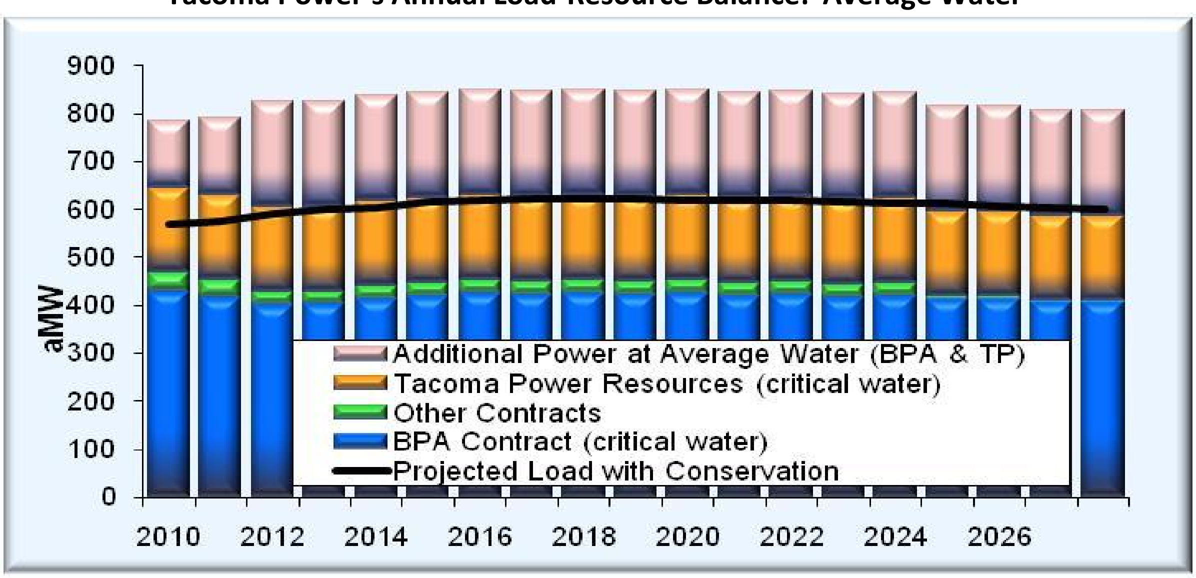
The annual load-resource balance is defined by the amount that power supplies exceed or fall below the expected loads. As Figure ES.1 shows, power supplies (the bars) exceed load (black line) through the first fourteen years of the planning horizon. Tacoma Power's load-resource balance is surplus during this period. This signals that Tacoma Power does not, at this time, need additional resources. However, over the last four years of the planning horizon, the analysis does project a small deficit of about 15 aMW for the utility.

**Without conservation, Tacoma Power would need new supply resources.** Load would begin to exceed demand around 2014 and the overall resource deficit would reach approximately 135 aMW by the end of the planning period.

While Tacoma Power plans for critical water conditions, river flows are typically much higher. Thus, the utility's supply resources will generally produce more electricity than Figure ES.1 indicates.

Figure ES.2 depicts Tacoma Power's load-resource balance under average water conditions. With average water, supplies exceed retail loads by about 200 aMW. The utility sells this excess power in the wholesale market. The revenue from these sales helps Tacoma Power maintain electric rates that are among the lowest in Washington and the nation.

**Figure ES.2**
**Tacoma Power's Annual Load-Resource Balance: Average Water**



### *Monthly Load Resource Balance*

Retail loads grow and fall throughout a year. Therefore, in addition to serving annual retail load, utilities must also have the resources to satisfy variable monthly loads. This type of analysis is especially difficult for hydro-based utilities like Tacoma Power where the quantity and timing of river flows into generating projects is highly uncertain.

This IRP used Vista LT©, a proprietary computer program, to model the operation of Tacoma Power's resources. Essentially, the model determines when it is best to use water for generation and when it is best to store water in project reservoirs. The model produces an estimate of the utility's load-resource balance under alternative river flow regimes.

To account for uncertain river flows, the model assessed Tacoma Power's monthly load-resource balance based on 75 operating years of actual river flow data (1928-29 through 2002-03).

Another important input is the monthly retail load. The monthly retail load profile, presented in Figure ES.3, was based on an annual average load of 622 aMW. This is the highest annual load projected for the IRP study period, and is forecast to occur during the 2017-18 operating year.

**Figure ES.3**
**Tacoma Power's Projected Monthly Load for 2017**

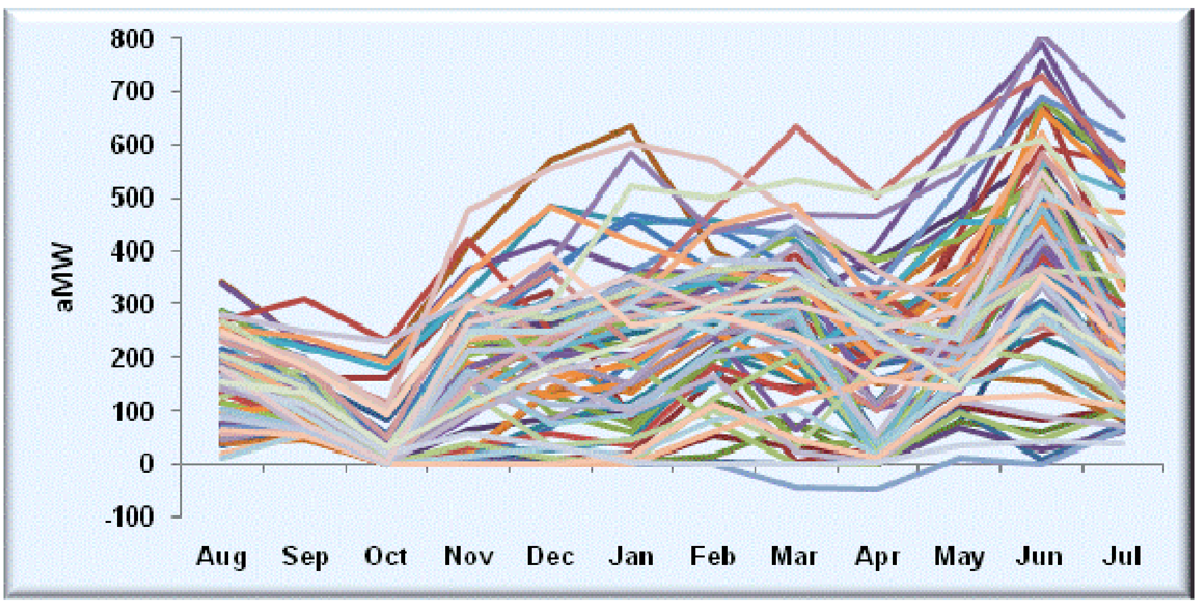

While monthly deficits would be an adverse outcome of this monthly model, they would not necessarily indicate a need for additional supply resources. That conclusion would depend on the number of deficit months and the magnitude of those deficits. The utility searched for two adverse trends when reviewing the model results:

- Whether 5 to 10 percent of operating years were resource deficit over the same month(s).
- Whether any operating year had a deficit load-resource balance over the entire water year.

Figure ES.4 shows the results of this analysis. The figure contains 75 lines, one for each year of actual river flows examined. Each line shows Tacoma Power's calculated load-resource balance over 12 months based on a historical year of actual river flows. Lines above the 0 aMW line indicate that the utility has surplus power for the month while those below 0 aMW indicate a resource deficit.

The lines in Figure ES.4 are nearly always above 0 aMW indicating that Tacoma Power's resources are virtually always surplus to monthly retail load. Only two of the 900 months plotted were resource deficit. And since the two deficit months occurred in the same year, no seasonal shortage reoccurred over multiple years. Furthermore, Tacoma Power was surplus for each of the 75 historic operating years assessed. The annual surplus ranged from 27 aMW to 406 aMW, with a median figure of nearly 220 aMW.

**Figure ES.4**
**Tacoma Power's Load-Resource Balance with 2017-18 Retail Load and Historical River Flow over Operating Years 1928-29 through 2002-03**




To stress-test these results, the IRP re-ran the model varying the:

1. Amount of electricity Tacoma Power will receive under the new BPA Contract.
2. Retail load growth.
3. Level of conservation successfully acquired.

In no case did these stress tests result in Tacoma Power having the same month resource deficit four or more times over the 75 operating years assessed. In a few of these stress tests, the months of March and April were deficit during in three operating years. And again, all operating years had a positive load-resource balance over the complete year.

Tacoma Power has options for dealing with limited deficits. The utility can use the storage capacity of the Mossyrock reservoir (Riffe Lake) to draw extra power in one month and then replace it in a future month. Tacoma Power could also buy power from the wholesale market to cover the shortage. Given the rarity and the limited magnitude of potential monthly deficits, these options are preferable to acquiring a new and expensive resource that would be needed only rarely to serve retail load.

Overall, these monthly load-resource balance stress tests further supports the conclusion that Tacoma Power does not need new supply resources beyond cost-effective conservation.

### *Capacity Adequacy*

The ability to meet peak retail load is also a utility responsibility. This IRP assessed Tacoma Power's ability to meet short-term peak load over three scenarios:

- 1-hour: to test peak loads against maximum resource capabilities;
- 18-hour: to test Tacoma Power's ability to meet 6-hour peaking events each day during a 3-day cold snap;
- 72-hour: to test Tacoma Power's ability to meet peak load over the entire duration of a 3-day cold snap.

The peak retail loads associated with each time period were calculated from actual hourly temperatures – over the coldest 72-hour period in each year from 1998 to 2008. Retail loads were projected assuming that these cold temperatures occurred during the time period of highest retail load: at the beginning of a non-holiday work week, during early morning hours, in mid-January.

The amount of power available to serve this peak load was calculated assuming that:

1. Generating resources were operating under critical water conditions.
2. All normal reserve requirements and regulating margins were maintained.

Table ES.1 shows that Tacoma Power has comfortable capacity reserve margins for all three short-term peak load scenarios.

**Table ES.1**
**Peak Load-resource Balance Summary**

| Period | Peak Load | Peak Supply | Peak Load Capacity Reserve Margin |
|---|---|---|---|
| 1-hour | 1003 MW | 1266 MW | 26% |
| 18-hour | 948 MW | 1266 MW | 36% |
| 72-hour | 833 MW | 1178 MW | 41% |

***Utility Load-Resource Balance Status Conclusions***

The 2010 IRP's modeling of annual, monthly and peak load-resource balance indicates that conservation is the only new resource that Tacoma Power needs. The combination of new cost-effective conservation and current resources are sufficient to meet Tacoma Power's current and projected retail electricity load.

## Additional Analyses

The development of Tacoma Power's 2010 IRP included a review of the 2008 IRP and discussions with utility management and to identify major issues opportunities facing the utility. Three issues were identified for investigation in the 2010 IRP:

1. Compliance status with the renewable requirements of the Energy Independence Act.
2. The potential effect of climate change on utility operations.
3. The potential effect of electric vehicles on utility load.

### *Energy Independence Act Renewable Resource Compliance*

Under state statute, 3 percent of Tacoma Power's retail load must be served with eligible renewable resources from 2012 through 2015. This percentage increases to 9 percent from 2016 through 2019, and 15 percent thereafter. Tacoma Power can apply either renewable energy credits (REC) or eligible renewable energy towards this mandate.

However, since Tacoma Power does not need new generating resources to serve retail load, the acquisition of new and expensive renewable resource(s) would solely be for regulatory compliance purposes. The electricity produced by that new renewable resource would likely be sold in the wholesale market, typically at a substantial loss.

Tacoma Power expects to need 153,000 MWhs per year of renewable power or RECs to meet the renewable energy mandate over the 2012-2015 compliance period. The IRP indicates that a combination of the utility's incremental hydro generation and purchased RECs should slightly exceed this amount.

### *Climate Change*

This IRP made a preliminary assessment of the potential effects of climate change on Tacoma Power for the 2024-25 operating year.

The assessment began by estimating the potential effects of climate change on Tacoma Power's own resources. The consulting firm 3Tier was retained for this effort. The 3Tier analysis indicated that overall precipitation in the river basins feeding into Tacoma Power's resources should remain about the same. However, due to warmer temperatures, more precipitation will run off during the winter. Such a result could better align the output from these resources with Tacoma Power's peak loads.

This preliminary assessment used data from the University of Washington's Climate Impacts Group to indicate the potential effects on BPA's resources. This data suggests a slight decrease in average precipitation in the Columbia River basin and more variability in river flow – dry years may be drier and wet years may be wetter. If so, climate change may have a long-term adverse impact on the power that BPA can produce under adverse and critical water conditions.

Independently, the warmer temperatures associated with climate change are not anticipated to significantly affect utility load. This preliminary assessment suggests that monthly loads in the winter could fall 5 to 6 aMW while summertime loads could increase 1 to 2 aMW. Overall, annual loads associated with climate change could fall by approximately 2.6 aMW.

The overall effects of climate change on Tacoma Power appear small through the mid-2020s. As such, this preliminary analysis does not indicate that climate change is likely to induce a need for additional resources or an altered resource portfolio.

### *Electric Vehicles*

The IRP estimated the possible impact of electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV) on the utility's load-resource balance. This technology has only recently emerged from the experimental stage and little is known about the commercial potential for these vehicles.

The utility has developed a spreadsheet computer model to estimate the added retail load caused by the use of electricity as a transportation fuel.

This model used two projections to estimate the number of electrical vehicles added to the vehicle fleet in Tacoma Power's service territory:

1. A high estimate taken from studies by the Electric Power Research Institute (EPRI) and National Renewable Energy Laboratory (NREL)
2. A base estimate from a National Research Council study.

Tacoma Power considers the National Research Council's projected penetration more likely because the Council took into account cost differences between PHEVs and vehicles with internal-combustion engines.

This assessment indicates that EVs and PHEVs are unlikely to impose significant additional retail load before 2018 at the earliest.

# 2010 Integrated Resource Plan

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## Acronyms

| | |
|---|---|
| aMW | Average megawatt |
| ARRA | American Recovery and Reinvestment Act |
| BPA | Bonneville Power Administration |
| CCCT | Combined-Cycle Combustion Turbines |
| CHWM | Contract High Water Mark (BPA contract) |
| CFS | Cubic Feet per Second |
| CIG | University of Washington Climate Impacts Group |
| $CO_2$ | Carbon Dioxide |
| CPA | Conservation Potential Assessment |
| CREB | Clean Renewable Energy Bond |
| DOC | Department of Commerce (WA state) |
| EPRI | Electric Power Research Institute |
| EV | Electric Vehicle |
| FERC | Federal Energy Regulatory Commission |
| GCPHA | Grand Coulee Project Hydroelectric Authority |
| GHG | Greenhouse Gas |
| GW, GWh | Gigawatt, gigawatt-hour |
| HDD | Heating Degree Day |
| HLH | Heavy Load Hour |
| IPCC | Intergovernmental Panel on Climate Change |
| IRP | Integrated Resource Plan |
| LED | Light Emitting Diode |
| LRB | Load-resource Balance |
| KW, KWh | Kilowatt, kilowatt-hour |
| MW, MWh | Megawatt, Megawatt-hour |
| NERC | North American Electric Reliability Corporation |
| NG | Natural Gas |
| NREL | North American Renewable Energy Laboratory |
| NWPCC | Northwest Power and Conservation Council |
| PHEV | Plug-in Hybrid Electric Vehicle |
| PTC | Production Tax Credit |
| RCW | Revised Code of Washington |
| REC | Renewable Energy Credit |
| RPS | Renewable Portfolio Standard |
| SCCT | Simple Cycle Combustion Turbines |
| WAC | Washington Administrative Code |
| WECC | Western Electricity Coordinating Council |

## Section One
# Integrated Resource Planning Overview

*Tacoma Power is in an enviable position. It has a portfolio of low cost resources that usually provide more electricity than customers demand. Retail rates are low relative to most utilities in the region and our customers consistently report that they are satisfied with utility services. Integrated resource planning is one mechanism Tacoma Power uses to achieve and maintain these results. The planning process provides a systematic approach to assess the timing and magnitude of future resource needs (if any), and to identify the new resources that, in combination with existing supplies, meets projected retail demand at the lowest cost and risk.*

*The importance Tacoma Power places on the IRP process can be seen in the utility's response to the findings of the 2008 plan. That plan found that the BPA "Slice-Block product" offered more benefits than did the alternative "Block product," and Tacoma Power opted for the Slice-Block product. Similarly, Tacoma Power entered into a contract to acquire Renewable Energy Credits based on the finding that they were the least-cost means to comply with the Energy Independence Act's renewable resource requirements for the 2012-2015 compliance period.*

*The development of a successful integrated resource plan must consider the regulatory, policy and operational environments in which the utility operates. This section discusses these environments. This section also notes a number of regulatory and policy mandates that affect the electric utility industry.*

## Why Prepare An Integrated Resource Plan?

Modern life demands electricity. It lights up the night. It heats and cools homes and businesses. It powers factories. It enables communications and computer networks. It facilitates wholesale and retail transactions. It runs lifesaving medical equipment. It is integral to the safety of the food supply. And, it may soon propel personal automobiles. Because electricity touches so many facets of everyday life, the public demands both highly reliable service at the lowest possible cost. Achieving these twin goals is a challenge.

## Tacoma Power Historical Synopsis


The Tacoma Light & Water Co was originally incorporated in 1884 as a private company. In 1893, the city of Tacoma purchased the company transforming it into a municipal utility. Over the next 117 years, Tacoma Power grew into one of the largest municipally owned electric utilities in the country. With a service territory of over 180 square miles, Tacoma Power serves the cities of Tacoma, University Place and Fircrest; portions of Fife, Lakewood, Federal Way, and Steilacoom; Joint Base Lewis - McChord; and other parts of Pierce County.

Tacoma Power's customers number around 160,000, and consume about 600 average megawatts (aMW) of electricity. In 2008, customer growth stalled and retail demand fell due to the ongoing economic conflagration. While economic conditions have begun to improve, Tacoma Power's overall electric growth expectations have declined due in large part to the utility's conservation efforts.

Virtually all of Tacoma Power's electrical energy comes from hydroelectric generation. About two-thirds of the electricity delivered to retail customers comes from a long-term contract with the BPA. Most of the remainder comes from four major hydroelectric generation projects owned by the utility and two contracts with outside suppliers. Tacoma Power does occasionally enter into short-term "balancing purchase" when system generation is not well matched with loads, or to take advantage of peak/off-peak price differentials. While a very small part of Tacoma Power's portfolio, the electricity acquired through these "balancing purchases" may come from non-hydrogeneration sources.

Tacoma Power's resources usually provide more electricity than needed to serve retail load. Tacoma Power sells the excess electricity in the wholesale market. The revenue from these sales helps Tacoma Power maintain electric rates that are among the lowest in Washington and the nation. Tacoma Power also contains a telecommunication unit, and is part of Tacoma Public Utilities which includes water and rail utilities.

Electric generation and transmission facilities are very expensive to build and operate, and take years to bring online. As a result, utilities must begin to plan, permit and construct such facilities well in advance of the growth in retail load that necessitates the new resource. This is problematic because future retail load is subject to unknown and unknowable factors (e.g., economic conditions, technological advancements, climate, and consumer preferences). An erroneous forecast could result in a huge investment in an unneeded resource. Conversely, utilities caught with insufficient resources must rely on an uncertain and potentially costly wholesale market. Thus, utilities could face reliability, costs and rate risks from having either too much, or too little, generation and transmission resources.

Utilities develop integrated resource plans (IRP) to systematically assess:

1. Whether additional resources are needed to satisfy projected retail demand.
2. And, if so, determine the combination of new resources that impose the least cost and the least risk.

These plans assess uncertain variables including long-term load projections, existing resources performance, wholesale electricity prices, and the cost and performance of a range of new generating and contracting options. The information gathered through this process helps guide managers towards resource decisions that are most likely to minimize long-run utility risks and costs.

Finally, it is important to recognize the limitations of integrated resource planning. It is a broad planning tool that identifies the general actions that are most likely to minimize long-run utility costs. Integrated resource planning does not specify specific resources or contracts to acquire, or direct operational decisions. Such actions require a full and careful evaluation of the attributes of the specific resource under consideration.

## Actions Resulting from the 2008 Plan

Tacoma Power has a long history of using the IRP process to evaluate resource needs and supply options.[3] The value that Tacoma Power places on integrated resource planning can be seen in the utility's response to recommendations of the 2008 plan.

### *Conservation*

The 2008 IRP recommended conservation as the only near-term resource to add to the utility's portfolio.[4] More specifically, 4.7 aMW in 2009 and 5.4 aMW per year thereafter. Tacoma

[3] Least Cost Resource Development Planning Process, Volume 1 Summary of Results, June 1990, Tacoma Public Utilities.

[4] Under limited circumstances, the 2008 IRP recommended the addition of modest amounts of wind and/or combined cycle combustion turbine generation beginning around 2015.

Power took a number of key steps to achieve these goals.

1. Conservation planning and assessment activities were moved into the Power Management section of the utility to ensure the consistent analysis of supply and demand-side resources. Cost-effectiveness screening and analysis was enhanced to ensure the dependability of the projected conservation savings.
2. The budget of the Conservation Resources Management group was increased from $15 million in the 2007-08 biennium, to $30 million in the 2009-10 biennium to accommodate the higher acquisition goals.
3. Finally, in June, 2009, the utility revised its Conservation Action Plan to provide a roadmap showing how Tacoma Power will achieve its conservation targets.

Through these actions, Tacoma Power acquired 2.2 aMW of conservation in 2008, 4.9 aMW in 2009 and is on target to exceed 5.4 aMW in 2010.

### *Renewable Energy Credits*

The Energy Independence Act mandates that eligible renewable resources or renewable energy credits (REC) supply at least 3 percent of utility retail load from 2012 through 2015. For Tacoma Power this mandate equates to about 153,000 MWhs of renewable energy or RECs per year.[5]

The 2008 IRP indicated that that Tacoma Power could expect about 70,000 MWhs/per year of eligible renewable energy from "incremental hydropower" and other sources. The IRP also indicated that purchasing RECs was the least cost and least-risk strategy to acquire the remaining amount.

In response, the utility issued a "request for proposal" that culminated in a contract for RECs. That contract, in combination Tacoma Power's incremental hydro resources, brings the utility into near compliance with the first phase (2012-2015) of the Energy Independence Act's renewable requirement.

### *BPA Contract*

BPA sells power to northwest utilities following criteria specified by the federal Pacific Northwest Electric Power Planning and Conservation Act. Tacoma Power's current contract with BPA will expire on September 30, 2011.

In 2005, BPA began a dialogue with its customers and other regional stakeholders to develop the next contract, and to define BPA's long-term electricity supply and marketing role.

[5] The energy independence act is codified at Chapter 19.285 RCW. Tacoma Power's 2008 IRP projected a need for some combination of 165,000 MWhs from renewable resources or RECs. The updated load forecast used in this IRP reduced this projection by 10,000 MWhs/RECs.

From this dialogue BPA developed two contract options: a "Block (with a shaping capacity option) product" and a "Slice/Block product." The Block product would provide pre-established monthly amounts of High-Load Hour and Low-Load Hour electricity. The optional shaping capacity would allow customers to modify their High Load Hour amounts to better fit hourly requirements.

The Slice/Block product was composed of two distinct elements: about half of the electricity will be delivered as a fixed monthly block while the remainder will be a direct portion of Federal hydro system generation. Thus, the Slice/Block product has the additional risk of month-to-month and year-to-year variability in the amount of electricity produced by the Federal hydro system.

The 2008 IRP assessed these two potential contracts. Over the life of the contract, the "Slice/Block" product was projected to provide about $9 million more in benefits to Tacoma Power's customers than the Block product.

Based on this analysis, the Public Utility Board granted approval for Tacoma Power to enter into a new 20-year Slice contract with BPA on October 12, 2008 (Resolution U-10251). This new contract will begin on October 1, 2011 and run through September 30, 2028.

## Integrated Resource Planning Policy Environment

Numerous entities directly and indirectly influenced the development of this IRP. These include Tacoma Public Utilities, the city of Tacoma, Washington State, the Northwest Power and Conservation Council (NWPCC), the BPA, public interest groups, and the federal government. These influences set the "environment" in which Tacoma Power develops its plan. Following is a discussion of some of these influences.

### *Tacoma Power*

Tacoma Power's mission statement sums up the utility's purpose:

> *"[To] provide competitive, environmentally responsible electric… services through teamwork, technology, and innovation."*

The values that Tacoma Power brings to this mission are:

- *Serving our customers.*
- *Respecting people.*
- *Caring for our community and the environment.*
- *Achieving excellence.*
- *Operating safely."*

Our mission and values affirm that cost, environmental impacts, and reliability are key criteria in the planning process.

Conservation is a fundamental ethic of Tacoma Power. Between 1990 and 2009 the utility spent about $81 million on conservation. As a result of these expenditures, Tacoma Power's 2010 load is estimated to be 20 aMW lower than what it otherwise would have been. The utility seeks cost-effective conservation for multiple reasons:

- Conservation is the least cost resource. Without conservation the utility would likely need to acquire new and expensive generation resources.
- Conservation benefits the environment in multiple ways, from reducing air pollution to allowing more "natural" operation of hydroelectric projects.
- Conservation is local. The money spent and the benefits received stay in Tacoma and surrounding communities.
- Conservation creates public benefits. For example, weatherizing the homes of low income customers can improve the health and welfare of the occupants.

### *Tacoma Public Utilities*

Tacoma Public Utilities' environmental statement (see below) directs a science based approach to environmental stewardship.

### *The City of Tacoma*

Climate policies in the City of Tacoma were adopted in April 2006. These policies support efforts to reduce greenhouse gas (GHG) emissions and encourage the growth and development of clean technology businesses.

In February, 2007, Tacoma created the Green Ribbon Climate Action Task Force to refine GHG reduction goals and recommend specific community and government GHG reduction measures. The Task Force delivered its findings to a joint meeting of the City Council and the Public Utilities Board in July, 2008. The recommendations included:

- GHG emission reduction targets (compared to 1990 levels) of 15% by 2012, 40% by 2020, and 80% by 2050.
- Over 40 new strategies to guide the city and the community in reducing GHG emissions.
- A citizen commission to oversee implementation of these strategies.
- A new Office of Sustainability.
- Forming a "Tacoma Green Team" to work with other jurisdictions.

The Office of Sustainability was created in October 2008. A manager was hired in June 2009. The Office of Sustainability is currently working to establish a sustainability framework and related goals and metrics.

An eleven member Sustainable Tacoma Commission was also created in October 2008. The Commission holds monthly public meetings and is working to oversee implementation of the Climate Action Plan and to educate and engage citizens.

## Tacoma Public Utilities' Environmental Policy Statement

Tacoma Public Utilities provides power, water, rail, and telecommunications services and operates facilities in six counties. We balance our obligation to provide our customers with reliable, competitively priced services with respect for the natural environment. We are committed to managing environmental impacts by fostering practices of protection, stewardship and conservation.

**Policy Development**
Our participation in local, regional and national forums helps structure responsible environmental laws. We will:

- Represent TPU's environmental interests with government decision makers.
- Collaborate with agencies, tribes and other organizations to develop agreements that balance our service and environmental obligations.
- Monitor new and amended regulatory proposals and recommend changes to minimize adverse environmental and economic impacts.
- Ensure that internal policies support the goals of this statement.

**Regulation**
Environmental regulations present an opportunity to ensure that our operations meet local, state and federal environmental regulatory obligations. We will:

- Develop and implement programs to meet all applicable regulatory requirements.
- Surpass minimum requirements when reasonable.

**Best Management Practices (BMPs)**
Our experiences, along with those of others, help guide our business practices. We will:

- Develop and implement practicable best management practices that reduce adverse environmental impacts.

**Science and Technology**
Technological development and best available science are keys to reducing or eliminating adverse environmental impacts. We will:

- Monitor and support promising technologies that may lead to improvements in TPU operations.
- Participate in research and trials of new technologies that may improve system operations, provide environmental benefits and reduce utility costs.
- Evaluate climate change impacts using best available science.
- Participate in studies that lead to a better understanding of the species and ecosystems affected by our operations

**Habitat and Species Protection**
The lands, waters and ecosystems entrusted to our care provide habitat for native fish and wildlife, provide clean water, protect soils and provide recreational opportunities. We will:

- Responsibly manage and protect the land, streams, rivers and shorelines owned by Tacoma Public Utilities.
- Use science, technology and judgment to manage fish and wildlife populations.
- Collaborate with communities, agencies and tribes to manage the natural systems that we influence.

**Conservation**
We promote the wise use of energy, water and other resources. We will:

- Encourage the responsible use of energy, water, and resources by our employees and customers.
- Seek practical ways to reduce energy and material needs of the utility.
- Promote recycling and reuse.

**Education**
As a major employer in the area and an organization that serves most of Pierce County, we can help shape environmental attitudes and behaviors. We will:

- Help our employees understand their role in meeting our environmental objectives.
- Assist and encourage our customers to use energy and water wisely.

**Transportation**
We are committed to reasonable, environmentally friendly transportation solutions. We will:

- Partner with national and regional environmental agencies to identify opportunities for transportation emissions mitigation solutions.
- Look for opportunities to limit emissions from utility-owned and personal vehicles.
- Participate in developing new technologies that reduce our environmental impact
- Provide employees with alternative transportation opportunities.

### *State of Washington*

Several laws, regulations and policies of Washington State affect electric utility operations.

Conservation Acquisition was made mandatory by the Energy Independence Act, (codified at RCW 19.285).[6] In 2009, each affected utility was required to determine the amount of cost-effective conservation available in its service territory over 10-years and set a specific conservation acquisition goal for 2010-2011. In 2012, these utilities will report whether they met their target. Any utility that does not is subject to a penalty ($50/MWh plus inflation since 2006).

Renewable Portfolio Standards were also established by the Energy Independence Act. Beginning in 2012, Tacoma Power must ensure that at least 3 percent of the electricity supplied to retail customers is generated by eligible renewable resources. This percentage rises to 9 percent in 2016, and 15 percent in 2020.

Carbon Dioxide Emissions Standards were established by RCW 80.80. New baseload electric sources (whether an owned generation unit or a power contract) may not emit more than 1,100 pounds of carbon dioxide ($CO_2$) per MWh produced. This emissions rate is about that of a new, relatively advanced natural gas fired, combined cycle combustion turbine.

Carbon Dioxide that is injected permanently in geological formations, permanently sequestered by some other approved means, or mitigated under an approved plan does not count against the performance standard.

This standard effectively precludes coal-fired generation until carbon sequestration becomes commercially available.

Carbon Dioxide Emissions Mitigation is required by RCW 80.70.020. The statute specifies that all new fossil-fueled electric generation facilities must mitigate 20 percent of their expected $CO_2$ emissions.

Greenhouse Gas Emissions Reduction Targets are codified at RCW 70.235:

- By 2020, reduce overall emissions of GHGs in the state to 1990 levels;
- By 2035, reduce overall emissions of GHGs in the state to 25 percent below 1990 levels;
- By 2050, the state will reduce overall GHG emissions to 50 percent below 1990 levels.

The Western Climate Initiative was launched in February 2007 by the Governors of Arizona, California, New

[6] Washington state citizens' initiative No. 937 was passed by public vote in November 2006. The initiative was codified as the Energy Independence Act at RCW 19.285. The initiative has two principal parts. Utilities with more than 25,000 customers must acquire all cost-effective conservation and include certain specified percentages of renewable energy in the electricity supplied to retail customers.

Mexico, Oregon and Washington. It is a collaborative effort to develop regional strategies to address climate change.

Washington's participation was formalized at RCW 70.235. Ecology is directed to:

> "…develop, in coordination with the western climate initiative, a design for a regional multisector market-based system to limit and reduce emissions of greenhouse gas consistent with the emission reductions [targets]."

In December 2008, Ecology recommended adoption of a cap-and-trade mechanism. Ecology indicated that this mechanism could achieve Washington's GHG emission reduction targets if adopted in combination with complimentary policies such as "…energy efficiency programs, green building [code] requirements, and increases in combined heat and power plants." The state legislature has not passed a bill to implement a cap-and-trade mechanism.

In May 2009, the Washington's governor directed Ecology to continue to participate in the western climate initiative and to work with the federal government towards a national GHG emission reduction program (Executive Order No. 09-05).

<u>Integrated Resource Planning</u> is mandatory for Washington utilities with more than 25,000 customers. RCW 19.280 requires integrated resource plans to contain the following elements:

1. A range of ten years forecasts of customer demand which take into account econometric data and customer usage.
2. An assessment of commercially available conservation and efficiency resources.
3. An assessment of commercially available, utility scale renewable and nonrenewable generating technologies.
4. A comparative evaluation of available resources: renewable, nonrenewable, conservation and efficiency (including transmission and distribution delivery).
5. The integration of the demand forecasts and available resources into a long-range projection of the mix of supply and demand side resources that meet current and projected needs at the lowest reasonable cost and risk.
6. A short-term plan identifying the specific actions to be taken by the utility to implement the IRP.

The Statute also encourages customer participation in the plan's development.

### *Regional*

<u>The Sixth Northwest Conservation and Electric Plan</u> was released by the NWPCC in February 2010. The NWPCC

summarized its resource strategy in five specific recommendations:[7]

1. "Improved efficiency of electricity use is by far the lowest-cost and lowest-risk resource available to the region. Cost-effective efficiency should be developed aggressively and on a consistent basis for the foreseeable future. The NWPCC's plan demonstrates that cost-effective efficiency improvements could on average meet 85 percent of the region's growth in energy needs over the next 20 years.
2. "Renewable resource development is required by resource portfolio standards in three of the four Northwest states. The most readily available and cost-effective renewable resource is wind power and it is being developed rapidly. Wind requires additional strategies to integrate its variable output into the power system and, in addition, it provides little capacity value for the region. The region needs to devote significant effort to expanding the supply of cost-effective renewable resources, many of which may be small scale and local in nature.
3. "Remaining needs for new energy and capacity should be based on natural gas-fired generation until more attractive technologies become available. The resource strategy does not include any additional coal-fired generation to serve the region's needs. Further, the NWPCC's plan demonstrates that meeting the Northwest power system's share of carbon reductions called for in some state, regional, and federal carbon-reduction goals will require reduced reliance on the region's existing coal plants.
4. "The challenges of wind integration and the need for additional within-hour reserves initially should be addressed through improvements in system operating procedures and business practices. Changes in wind forecasting, reserve sharing among control areas, scheduling the system on a shorter time scale, and advancing dynamic scheduling can all help address wind integration and contribute to a more efficient use of existing system flexibility. The region is already making significant progress in these areas.
5. "Finally, the NWPCC's resource strategy calls for efforts to expand long-term resource alternatives. The region should demonstrate the potential of smart-grid applications to improve the operation and reliability of the regional power system and to access the potential of consumers to provide demand response for the capacity and flexibility of the power system. The region should continue

[7] Sixth Power Plan Overview, Sixth Northwest Conservation and Electric Power Plan, NWPCC, February, 2010. Accessed at http://www.nwcouncil.org/energy/powerplan/6/final/SixthPowerPlan_Overview.pdf

to assess new efficiency opportunities, expand the availability of cost-effective renewable energy technologies, and monitor development of carbon capture and sequestration, advanced nuclear technologies, and other low-carbon or no-carbon resources."

### *Federal*

Mandatory Resource Adequacy Reliability Standards changed in 2005 with passage of the federal Energy Policy Act. Prior to this Act, Tacoma Power voluntarily complied with reliability standards of the North American Electric Reliability Corporation (NERC) and the Western Electricity Coordination Council (WECC).[8] The Act placed the Federal Energy Regulatory Commission (FERC) in charge of the reliability standards and mandated compliance. NERC, through WECC, was tasked with ensuring compliance throughout the western interconnection.

The focus of NERC and WECC is to ensure that bulk power system operators have the tools, processes, and procedures in place to operate reliably, even under emergency conditions. These tools and procedures are unique to the circumstances of individual utilities and power grid they operate within. As such, Tacoma Power could not, for example, significantly change its mix of resources without modifying the way it complies with the NERC/WECC standards.

Pursuant to NERC/WECC standards utilities perform yearly self-assessments. NERC/WECC conduct on-site compliance audits every three years. Tacoma Power was last audited in early 2010 and was found in compliance with the standards.

The Energy Independence and Security Act of 2007 stated goals were to move the United States toward greater energy independence and security; increase the production of clean renewable fuels; protect consumers; increase the efficiency of products, buildings, and vehicles; promote research on and deploy GHG capture and storage options; and, improve the energy performance of the Federal Government. Key provisions of the law are:

- Energy security
  - Provided incentives to develop plug-in hybrids and electrify transportation.
- Energy savings
  - Revised standards for appliances and lighting.
    - Requires roughly 25 percent greater efficiency for light bulbs, phased in from 2012 through 2014. (Exempts some specialty lights.)
    - Requires roughly 200 percent greater efficiency for light bulbs by 2020.
  - Initiatives for conservation in buildings and industry.

[8] Tacoma Power is a participating member of WECC. WECC is one of eight reliability organizations that compose NERC.

  - Requires Federal buildings to use Energy Star lighting products.
  - New standards promoting efficiency in government and public institutions.
- Funded research and development of solar energy, geothermal energy, and marine and hydrokinetic renewable energy technologies.
- Expanded federal research on carbon sequestration technologies.
- Green jobs - creation of a training program for "Energy efficiency and renewable energy workers".
- Smart grid - modernization of the electricity grid to improve reliability and efficiency.

The American Recovery and Reinvestment Act of 2008 was a package of spending actions by the federal government to address the ongoing economic downturn. The American Recovery and Reinvestment Act directed some $61.3 billion towards the energy sector through a multitude of grant programs. Tacoma Power was selected to receive grant funding under several different programs as delineated in Table1.1.

**Table 1.1**
**Tacoma Power's Efforts to Secure American Recovery and Reinvestment Act Funding**

| Grant Description | Status of Tacoma Public Utilities' Funding Request |
|---|---|
| **Alternative Fuel Vehicles Pilot Program** | |
| The ARRA set up two alternative vehicle fuels programs:<br>• Alternative Fuel and Advanced Technology Vehicles Pilot Program<br>• Transportation Electrification<br>Applicants were required to partner with a Clean Cities Coalition. Allowable technologies include: plug-in hybrid electric vehicles, electric vehicles, fuel cell vehicles, electric idle reduction technologies, electric rail technologies, and the recharging and support infrastructure required for each technology. Both programs require a 50% cost share for the entire project. | TPU partnered with the Puget Sound Clean Air Agency Clean Cities Coalition to apply for this grant. TPU requested funding for the incremental costs to acquire multiple hybrid electric vehicles: 3 trucks, 6 step vans, 9 SUVs and 3 sedans. TPU also requested support for "Dedicated Electric" vehicles for fleet operations, as well as the construction and installation of electric charging stations.<br>The U.S. Department of Energy has awarded the Puget Sound Clean Cities Coalition $15M for alternative fuel and vehicle projects. TPU will receive about $500,000 of this grant to pay the incremental cost for 21 hybrid electric vehicles (purchased in 2010 and 2011). TPU will receive additional funding to provide, test and evaluate commercial electric vehicle charging stations. |

<table>
<tr><th>Grant Description</th><th>Status of Tacoma Public Utilities' Funding Request</th></tr>
<tr><td colspan="2">Energy Efficiency and Conservation Block Grants (formula funds) for jurisdictions with populations >35K</td></tr>
<tr><td>This grant program is to help local governments and tribes to develop and implement clean energy programs, including energy efficiency strategies, energy audits and retrofits, energy efficiency improvements at buildings and facilities, energy conservation in transportation, building codes and inspection services, energy distribution technologies, recycling programs that increase energy efficiency, renewable energy technologies for government buildings, and the capture and use of methane and other greenhouse gasses from landfills.<br><br>Funding directly allocated to counties and cities – not available to utilities. Tacoma Power assisted the City of Tacoma to leverage utility expertise with city funding to seek these funds.</td><td>Tacoma Power conservation programs are being leveraged through projects funded through these grants:<br>• $1.2M of the City of Tacoma's $1.9M block grant will go to: HVAC in Fire Headquarters; Woodstove Change out; Weatherization in South Tacoma; Traffic signals; and Metro Parks energy upgrades. All Tacoma Power programs.<br>• $2 M of Pierce County's $4.3M block grant will leverage Tacoma Power programs including energy audits of county facilities, energy efficiency corrective measures, light-emitting diode (LED) traffic signals @78 intersections, LED message boards, woodstove conversion and weatherization, and data server efficiency.</td></tr>
<tr><td colspan="2">Clean Renewable Energy Bonds</td></tr>
<tr><td>Authorized in the Energy Policy Act of 2005, Clean Renewable Energy Bonds (CREBs) are "tax-credit bonds" that provides the issuer with a 70% interest subsidy. CREBs were recently revised to allow them to be issued like a "Build America Bond" with a tax credit to the issuer instead of the bond purchaser which has improved the ability to place the bonds. The ARRA provides $1.6 billion for these bonds, divided in equal thirds between municipal utilities, general local government, and rural electric cooperatives.</td><td>Tacoma Power applied for CREBs for two power projects:<br>• Cushman No. 2 Dam, Fish Collection and Powerhouse - $24,857,400<br>• Refinance Mossyrock - $19,686,000<br><br>In January, 2010 Tacoma Power received a total CREB allocation of $24,185,338 (54% of the original request):<br>• Mossyrock Rebuild Project - $10,688,734<br>• North Fork Skokomish Powerhouse at Cushman No. 2 Dam - $13,497,604<br><br>Clean Renewable Energy Bonds for the full allocation are planned to be issued in July 2010 for both projects.</td></tr>
<tr><td colspan="2">Hydroelectric Facility Modernization</td></tr>
<tr><td>This ARRA grant is for modernizing existing non-Federal hydropower projects to increase hydro-generation and improve environmental performance (e.g., reduce fish mortality or improve fish passage around the project).</td><td>Tacoma Power was selected to receive up to $4.7M to build a new small generation facility and upstream fish passage system at the Cushman Hydroelectric Project. The project increases both the quantity and value of hydropower generation as well as improves environmental performance.</td></tr>
</table>

| Grant Description | Status of Tacoma Public Utilities' Funding Request |
|---|---|
| **State Energy Program** | |
| Washington's State Energy Program contained four major funding opportunities. However, only one was relevant for Tacoma Power: $14.5 million for **Community-Wide Urban Residential and Commercial Energy Efficiency (**large neighborhood based building energy efficiency projects). | Tacoma Power responded to the first of these opportunities by signing a letter of agreement with SustainableWorks with outreach to over 1,000 homes in TP Service area. The program intends 400 audits and weatherization jobs, using up to $400,000 of Tacoma Power weatherization budget to secure matching ARRA funds. Incentives will be slightly higher than Tacoma Power program's justified by acquisition of additional federal funding. However, all measures funded by Tacoma Power will pass the total resource cost test. Sustainable Works began its work in urban areas north of Tacoma Power's service area and is slowing moving south. While as of June, 2010, Sustainable Works has not weatherized any homes in the Tacoma area, the utility will work with Sustainable Works when they reach and begin to treat Tacoma neighborhoods. |

## The Regional Electricity System

The combined generating capacity of all resources across the Pacific Northwest amounts to approximately 50,700 MW. Under normal precipitation, these resources produce about 31,000 aMW of electricity.

Hydroelectric dams supply 33,000 MW of the region's generating capacity and produce about 16,200 aMW of electricity under normal precipitation.

The Federal Columbia River Power System, consisting of 31 dams, provides about 20,200 MW of this hydroelectric capacity and nearly 7,000 aMW of firm energy. Output from the Columbia River Power System generally varies from 18,000 aMW in good water years to 11,700 aMW in poor water years.

The BPA markets the output of the Federal System, along with the output of the Columbia Generating Station, a 1,200 MW nuclear plant.

Across the region, electricity consumption exceeds the generation provided by hydro and nuclear resources. To fill the supply gap, utilities have turned to natural gas turbines. As a result, natural gas generation is now the marginal supply resource during much of the year, and as such often drives wholesale electricity prices.

Figures 1.1 and 1.2 provide some additional information on the resources that make up the Pacific Northwest regional system.

**Figure 1.1**

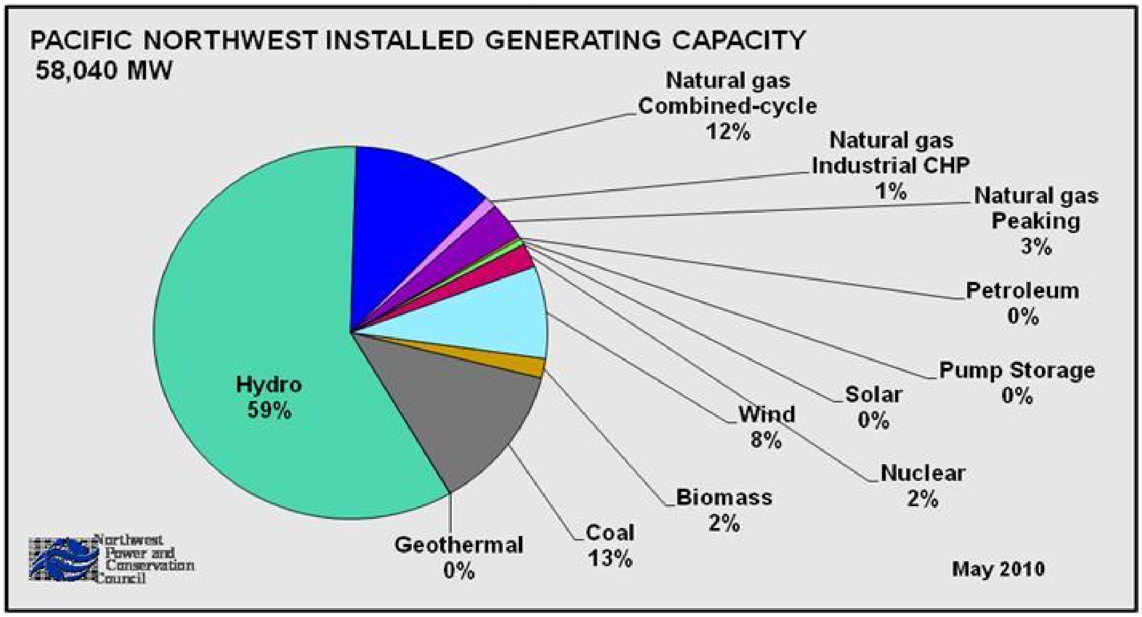
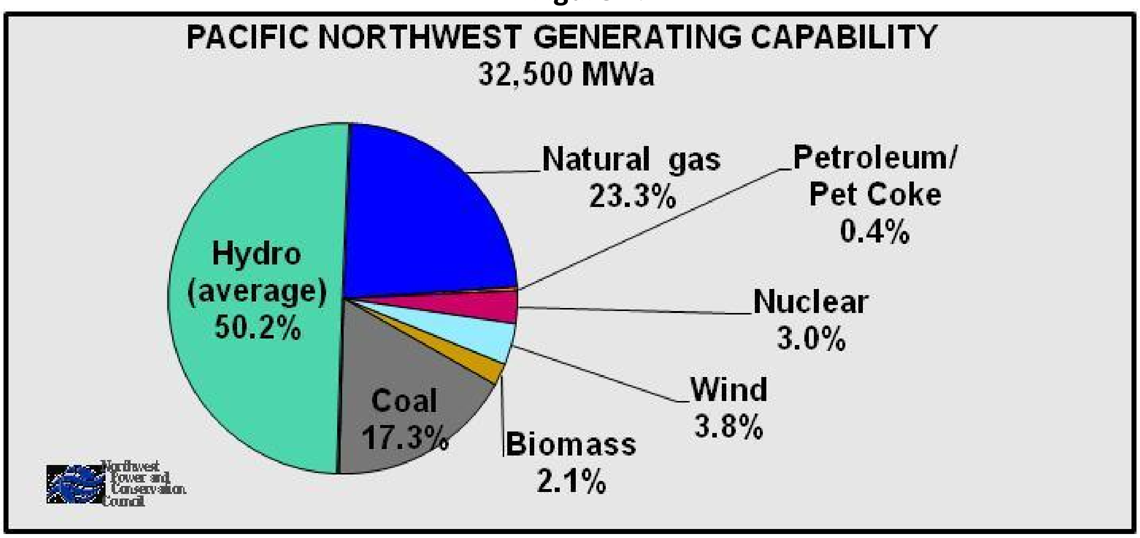



**Figure 1.2**




The medium forecast of the NWPCC's Sixth Northwest Conservation and Electric Power Plan places regional load at 25,000 aMW in 2030. The Sixth Power Plan further asserts that an aggressive conservation effort would cover 85 percent of this load growth. The residual load would be met with renewable and natural gas resources.

The Sixth Power Plan also notes that the regional power system is under pressure:

- The seasonal load shape is changing.
- Operating constraints to protect fish are growing.
- The amount of wind and other variable generation is rapidly increasing.

Wind generation, with its unexpected changes in output, is placing significant strain on the flexibility and capacity of the regional power system. The Sixth Power Plan discusses a two-step process to address this concern. The first step is to change operating procedures and business practices to more fully utilize the inherent flexibility of the existing system. Actions include: establishing metrics for measuring system flexibility; developing methods to quantify the flexibility of the existing resources; improving forecasting of the region's future load; improving forecasts of wind; improving wind scheduling; transitioning from the current whole-hour scheduling to an intra-hour framework; and, increasing the availability and use of dynamic scheduling. These improvements may require physical upgrades to transmission, communication, and control facilities.

The second step is to add resources that are flexible enough to respond to unexpected changes in wind plant output. Actions include: developing rapid-response natural gas generators, pumped-storage hydro plants and other storage resources, utility demand response programs and other potential smart grid applications, and the geographic diversification of wind generation as options to meet the region's future demand for flexibility.

Some balancing authorities, BPA in particular, may need additional flexibility, either from new resources or better use of existing resources, solely to integrate wind generation.

The electric power system is organized into **Balancing Authorities** in order to maintain system reliably. There are 17 balancing authorities in the Northwest Power Pool Area. Each balancing authority must, among other responsibilities, continuously balance loads and resources, maintain interconnection frequency at the required level, monitor and manage transmission power flow, maintain system voltages within required limits, and deal with generation or transmission outages.

## Tacoma Power and Regional Electricity System

Compared to the regional electric grid, Tacoma Power is a small utility with little or no ability to affect the overall grid. Utility owned hydro resources generate 325 aMW in an average year – only about 1.2 percent of the regional output. Nevertheless, Tacoma Power's resources do have certain geographic diversity benefits relative to the Federal Columbia River Power System. Located on the west side of the Cascade mountain range, Tacoma's resources are subject to different weather patterns than those that occur east of the Cascades. As a result, Tacoma Power's resources have a different critical water year than the federal system and are also subject to different river run-off patterns. This diversity among utility hydro resources and the BPA power contract improves the reliability of Tacoma Power operations.

As a local balancing authority, Tacoma Power is subject to the reliability standards of NERC, WECC, and the Northwest Power Pool. The reliability standards are designed to prevent a single contingency (the loss of a major generation facility or transmission line) from causing the regional system to fail.

The reliability standards require each balancing authority to provide a "contingency reserve" to cover the potential event of a generating or transmission facility tripping off-line. A "regulating reserve" is required to instantaneously follow changes in load. Together, contingency and regulating reserves are referred to as "operating reserves."

Half of the contingency reserve and all of the regulating reserve must be spinning – the unit providing the reserve must be operating and connected to the electric system. The remainder may be spinning reserve or non-spinning – a non-spinning reserve must be fully accessible within 10 minutes. Interruptible load or interruptible exports can also be used to meet the non-spinning requirement.

Tacoma Power is responsible for meeting these operating reserve requirements at all times.

## Tacoma Power System Management

Tacoma Power relies nearly completely on electricity generated by hydro resources. As such, the amount of power available for retail customers is subject to the uncertainties of annual precipitation and, to a lesser extent, snow melt.

Precipitation in the Northwest can vary widely from year-to-year. For example, in the 2000-2001 operating year, 37 inches of rain fell in Tacoma Power's Cowlitz project watershed while 81 inches fell during 1996-1997.

> An **operating year** begins in August and ends the following July. This period coincides with our region's hydrological cycle, beginning and ending when storage reservoirs are nearly full and river flows are at their lowest. This cycle dictates how hydroelectric projects are operated, hence the term "operating" year.
> A **water year** begins in October and ends the following September.

Monthly variability can be even more pronounced. In January of the years 1985 and 2006, 0.4 and 16.1 inches of rain fell in the Mossyrock watershed, respectively. This variance in precipitation creates uncertainty about the amount of electricity Tacoma Power will have over a month or year to serve retail load.

This supply variability creates operational risks and managerial challenges for the utility. On one hand, being caught short of power during a dry year could necessitate purchasing high-cost electricity from the wholesale market. On the other hand, during average or wetter than normal years the additional power from expensive new resources would be sold in the wholesale market, usually at a significant loss.

Over the long-run, Tacoma Power manages these risks by working to maintain a modest surplus load-resource balance and selling the surplus power in the wholesale market.

On a short-term basis, Tacoma Power utilizes the wholesale power market to optimize its own portfolio of supply resources (e.g., sell when prices are high, buy when prices are low). Through careful resource management and attention to price differentials, Tacoma Power enhances net wholesale sales revenues and thus reduces the amount of revenues the utility must recover through retail rates.

However, Tacoma Power is mindful of the risk of retaining too little supply to satisfy retail customer load. To mitigate this risk, the utility constantly monitors its supply resources and near-term demand forecasts in order to maintain a reasonable balance between the potential revenues from forward electricity sales and the need to serve native customers.

Tacoma Power also ensures that trading partners have the ability to pay for and/or deliver electricity promised in a contract. To manage counterparty risk, Tacoma Power maintains a set of trading guidelines and has established procedures for monitoring the continued creditworthiness of approved trading partners.

## Transmission

### *Regional Transmission Adequacy*

As a Balancing Authority Area, Tacoma Power is a significant participant in regional transmission planning and operating activities. Tacoma Power is an active member of ColumbiaGrid, a non-profit membership corporation formed to improve the operational efficiency, reliability, and planned expansion of the Pacific Northwest transmission grid. ColumbiaGrid has substantive responsibilities for transmission planning, reliability, the Open-Access Same-Time Information System, and other development services. There are seven other members that actively participate in ColumbiaGrid.

In addition to Tacoma Power's participation in regional transmission system planning and operations, Tacoma Power has complied with the NERC and WECC reliability standards, policies and procedures.

The focus of NERC and WECC is the compliance to, and enforcement of, the mandatory standards designed to ensure that bulk power system operators have the tools, processes, and procedures in place to operate reliably – even under emergency conditions. These tools, processes, and procedures are unique to the circumstances of individual utilities and the larger power grid within which they operate. As such, Tacoma Power could not, for example, significantly change its mix of resources without modifying its compliance with the NERC/WECC standards.

NERC/WECC conducts self-assessments each year, and on-site audits every three years. These audits are to measure compliance with the standards and to assess penalties for non-compliance. Tacoma Power was last audited in early 2010 and was found to be in compliance with the standards, recognizing that some mitigation plans were already in place.

### *Tacoma Transmission Adequacy*

Two other components comprise Tacoma Power's transmission adequacy at the subregional level: utility owned and contracted transmission facilities. Tacoma Power owns and operates its high voltage transmission and distribution system for purposes of delivering both owned and purchased generation to retail customers. Tacoma Power also purchases transmission capacity from Bonneville Power Administration (BPA) and other subregional Transmission Providers in order to deliver remote resources to the Tacoma Power system and to facilitate the purchase and sale of wholesale power.

Tacoma Power owns and operates 416 circuit miles of 230kV and 110kV transmission facilities and achieves its commitment to reliable energy delivery through system planning and reliability centered maintenance programs in its transmission and distribution business unit. Tacoma Power's Transmission and Distribution business unit actively plans, constructs, operates and maintains the transmission and distribution network on an ongoing basis. Tacoma Power prepares both a Six-Year and 15-Year Facility Horizon Plans and implements capacity additions, reliability projects, renewal and replacement projects, and technology enhancements following the strategic priorities established through these planning processes.

BPA's transmission system includes over 15,000 circuit miles of transmission lines and provides about 75% of the Pacific Northwest's high-voltage transmission capacity. BPA sells electric power at wholesale rates to 127 utility, industrial and governmental customers in the Pacific Northwest. Tacoma Power has Point-to-Point and other various contractual transmission arrangements that allow for the delivery of owned and contracted for power resources to our BAA. Portions of these contracts are also used to transmit surplus energy in the wholesale power market when appropriate.

A detailed analysis of Tacoma Power's current wholesale transmission resource portfolio was completed in 2009 and updated in 2010. An important portion of the analysis included modeling current and future wholesale power supply contracts with BPA. Should Tacoma Power decide to request additional transmission capacity from BPA, the utility would have to apply through BPA's annual Network Open Season process and would most likely not receive the additional capacity for three to five years. A formal recommendation, that Tacoma Power currently has sufficient transmission capacity from BPA and other transmission providers, has been accepted by senior management.

# Section Two
# Load-Resource Balance

*A primary component of integrated resource planning is determining a utility's long-term load-resource balance. The load-resource balance identifies both the timing and magnitude of potential future resource deficits. This information is fundamental to assessing whether the utility needs additional resources. For the purposes of this IRP, this analysis' planning period ran through the year 2028 to coincide with the expiration of the new BPA contract.*

*This integrated resource plan assessed Tacoma Power's load-resource balance over three timeframes: annual, monthly, and peak. This assessment indicates that new cost-effective conservation coupled with existing supply resources will likely to be sufficient to meet retail load under critical water conditions. Under more normal or median water conditions, the utility has a projected annual surplus of over 200 aMW.*

*To confirm these results, the integrated resource plan stress-tested Tacoma Power's monthly load-resource balance. Several fundamental inputs to the monthly model were altered with the effect of either increasing Tacoma Power's load or reducing its power supply. These stress tests produced a small number of months that were resource deficit during certain low-water years. However, neither the number of deficit months, nor the magnitudes of those deficits were sufficient to indicate a need for new resources. Based on this assessment, this IRP concludes that the only new resource that Tacoma Power needs is conservation.*

## Tacoma Power Planning Objectives

Tacoma Power's first step in the process to develop this IRP was to identify a clear set of analytic objectives. Toward this end, the planning staff reviewed the 2008 IRP and interviewed mid-level and senior utility leadership (See Appendix B). Of the issues identified for potential assessment in this IRP, dominant question was whether Tacoma Power will need new supply resources to serve retail load. To fully evaluate this issue, the IRP assessed the utility's balance between loads and supplies over three timeframes:

- Annual. The 2008 IRP indicated that Tacoma Power's annual load-resource balance was likely to turn deficit around 2018.
- Seasonal. The 2008 IRP indicated that the new BPA slice contract will increase the variability of supply resources. This could potentially lead to wintertime load-resource balance deficits in years with below normal rainfall.
- Capacity Adequacy. Capacity adequacy is the ability to meet short-term peak demand. Interviews with utility management noted the

importance of ascertaining Tacoma Power's status relative to the NWPCC's new voluntary regional capacity standards.

With the analytic objectives established, the next step was to select, for each timeframe, an approach to assess Tacoma Power's load-resource balance. To aid this selection, the planning staff reviewed recent IRPs prepared by five similarly situated regional utilities. (See Appendix C) This review considered these utilities planning practices over 18 specific areas. A particular focus was on how these utilities assessed energy and capacity adequacy. While their analytic techniques were generally similar, there were differences that proved useful as Tacoma Power developed its assessment approach for each timeframe.

Tacoma Power wants to make clear that this review did not, in any way, judge the quality of any other utility's plan. A utility's response to an issue will depend on its own unique set of circumstances. The sole goal of this review was is to gain information that Tacoma Power could use to improve the 2010 IRP.

## Load-Resource Balance – Background Information

Prior to assessing Tacoma Power's balance between loads and supplies over the three timeframes, the IRP had to first project the utility's retail loads and power supplies. This assessment ran through the year 2028 to coincide with the expiration of the new BPA contract.

### *Load Forecast*

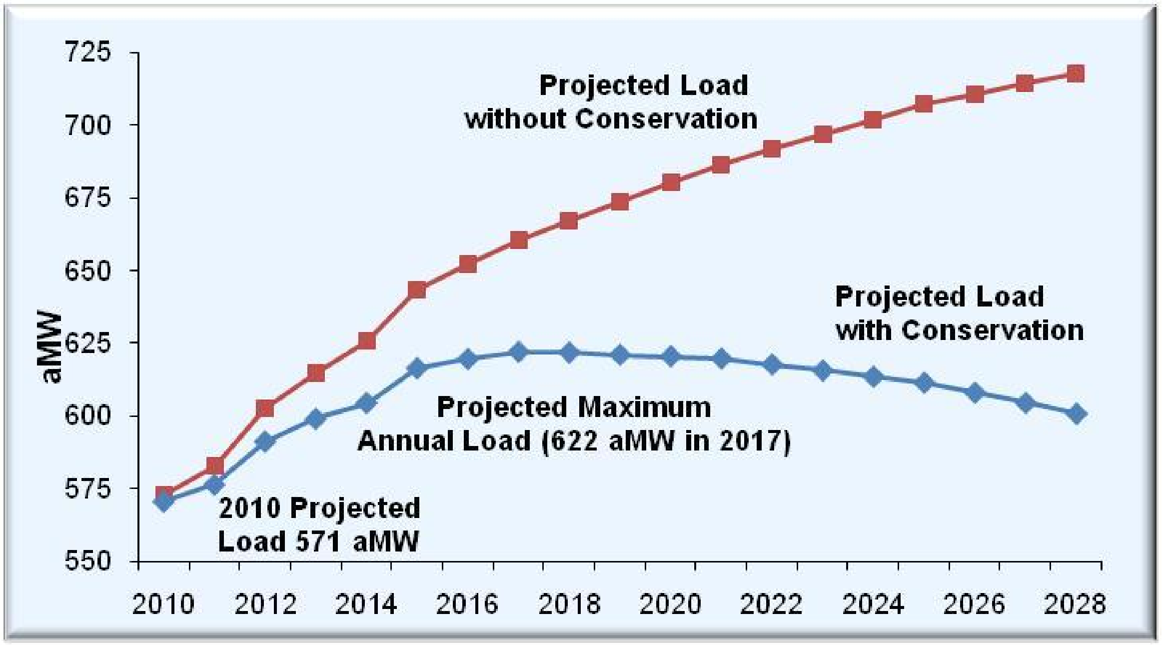
Tacoma Power's load forecast is the amount of power that retail customers are projected to demand over the next twenty years assuming normal weather conditions. The utility releases a new load forecast every year – the forecast used for this IRP was released in July, 2009.

Tacoma Power's load forecast began with a projection of retail demand for each of the utility's seven customer classes:

- For the Residential Service, Small General Service, General Service classes, retail load are projected with econometric models. These models are based on economic, demographic and weather-related factors.
- The Contract Industrial and High Voltage General Service class loads come from individual estimates for each large customer.
- Street Lighting load is based on a trend analysis.

These class specific projections were combined into a utility-wide load number which was then adjusted for system losses, self consumption and theft. The red line in Figure 2.1 depicts the resulting forecast, without accounting for conservation. Appendix D provides more information on how Tacoma Power projects retail load.

**Figure 2.1**
**Tacoma Power's Projected Annual Load**




Predicting Conservation Savings is challenging. The industry is rapidly changing; new technologies are becoming commercially available, and existing technologies are being improved. These changes are affecting the amount of cost-effective energy savings available. In this environment, conservation projections can quickly become out-of-date.

When the development of this IRP began, the 2007 Conservation Potential Assessment (CPA) was the most recent assessment of conservation available for Tacoma Power. However, for the reasons described above, the utility was concerned that the 2007 CPA no longer provided an accurate picture of the energy savings available.

To address this concern, the utility updated the 2007 CPA with information from the Energy Efficiency Alliance, the Regional Technical Forum and the NWPCC's Draft Sixth Power Plan. This update revised the residential and commercial sector energy savings estimates based on some new technologies, and cost reductions for some existing technologies. Conservation expected from industrial customers was also updated but the projected savings

> As is common practice in the industry, the **predicted conservation** reflects first year achievable savings. However, virtually all conservation measures last more than one year. A typical range is from three years (fluorescent lighting in commercial buildings) to as much as 45 years (home and building insulation). As a result, acquired conservation has a cumulative effect on energy consumption over time.

changed little. The updated conservation forecast, started at 5.4 aMW in 2010 and increased to 7.2 aMW by 2018.

Retail Load Net of Conservation is shown by the blue line in Figure 2.1. Retail load begins at 571 aMW in 2010, and grows at 1.2 percent per year until it reaches 622 aMW in 2017. In subsequent years conservation exceeds inherent growth. As a result, the retail load is projected to slowly decline to 602 aMW by 2028.

### *The 2010 CPA*

The release of the NWPCC's Sixth Regional Power Plan in February, 2010 allowed Tacoma Power to continue work on a new CPA. This new CPA was completed in August, 2010. While not sufficiently developed to be used in the base IRP analysis, data from the new CPA did contribute to the recommended annual conservation targets.

The 2010 CPA was specifically designed to comply with the conservation mandates of the Energy Independence Act. The Act requires utilities with more than 25,000 customers to acquire all cost-effective conservation. To ensure this is accomplished, eligible utilities must determine their 10-year conservation potential using methods consistent with those of the NWPCC. Utilities must then pro-rate the 10-year potential into a 2-year conservation target. Failure to meet the conservation target will cost the offending utility $50 (adjusted for inflation) for each MWh it falls short of the target.

Avoided Cost is the threshold at which conservation is not longer cost-effective. Tacoma Power's avoided cost is based on a forecast of wholesale market prices.[9]

Tacoma Power uses the Aurora[XMP] computer model by EPIS, Inc. to project long-term wholesale electricity prices. On an hourly basis, and subject to various constraints, the Aurora model adds progressively more expensive resources to the resource stack until the regional electrical supply equals the load forecast. The cost of the last resource added sets the wholesale price.

For the Northwest, the cost of natural gas is an important variable to the Aurora model. This is because typically the last generating resource added is a natural gas combustion turbine. And since fuel makes up the majority of costs of operating a natural gas combustion turbine, the price of natural gas is the primary driver of the wholesale electric price projections.

Tacoma Power does not estimate the market price of natural gas. Rather, the utility purchased a forecast by the consulting firm Global Insight. Global Insight uses a fundamentals based approach to project natural gas prices.

9 WA Department of Commerce regulations specify that avoided cost equals a utility's wholesale market price forecast:

> "Set avoided costs equal to a forecast of regional market prices, which represents the cost of the next increment of available and reliable power supply available to the utility for the life of the energy efficiency measures to which it is compared;" (WAC 194-37-070(6)(iii))

***The Aurora Price Forecasting Model*** is widely used in the Northwest and nationally. The Aurora model uses resource and market fundamentals to project the most likely power resource supply stack under a competitive market. The model adds virtual resources to this stack to meet demand conditions simulated in the model runs. Aurora iterates these simulations until it arrives at the least-cost result. The model identifies the cost of the marginal resources associated with the final stack – or the theoretical market clearing price (i.e. fuel costs plus variable operating costs). The Aurora model inputs include existing resources and their specific operating characteristics, fuel prices, transmission constraints, and electricity demand. Aurora models the Northwest hydro system with greater speed and rigor than alternative models and approaches.

The cost of environmental regulations is another important input. Tacoma Power ran the Aurora model assuming carbon dioxide emissions limits associated with federal legislative bills proposed by Bingaman-Spector and Lieberman-Warner. It is important to account for these potential environmental costs. Any new limits on $CO_2$ emissions will raise the operating costs of fossil fuel powered generation, including that of natural gas combustion turbines which typically set wholesale electricity market prices in the Northwest.

Tacoma Power varied input prices for natural gas prices and carbon dioxide to produce nine individual wholesale power price forecasts. Figure 2.2 shows the middle three forecasts that the IRP judged to represent the wholesale prices that are most likely to occur over the planning period. However, in some years wholesale power prices could diverge (higher or lower) from these forecasts, perhaps significantly.

**Figure 2.2**
**Projected Wholesale Power Prices**

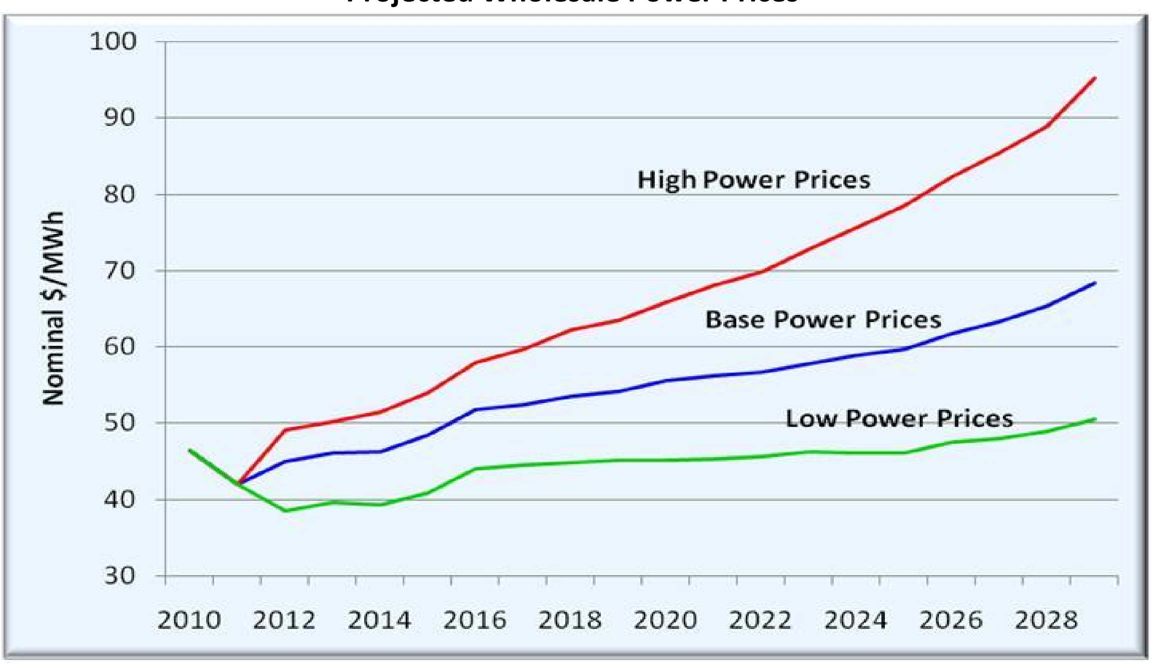


**Table 2.1**
**Tacoma Power's Calculated Conservation Based Upon Three Different Avoided Cost Projections**
**(Conservation potential, benefits and costs over 10 years)**

| Scenario | Technology Differences | Benefit | Costs |
|---|---|---|---|
| **Low Avoided Cost** 61.7 aMW | | | ▪ All sector 10-year direct costs could be $109M<br>▪ Residential 10-year directs costs could be $62M<br>▪ Commercial 10-year direct costs could be $29M<br>▪ Industrial 10-year direct costs could be $14M<br>T&D 10-year direct costs could be $4M |
| **Base Avoided Cost** 62.6 aMW | ▪ Residential Ductless heat pump<br>▪ Residential - Manufactured Homes Window Retrofit | ▪ Opportunity for residential customers with electric heat (high electric bills), that do not qualify for other weatherization programs.<br>▪ Expect good customer interest in ductless heat pump technology | ▪ All sector 10-year direct costs could be $145M<br>▪ Major measures added<br>▪ Residential 10-year costs for Ductless Heat Pump could be $25M<br>▪ Residential 10-year costs for Manufactured Home windows could be $8.5M. However, the current program requires the participant to own the property on which the manufactured home sits (most will not qualify).<br>▪ Other measures add $111.5M |
| **High Avoided Cost** 63.9 aMW | ▪ Residential- Convert electric resistance to Heat Pump<br>▪ Residential -Floor insulation<br>▪ Commercial – Refrigerated case lighting<br>▪ Commercial - Expanded use of certain commercial measures | ▪ Manufactured Home conversion from electric resistance to standard heat pump.<br>▪ Commercial case lighting refrigeration captures lost opportunity savings.<br>▪ Expanded opportunities to commercial customers. | ▪ All sector 10-year direct costs could be $157M<br>▪ Residential 10-year directs costs could be $107M<br>▪ Commercial 10-year costs could be $31M<br>▪ Major measures added<br>▪ Residential 10-year costs for conversion to heat pump could be $9.3M<br>▪ Commercial 10-year costs for case LED lighting could be $424k<br>▪ Other measures add $19M |

The Conservation Resource Assessment was performed by The Cadmus Group, Inc. (Cadmus), a conservation consulting firm. As part of this contract, Tacoma Power tasked Cadmus to develop a computer model to project conservation potential in a manner consistent with methodologies of the NWPCC. Table 2.1 shows the utility's estimated conservation potential based on the three different avoided cost projections. (See Appendix E for the complete Cadmus report.)

With a low avoided cost assumption, the conservation potential includes over 200 discrete program activities. Over 10 years, these activities would cumulatively acquire about 62 aMW of energy savings at an average cost of $31.7/MWh. (See Table 2.2) The base avoided cost adds 2 conservation measures and increases energy savings to nearly 63 aMW. The incremental cost of these measures is $53.8/MWh. The high avoided cost scenario adds several small conservation programs for a total of about 64 aMW of cumulative energy savings. The last 1.3 aMW of conservation comes at a cost of $66.4 per MWh.

After carefully considering the three avoided cost options, the IRP determined that base wholesale price forecast is most appropriate for Tacoma Power. The base price forecast used the median estimate of natural gas prices from Global Insight, and carbon dioxide emission limits associated with the proposed Bingaman-Spector bill. Tacoma Power has used this forecast for other purposes such as budgeting, load forecasting, and project assessment. Also, the base forecast aligns well with the prices at which electricity is current traded in the forward wholesale market. Thus, the 2010 CPA indicates that Tacoma Power's 10-year conservation potential is 62.6 aMW. This level of conservation is within 2 percent of the updated 2007 CPA amount used in the base analysis for this IRP.

**Table 2.2**
**Cost Effectiveness of Alternative Conservation Acquisition Levels**

| Avoided Cost | Cumulative Cost | | Cumulative MWH Savings | | Increm. $/MWh |
|---|---|---|---|---|---|
| | Total | Incremental | Total | Incremental | |
| Low | $87,614,013 | | 2,761,262 | | 31.7 |
| Base | $131,461,853 | $43,847,841 | 3,575,773 | 814,511 | 53.8 |
| High | $141,148,060 | $9,686,206 | 3,721,646 | 145,872 | 66.4 |

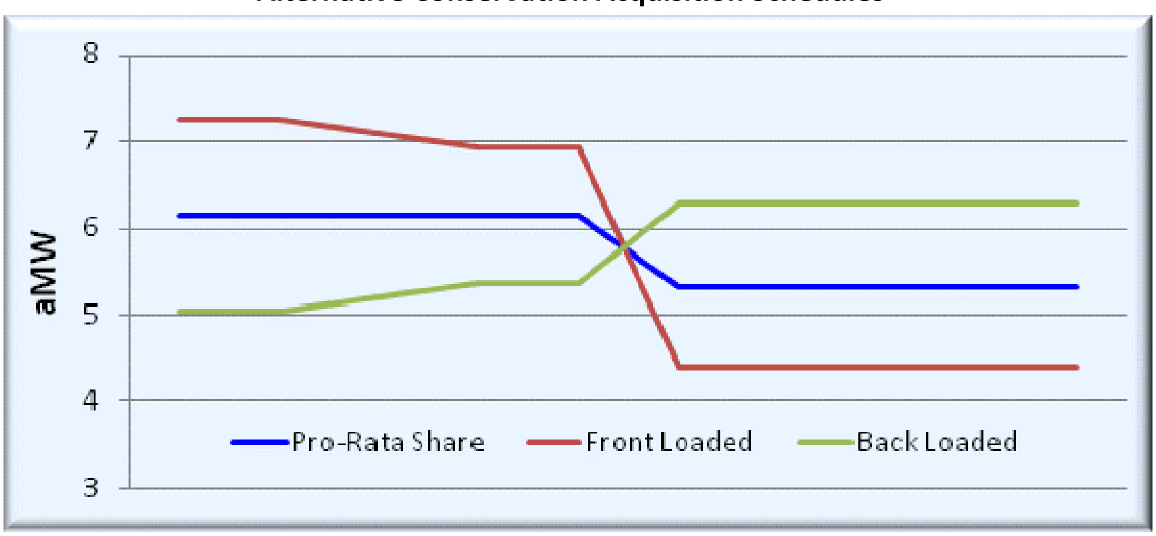
Ramp Rates are the final consideration when setting 2-year conservation targets. The Energy Independence Act requires that 2-year acquisition target be a *pro-rata* share of a utility's 10-year potential. The blue line in Figure 2.3 represents

Tacoma Power's annual conservation acquisition following the *pro-rata* share schedule. The level falls in 2015 as a result of the establishment of new federal regulations designed to phase out the use of incandescent light bulbs and thereby improve lighting efficiency.

Regulations governing the implementation the Energy Independence Act require utilities to investigate scenarios that accelerate conservation acquisition (WAC 194-37-070). The red line in Figure 2.3 represents Tacoma Power's annual conservation following a front-loaded schedule where acquisition is 20 percent higher from 2010 through 2014, and 20 percent lower from 2015 through 2019. The green line represents annual conservation following a back-loaded schedule where acquisition is 20 percent lower from 2010 through 2014, and 20 percent higher thereafter.

Tacoma Power assessed the economics of each schedule. The back-loaded schedule produces the most net benefits by acquiring less conservation in the early years when the value of the power saved is lower, and more in later years when electricity is more valuable. (Figure 2.2 shows the projected rise of wholesale electricity prices over time.) As a result, the net present value of the back-loaded schedule is about $1.2 million more than the *pro rata* schedule. The front-loaded schedule has the opposite result. Its net value is about $2.0 million lower than the *pro rata* schedule because it would acquire more conservation during the lower value early years, and less in the later years when the electricity saved has a higher value.

**Figure 2.3**[10]
**Alternative Conservation Acquisition Schedules**




[10] This conservation acquisition represented by the blue line includes only conservation directly acquired through Tacoma Power programs. It does not include conservation BPA expects to acquire at Joint Base Lewis McChord or conservation resulting from the transition to new federal standards.

Of the three conservation acquisition schedules assessed, the back-loaded schedule would most benefit Tacoma Power's customers. Unfortunately, the Energy Independence Act does not allow a back-loaded acquisition schedule. Therefore, the *pro rata* acquisition schedule is most appropriate for Tacoma Power.

<u>Tacoma Power's Recommended Level of Conservation</u> for the years 2012 and 2013 is 12 to 13 aMW. The final target will be developed through the conservation market plan which is due in the Fall. This conservation market plan will analyze the opportunities for conservation in the utility's service territory and will set forth a plan to deliver conservation to each market sector. Tacoma Power's Conservation Resources Management group develops and publishes a market plan every two years.

***Tacoma Power's 2010-2011 Conservation Targets***

On October 28, 2009, and pursuant to the Energy Independence Act, the Tacoma Board of Public Utilities identified Tacoma Power's 10-year conservation potential at 41.0 aMW and conservation target for the years 2010-2011 of 9.3 aMW. These figures were based on the NWPCC's Conservation Calculator. At the same time Tacoma Power announced an aspirational conservation goal for the 2010-2011 period of 10.8 aMW. This goal was from the utility's 2008 IRP and based on the 2007 Conservation Potential Assessment.

# Supply Resources

Tacoma Power obtains electricity from a variety of sources which are briefly described below. (Appendix F provides additional information about utility resources.)

### *The BPA Contract*

The majority of the electricity that the utility delivers to retail customers comes through a power supply contract with BPA. Through September 2011, Tacoma Power will receive this electricity under a Block Power Sales Agreement. Starting in October 2011, a new Slice/Shaped Block contract will replace the existing Agreement. One challenge with assessing the utility's load-resource balance is that certain provisions of the new BPA contract are not fully developed, including the amount of power BPA will deliver.

At the time of this analysis, Tacoma Power presumed that the new Slice/Shaped Block contract would have a contract high-watermark maximum (CHWM) of 414 aMW. This amount was a combination of 210 aMW from the "Slice" portion (2.989% of BPA's Tier 1 system) and 204 aMW from the "shaped block" portion.[11] More recent

[11] The "Shaped Block" portion of the BPA contract delivers a different flat amount of power every month based on Tacoma Power's monthly load shape. Over the course of a year, Tacoma Power projects to receive 204 aMW of electricity from the shaped block portion of the BPA contract.

information indicates a CHWM of between 390 and 414 aMW, with a best estimate of slightly more than 400 aMW. The final amount will be set in 2013.

The new BPA contract further caps the annual amount of firm electricity Tacoma Power will receive. BPA will calculate this amount by subtracting the amount of electricity generated by the utility's own resources at critical water from Tacoma Power's retail load. This is known as the "net requirements" calculation. As a result of this calculation, Tacoma Power projects to receive approximately 385 aMW of firm electricity in 2012. This leaves approximately 29 aMW of "headroom" to accommodate load growth.

> Tacoma Power defines "**critical water**" as the amount of electricity that the utility would generate if the combined annual streamflow into Tacoma Power and BPA projects equaled the lowest amount on record. This streamflow occurred from August 1940 to July 1941.
>
> "**Adverse water**" is the amount of streamflow associated with the 75th percentile year – three-out-of-four years have higher flows, while one-out-of-four years has a lower flow.

The Slice/Shaped Block Contract also provides utilities with a limited new ability to shape the Slice energy as if the utility were operating the Federal Hydro system. Thus, Tacoma Power can manage the storage assets of the federal system in a manner that benefits its facility operations. This could change the way Tacoma Power plans for and operates our resource portfolio.

### *Utility Owned Hydroelectric Projects*

Tacoma Power's seven hydroelectric dams make up the utility's second largest source of electricity. Three of these dams are located in the Olympic mountain range while the other four have headwaters in the Cascade Mountains. These separate locations provide some geographic diversity; river flow patterns vary somewhat among Tacoma's own resources, and between those resources and BPA's generating projects whose headwaters mostly begin in the northern Rocky Mountains.

Mossyrock is the largest of Tacoma Power's dams. It was built in 1968 on the Cowlitz River. In 2007, Tacoma Power undertook a complete rebuild of the turbine-generator units. The first rebuilt unit, No. 51, was brought back online in late 2009. The second unit, No. 52, is currently out of service and expected to return to service in late 2010. In a normal water year the Mossyrock dam produces about 127 aMW of electricity.

Tacoma Power's six other major dams produce 197 aMW of electricity in an average water year. The utility also has a small generator at the Hood Street Reservoir within the city limits.

### *Power Purchase Contracts*

Tacoma Power has several long-term agreements with Grant County PUD to purchase a small amount of power from the Priest Rapids Hydroelectric Project. Tacoma Power also has power purchase agreements with the Grand Coulee Project Hydroelectric Authority (GCPHA) which operates generating stations along irrigation canals in Eastern Washington.

### *Summary of Tacoma Power Resources*

Table 2.3 summarizes the electricity expected from all of Tacoma Power's resources for the year 2012, the first full year of the new BPA contract.

**Table 2.3[12]**
**Tacoma Power's Owned and Contracted Resources**

| Resource | Facility (Nameplate Capacity in MW where appropriate) | Average Energy Production (aMW) | Critical Energy Production (aMW) |
|---|---|---|---|
| **New BPA Contract (critical year 1937)** | | | |
| | Multiple | 460.0 | 414.0 |
| **Utility Owned Projects (critical year 1941)** | | | |
| Cowlitz | Mayfield (162) | 83.2 | 46.0 |
| | Mossyrock (300) | 127.5 | 70.5 |
| Nisqually | Alder (50) | 27.5 | 15.3 |
| | La Grande (64) | 41.1 | 24.6 |
| Cushman (Skokomish River) | No. 1 (43) | 14.3 | 8.0 |
| | No. 2 (81) | 19.4 | 8.0 |
| Wynoochee | Wynoochee (13) | 3.8 | 3.6 |
| Hood St. | Hood St. (0.8) | 0.3 | 0.3 |
| **Other Contracts** | | | |
| Grand Coulee Project Hydroelectric Auth. | | 27.5 | 27.5 |
| Priest Rapids | | 2.5 | 2.0 |
| Federal System Diversity Benefit | | | 12.0 |
| **Total** | | **807.1** | **631.2** |

12 Production figures from Tacoma Power's July 13, 2010, Official Statement associated with a new bond issuance by the utility. The amount associated with the Priest Rapids project was reduced to account for an expected decline in electricity from this contract. Also, the generating projects operated by the Grand Coulee Project Hydroelectric Authority only operate during part of the year, typically from late March until mid-late October.

# Annual Load-Resource Balance

This IRP followed long-standing utility practice when assessing Tacoma Power's annual load-resource balance. The output of Tacoma Power's collective resources operating under critical water conditions was compared to expected annual utility retail load over the planning period. The black line in Figure 2.4 indicates the utility's forecasted annual load after conservation. As discussed earlier, the forecasted load grows slowly until 2017 at which point conservation begins to slowly reduce load.

Calculating the amount of power available to Tacoma Power under critical water conditions requires first reconciling the fact that the utility and BPA have different critical years. Tacoma Power's occurred during the 1940-41 operating year, while BPA's critical year occurred in 1936-37. This IRP determined that the lowest overall water conditions for the combined Tacoma Power/BPA hydroelectric resources occurred in the 1940-41 operating year.

The bars in Figure 2.4 represent Tacoma Power's supply projections assuming a reoccurrence of the water conditions of the 1940-41 operating year. The dark blue portion represents the power from the utility's current and upcoming BPA contract, the green portion electricity from other contracts, and the orange portion electricity from the utility's own hydroelectric resources.

The total amount of power available declines through 2012, as the current BPA contract comes to an end and the new one begins. Then the power from BPA increases as Tacoma Power grows into the "headroom" available through the "net requirements" calculation. The total amount of power available to Tacoma Power in 2017 assuming critical water is projected at 622 aMW.

In the years 2012 through 2024, Tacoma Power's resources exceed load by an average of 7.6 aMW assuming critical water conditions. However, from 2025 through 2028, Tacoma Power's load-resource position transitions to an average 15 aMW deficit as the GCPHA supply contracts begin to expire. This analysis indicates that Tacoma Power is resource adequate throughout most of the IRP planning horizon.

While Figure 2.4 represents Tacoma Power's annual load-resource balance at critical water, the utility will typically have a much larger supply of electricity. The pink bars in Figure 2.5 show the added energy expected from utility resources and the BPA contract in a median water year. With median water conditions, Tacoma Power's annual energy surplus is over 200 aMW.

**Figure 2.4**
**Tacoma Power's Load-Resource Balance: Critical Water**

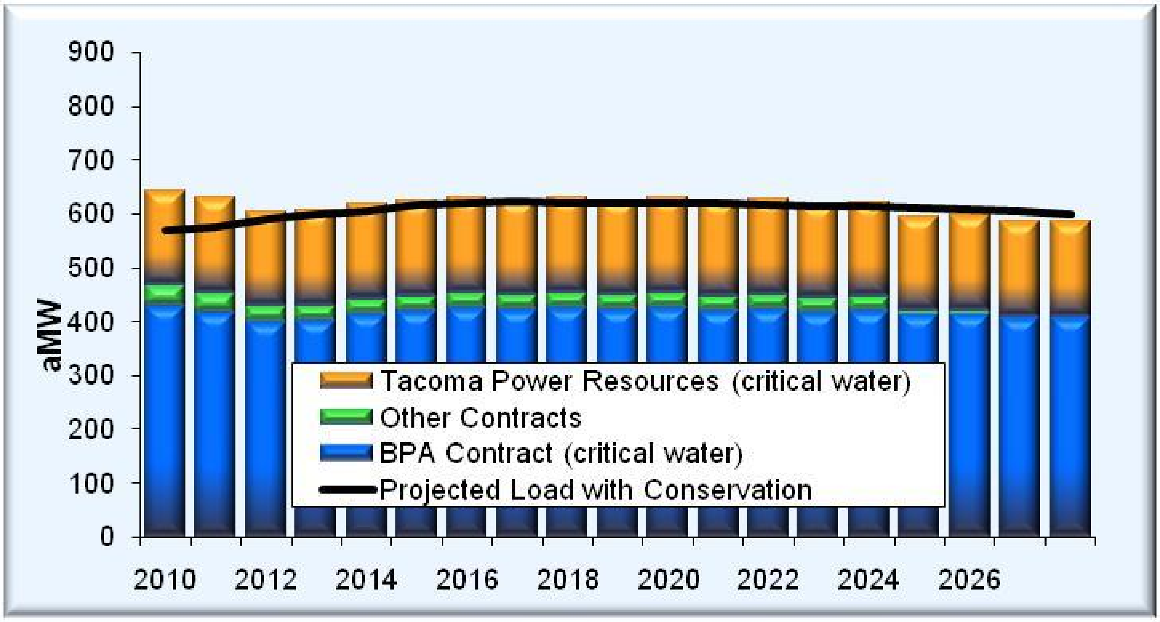
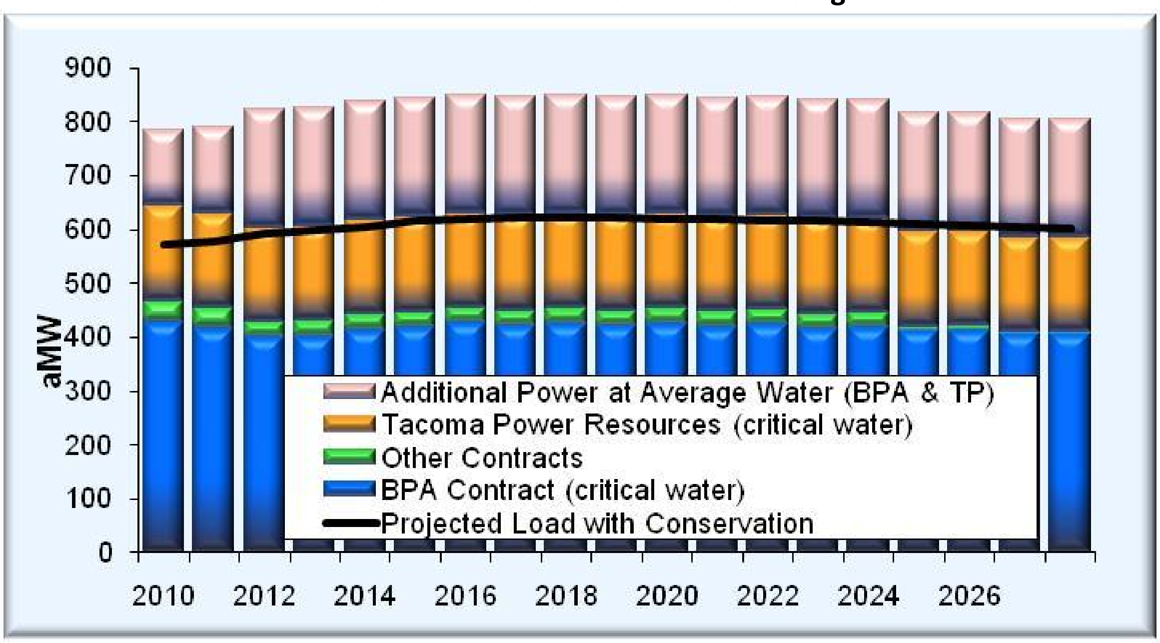



**Figure 2.5**
**Tacoma Power's Load-Resource Balance: Average Water**




## Monthly Load-Resource Balance

Tacoma Power's 2008 IRP indicated that the utility could face seasonal or monthly load-resource balance deficits as a result of moving to the BPA Slice/Block Contract. As such, Tacoma Power's monthly load-resource balance was a principle focus of the 2010 IRP. The monthly analysis was conducted using Vista LT©, a load-resource optimization computer model (monthly model) by Synexus Global®. Because this model is new to Tacoma Power, the analytical methods and results are discussed in somewhat more detail than the annual or peak load-resource assessments.

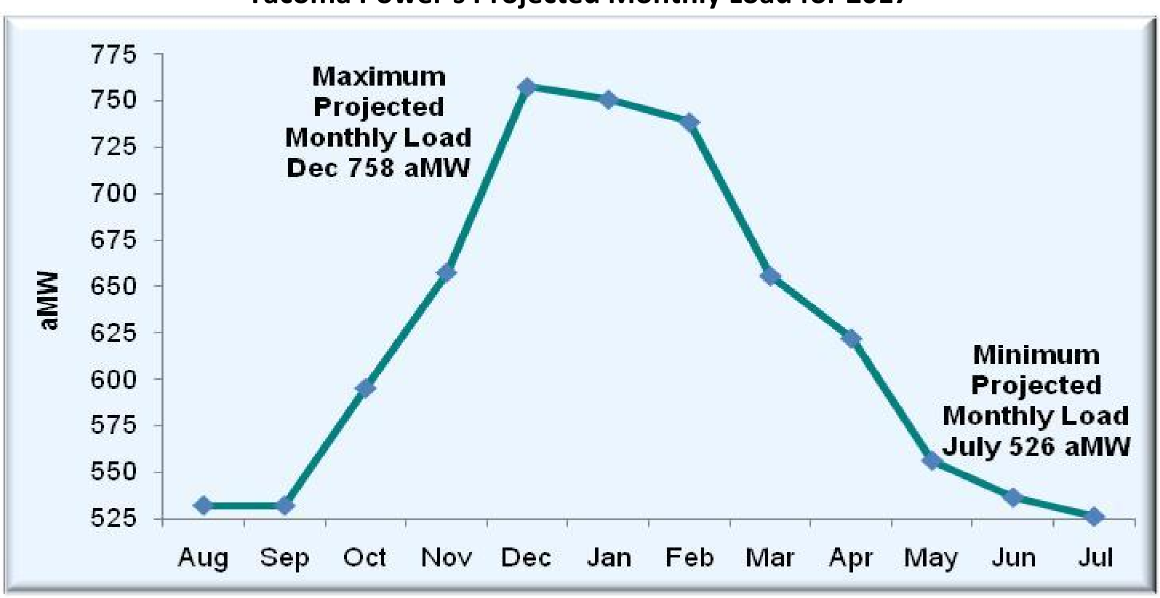
The monthly model is designed to identify the resource operating regime (the timing and quantity of generation) that maximizes the value of electricity generated over an entire operating year. Achieving maximum value is important as the revenues received from wholesale power sales help Tacoma Power to maintain low retail rates. Inputs to the model include retail loads, river flows and wholesale power prices, as well as the operational paradigms and regulatory constraints of individual hydro-generation facilities.

The monthly model produces a multitude of data but the output of most interest for this analysis is wholesale transactions – energy sales represent a positive load-resource balance while energy purchases signal a supply deficit.

### *Monthly Load*

Tacoma Power forecasted monthly loads by apportioning the annual load estimates into monthly forecasts based on historical daily system loads. For this analysis, monthly retail loads were based on the 2017-18 operating year, the year when the annual retail load is projected to peak. The 622 aMW load projected for that year has the potential to be the most challenging for the utility from a resource supply perspective. Figure 2.6 presents Tacoma Power's projected load shape for the 2017-18 operating year. This figure clearly shows that Tacoma Power is a winter peaking utility.

**Figure 2.6**
**Tacoma Power's Projected Monthly Load for 2017**



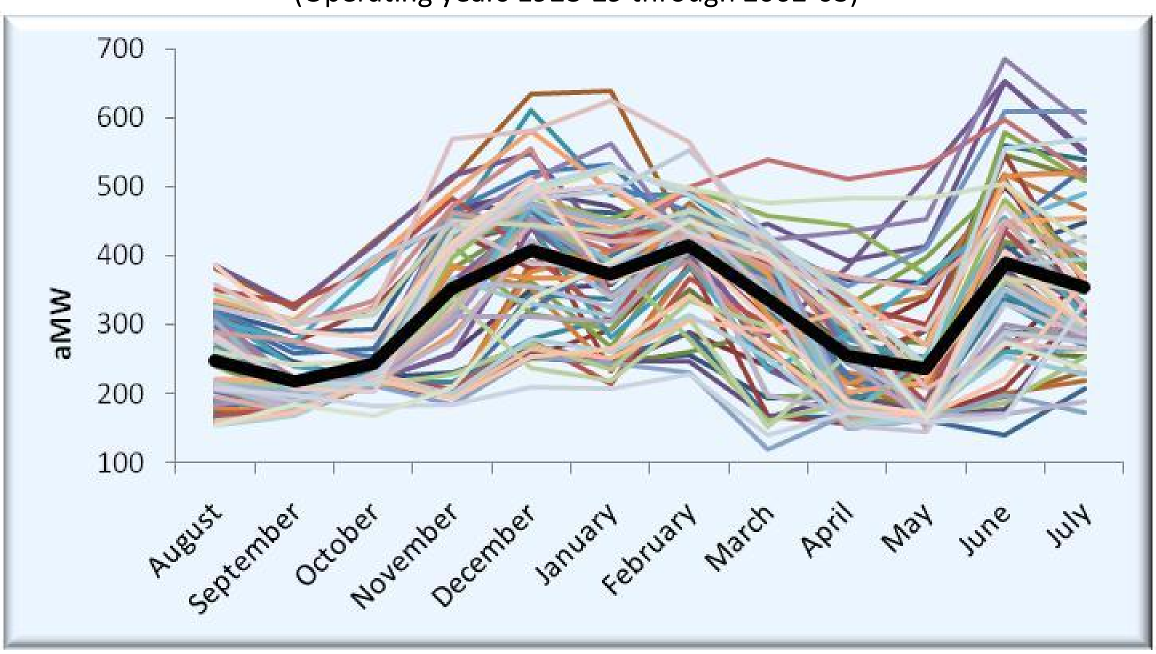
### *Monthly Resources*

Tacoma Power's monthly resources are largely the same as the annual resources identified in Table 2.3. However, the amount of energy these resources can produce in any given month depends on several factors including: precipitation, temperature (induced snow melt), reservoir level, stream flow requirements and ramping restrictions, recreational activity expectations, weather forecasts, and flood control mandates.

Figure 2.7 illustrates the historic variability in output from Tacoma Power's generating projects. Each line represents the monthly generation over a specific operating year. The black line represents the average generation for each month. As can be seen, the variability around this average can be significant: about 200 aMW in winter months and nearly 300 aMW in the summer. The challenge when assessing Tacoma Power's monthly load-resource balance status is to determine how generating resources will operate under real world conditions that vary from year-to-year and month-to-month.

An additional consideration is the revenue potential of selling excess power to the wholesale market. Tacoma Power will, when prudent, withhold production (store water) in one month so that extra power can be generated in a following month when higher electric prices are expected.

**Figure 2.7**
**Total Electrical Production at Tacoma Power's Owned Projects by Month**
(Operating years 1928-29 through 2002-03)



### Set-Up of the Monthly Model

The monthly model was specifically designed to represent operations of hydro-based generation systems. Important model inputs include retail load, project inflows, non-hydro electricity supply (e.g., contracts and thermal resources), and wholesale power prices. The monthly model maximizes the value of the output from a utility's resources subject to the constraints and inputs described above.

Electricity supplies were accounted for in two ways. Power from the GCPHA contract, the Priest Rapids contract and the Wynoochee hydro project were input as fixed amounts based on historical monthly generation.

For other hydro resources, the monthly model determined the timing and quantity of electricity production that would maximize the value of that energy. This determination was based 75 operating years of historical daily project inflows, beginning in August 1928 through July 2003. Each of these years represents a unique set of actual inflows to Tacoma Power and BPA projects. This river flow data is assumed to represent the range of hydro-project inflows that the utility is likely to experience.

The monthly model was calibrated during initial runs to ensure compliance with all operating constraints, including: reservoir minimum, maximum and target elevations; minimum seasonal river flow requirements and ramping restrictions; and, transmission capacities and equipment outages. Other adjustments were made to ensure the model reasonably followed Tacoma Power's resource operating conventions.

### Monthly Model Results

When reviewing the monthly model results, Tacoma Power looked for two adverse outcomes, either of which could indicate a potential need for new resources. The utility considered first whether any operating year had a negative load-resource balance over the entire water year. And second, whether multiple operating years had load-resource balance deficits over the same season. While no firm adequacy standard exists for seasonal deficits, it was also assumed for this IRP that eight or more operating years with deficits over the same season would be problematic. Further, 4-to-8 operating years with deficits over the same season could be of concern depending on the magnitude of those deficits. An outcome where less than four operating years had seasonal deficits would generally not indicate the need for new resources.[13]

Figure 2.8 shows the results of the monthly model. Each line represents Tacoma Power's monthly load-resource balance based on a particular year of actual river flows. Months above 0 aMW indicate a load-resource surplus while

[13] Eight operating years roughly equates to 10 percent of all operating years assessed, whereas four operating years equals approximately 5 percent of the assessed operating years.

those below 0 aMW indicate a deficit. The monthly model indicates that June is the most energy rich month. The average surplus for June is more than 400 aMW. June also has the highest surplus month, with 808 aMW occurring during the 1973-74 operating year.

Conversely, October has consistently produced the lowest electricity sales. This is largely due to wholesale electricity prices being lower in October than in November and December. The model took advantage of this price differential by throttling back October energy production – within the limits of environmental and flood control protocols – in favor of production in November and December.

On an annual basis, the monthly model indicated that project inflows of the 1954-55 operating year produced the median amount of electricity; nearly 220 aMW over that needed to serve retail load. The range of excess annual generation spanned from 27 aMW for the 1940-41 operating year, to 406 aMW for the 1955-56 operating year.

Overall, Figure 2.8 shows that Tacoma Power's resources are virtually always surplus to retail load.

Table 2.4 focuses on Tacoma Power's monthly load-resource balance over the 12 operating years that produce the least generation. This table indicates that in dry operating years, Tacoma Power has little to no surplus power to sell during the months of October through March. During some of these dry years, the water needed for generation exceeds inflow during the winter. Under these conditions, the model's first response was to cease wholesale power sales.

**Figure 2.8**
**Tacoma Power's Load-Resource Balance with 2017-18 Retail Load over Operating Years 1928-29 through 2002-03**

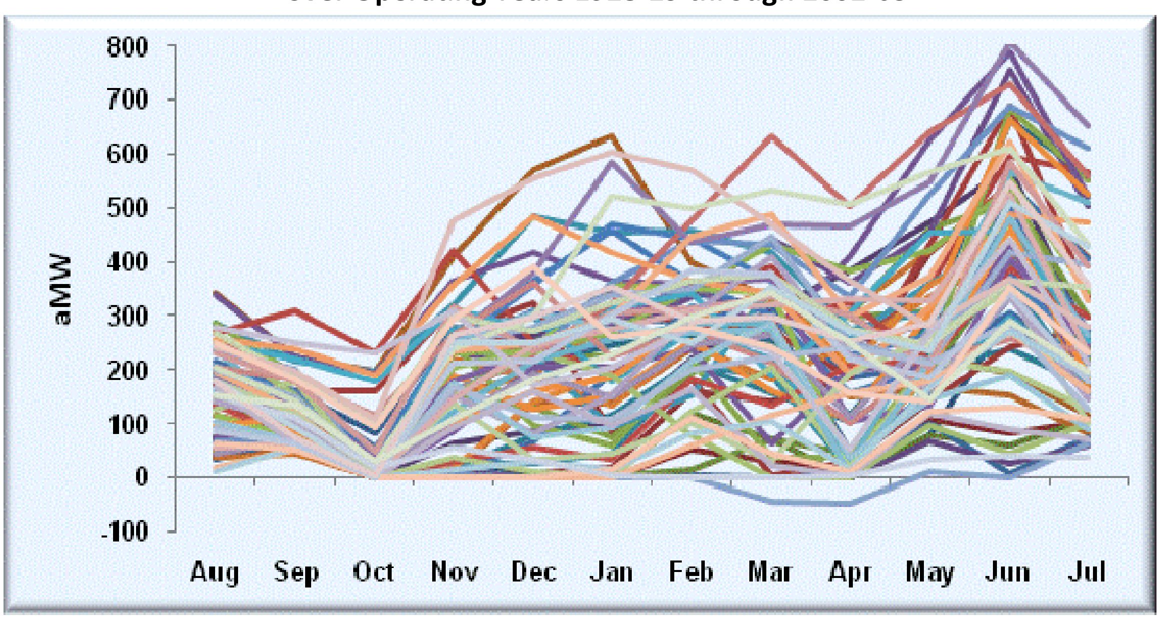


**Table 2.4**
**Monthly Load-Resource Balance (aMW) for the 12 Lowest Production Operating Years**

| | 1928-29 | 1929-30 | 1930-31 | 1936-37 | 1940-41 | 1943-44 | 1976-77 | 1987-88 | 1991-92 | 1992-93 | 1993-94 | 2000-01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUG | 75 | 39 | 47 | 40 | 34 | 70 | 235 | 18 | 169 | 12 | 64 | 151 |
| SEP | 67 | 62 | 69 | 53 | 75 | 55 | 203 | 53 | 64 | 58 | 54 | 113 |
| OCT | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| NOV | 29 | 0 | 0 | 0 | 16 | 10 | 2 | 0 | 94 | 16 | 0 | 55 |
| DEC | 6 | 0 | 0 | 7 | 1 | 0 | 0 | 0 | 161 | 29 | 0 | 32 |
| JAN | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 95 | 16 | 13 | 5 |
| FEB | 3 | 53 | 119 | 16 | 0 | 0 | 0 | 59 | 164 | 83 | 112 | 0 |
| MAR | 0 | 29 | 72 | 72 | 0 | 0 | -45 | 117 | 24 | 105 | 43 | 0 |
| APR | 0 | 20 | 0 | 44 | 17 | 0 | -48 | 156 | 6 | 16 | 10 | 2 |
| MAY | 80 | 107 | 80 | 189 | 99 | 69 | 13 | 178 | 119 | 168 | 121 | 32 |
| JUN | 302 | 81 | 60 | 402 | 7 | 27 | 0 | 273 | 91 | 273 | 129 | 40 |
| JUL | 155 | 105 | 109 | 222 | 73 | 58 | 63 | 161 | 72 | 188 | 107 | 38 |

The model's next response, if necessary, was to draw more water from the Riffe Lake reservoir than normal – an action Tacoma Power has employed in some dry years. The model's ability to simulate such real world behavior allowed it to keep Tacoma Power resource neutral or better in all but 2 of 900 months. Only during March and April of the 1976-77 operating year did monthly retail load exceed resource supply – by about 47 aMW.

**The Riffe Lake Reservoir** is part of the Mossyrock project. Under Tacoma Power's preferred operating regime, the elevation of Riffe Lake begins at 770 feet above sea-level in August. In the fall and winter, Riffe Lake is drawn down to 710 feet make room for potential flooding and then refilled through the spring and early summer. However, during dry years Tacoma Power has the flexibility to draw extra water from Riffe Lake or limit refill to generate extra electricity. For example, during the 2000-01 operating year – Tacoma Power's third driest year on record – the Riffe Lake reservoir was brought down to 645 feet and refill topped out at 739 feet.

This analysis does not indicate a need for new supply resources. Neither an entire operating year nor a seasonal resource deficit was evident. Moreover, Tacoma Power has options in dealing with the rare monthly shortage. The utility can use the storage capacity of the Mossyrock reservoir (Riffe Lake) to draw extra power in one month and replace it in a future month. Tacoma Power can also buy power from the wholesale market to cover a shortage. Given the rarity, the short-term nature, and the relatively small magnitude of the potential monthly deficits, these options are preferable to acquiring a new expensive resource that would rarely be needed to serve retail load.

### *Monthly Load-Resource Balance with Weather Adjusted Loads*

Tacoma Power experiences a wide range of weather in its service territory. Figure 2.7 illustrates the range of monthly power production of utility generating projects (and by extension precipitation in project watersheds and river flows). Figure 2.9 shows that the number of heating degree days (HDD), a primary determinate of electric load, can vary significantly during winter months. For example, while January averages about 600 HDD, during extremely cold years it can reach 1000, a 65 percent increase.

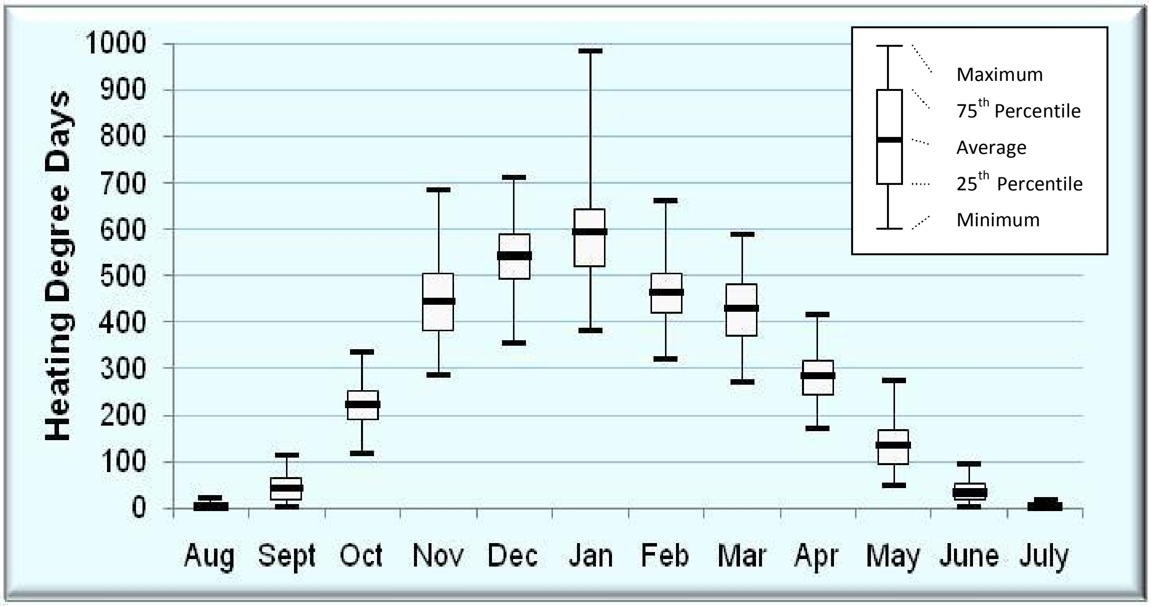
> **Heating degree-days** are calculated by 1) averaging the daily maximum and minimum temperatures (Fahrenheit scale), and 2) subtracting the mean temperature from 58ºF. Each degree of mean temperature below 58ºF is counted as one heating degree day.

Tacoma Power was concerned that if years with high winter month HDD numbers also had low precipitation, then the above analysis could understate likelihood of monthly resource deficits. To evaluate this concern, individual load forecasts were developed for the six driest water-years from 1940-41 through 2002-03 based on actual weather that occurred during those years. (Earlier years were not included due to an unavailability of weather data.)

The monthly model projected Tacoma Power's load-resource balance for these six years – based on loads predicted from actual weather and generation associated with actual project inflows.

**Figure 2.9**
**Heating Degree Day Variance by Month**[14]

[14] Data on heating degree days came from National Oceanic Atmospheric Administration temperature records at McChord Airforce Base (Now Joint Base Lewis McChord).




For this IRP two methods to develop adjusted load projections based on the actual weather from those 6 dry years. The first method was based on an internally developed econometric model that predicts commercial and residential hourly loads based on cloud cover, temperature, and wind speed. The second method used a MW/HDD conversion factor used to project Tacoma Power's long-term retail loads.

Re-running the monthly model with the adjusted loads again produced two months with negative resource balances (see table 2.5). The deficits for those months were slightly less (38 aMW for the adjusted loads vs. 47 aMW) on average for the unadjusted loads. One observation regarding the adjusted load model runs is that dry years typically had higher annual surpluses than the unadjusted dry years. This suggests that weather tends to be warmer than normal during dry years.

A similar concern is whether or not the load induced by an especially cold year would create problems with the utility's load-resource balance. The IRP identified the six coldest years and developed unique load forecasts for those years. (It is interesting to note that all but one of these cold weather years were wetter than normal.) The load-resource balance surplus fell modestly (about 14 aMW) for the six cold weather years assessed. Nevertheless, Tacoma Power remained substantially surplus in these years.

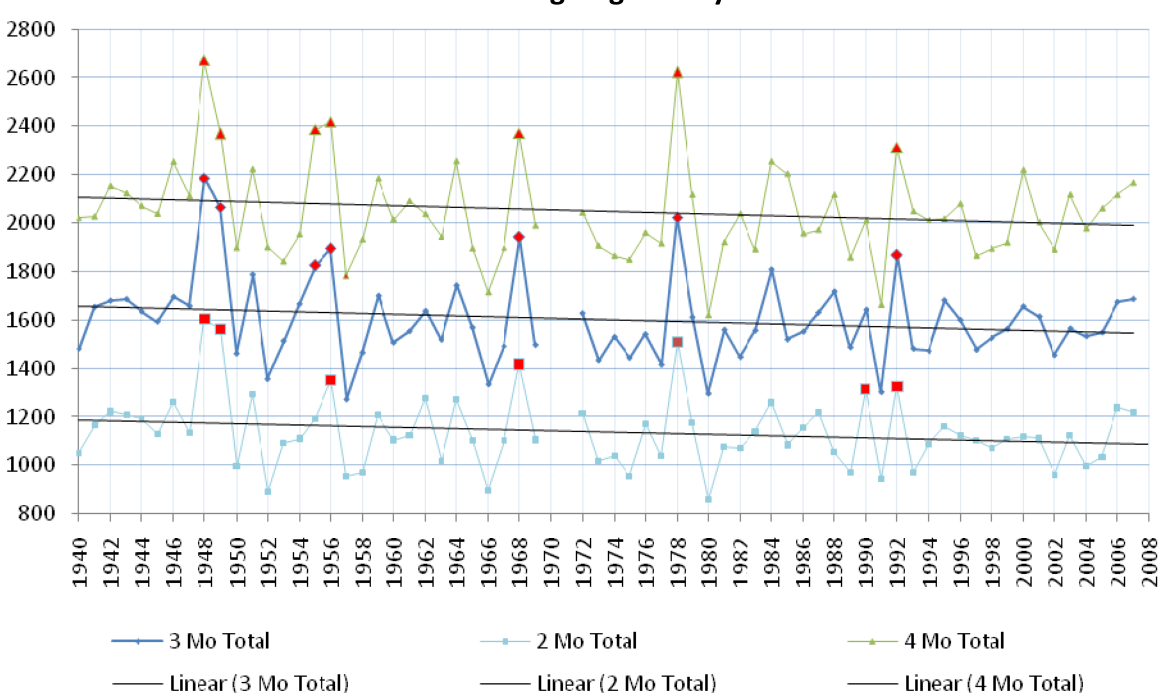
The outcome of the monthly load-resource balance assessment using weather adjusted loads provides further assurance that Tacoma Power does not face significant risks of becoming resource deficit.

**Table 2.5**
**Load-Resource Balance With Adjusted Loads**

| Hydro Year | Year Type | Original load forecast | | Adjusted Load Forecast | |
|---|---|---|---|---|---|
| | | Annual Surplus (aMW) | Number of Months Deficit | Annual Surplus (aMW) | Number of Months Deficit |
| 1940-41 | Dry | 27 | 0 | 46 | 0 |
| 1943-44 | Dry | 24 | 0 | 36 | 0 |
| 1948-49 | Cold | 226 | 0 | 207 | 0 |
| 1949-50 | Cold | 310 | 0 | 294 | 0 |
| 1955-56 | Cold | 406 | 0 | 392 | 0 |
| 1956-57 | Cold | 218 | 0 | 207 | 0 |
| 1968-69 | Cold | 294 | 0 | 286 | 0 |
| 1976-77 | Dry | 35 | 2 | 34 | 2 |
| 1978-79 | Cold/Dry | 104 | 0 | 89 | 0 |
| 1992-93 | Dry | 80 | 0 | 99 | 0 |
| 1993-94 | Dry | 54 | 0 | 80 | 0 |
| 2000-01 | Dry | 41 | 0 | 51 | 0 |

Finally, during the process to adjust the load forecast, it was noticed that most cold years occurred 40 to 50 years ago. (See Figure 2.10). This observation led to an effort to look for trends in the historical HDD data. Within the high year-to-year variability in the data, there appears to be a slow but steady decline in fall and winter HDDs. A regression analysis indicated a drop of 17.4 HDDs every 10 years. Should this decline continue, it could lower Tacoma Power's 2017-18 wintertime retail load (November – February) about 1.5 aMW.

**Figure 2.10**
**Fall and Winter Heating Degree Day Totals Over Time**



### *Monthly Load-Resource Balance Stress Tests*

Stress testing can illuminate how variations in uncertain inputs might affect Tacoma Power's load-resource balance. Three key inputs to the monthly modeling are uncertain:

1. The amount of power BPA will provide under the new contract.
2. The amount of load growth.
3. The amount of conservation the utility will acquire.

Additional modeling was performed to further confirm Tacoma Power's load-resource balance position.

***Updated Load Forecast***

In July 2010, well after the completion of analysis portion of this IRP, the utility released a new long-term retail demand forecast. This new forecast indicates a 2017-18 retail demand of approximately 601 aMW, significantly lower than the 622 aMW assumed for this IRP. On the other hand, that forecast predicts demand will continue to rise, reaching 622 aMW in 2022-23 and topping off in 2027-28 at 628 aMW. This new forecast increases

<u>The BPA Contract</u> As discussed above, the amount of power that Tacoma Power will receive under the new BPA contract is, as yet, uncertain. At the time of the base analysis, Tacoma Power projected to receive 414 aMW through the BPA contract. The utility now expects between 390 and 414 aMW with a best estimate of around 400 aMW.

The first stress test re-ran the monthly model with BPA contract amounts of 405 and 395 aMW. With the 405 aMW contract amount, only the months of March and April in the 1976-77 operating year were deficit. At a BPA contract amount of 395 aMW, nine months were deficit during three operating years (1940-41, 1943-44, and 1976-77). For four of those months, the deficit was less than 10 aMW. The deficit for the remaining five months averaged about 85 aMW.

Neither of these stress tests indicates that Tacoma Power needs additional resources. All operating years were surplus over the entire year and in no case was the same month deficit in more than 3 operating years. At the 405 aMW contract level, only 0.2 percent of all months assessed was deficit. Even at the lower 395 aMW contract amount, deficits occurred in only 1 percent of the months assessed. And as discussed above, Tacoma Power has a variety of tools to deal with short-term deficits of the magnitude projected here.

<u>Retail Load</u> projections have typically been quite accurate at Tacoma Power (on a weather adjusted basis). However, ongoing economic recession presents a significant forecasting challenge. The base projection assumes load growth of about 1.8 percent over the first 10-years

of the planning period absent additional conservation.[15]

To stress test the load effects, the utility's year-over-year load growth was assumed to increase 25 percent faster than in the base case. The higher load projection equates to an annual growth rate of about 2.3 percent, or a load of 646 aMW in 2017-18.

The adverse consequence of the higher load was particularly evident in three operating years (1940-41, 1943-44, and 1976-77). A total of nine months over these three years were deficit. For four of those months, the deficit was less than 20 aMW. The remaining five months had an average deficit of about 85 aMW.

This stress test did not alter the conclusion that Tacoma Power has sufficient resources. No full operating year was resource deficit and no calendar month was deficit over four or more operating years.

Conservation Acquisition is a final major uncertainty of the load-resource balance assessment. This stress test checked the utility's load-resource balance status in the event that only 80 percent of projected conservation is acquired. The consequences of this reduction were limited: only 2 months over a single operating year (1976-77) were deficit and that operating year was net surplus. The magnitude of those monthly deficits, around 78 aMW, is manageable by the utility.

Stress Test Results support the conclusion that Tacoma Power does not need new supply resources beyond conservation.

### *Authentication of the Monthly Model*

The monthly model is relatively new to Tacoma Power and has not been used before as part of the IRP assessment process. Thus, there was concern about whether it accurately represents the utility's actual operations.

For this IRP, the output of the monthly model was compared with that of an existing (and internally developed) operations model that Tacoma Power uses to guide generating facility operations. This comparison was made for the utility's three main projects using the actual hydro conditions of the 1940-41 and 1988-89 operating years. These years represent Tacoma Power's critical and median operating years, respectively.

This comparison indicates that both models produce similar results. The projected end-of-month elevations at project reservoirs were within 0.4 feet of each other. The difference in projected elevations for Riffe Lake and Lake Cushman were within 0.2 feet. Further, though the monthly elevations projected by each model differed slightly more for Alder Lake, those differences

[15] On a regional basis, the NWPCC predicts a 4 percent growth in load through 2030. Sixth Regional Power Plan, Chapter 3, NWPCC, 2010.

disappeared when averaged over an entire year.

Overall, the monthly model projected approximately 5 aMW per year more power from the Cowlitz, Cushman, and Nisqually projects combined, than did the internal operations model. On a monthly basis, differences between monthly model and the operations model ranged from 2 aMW to 10 aMW. This difference is largely due to:

- Differing methods used to calculate the energy produced at different project reservoir levels.
- The monthly model's perfect foresight regarding project inflows and future market prices which allows it to run the projects at a higher efficiency.
- The operations model including efficiency losses and rounding errors that are omitted from the monthly model.

On a utility wide basis, the monthly model annual supply projection was about 7 aMW higher than that of the operations model.

Given the similarities of the outputs of the two models, Tacoma Power is confident that the monthly model reasonably represents how the utility operates its system. The reservoir elevations were very close, as were the load-resource balance figures. Tacoma Power believes that the differences in generation are within the margin of error for both models.

## Capacity Adequacy

In addition to meeting annual and seasonal retail loads, utilities must have resources to meet short-term peak loads. This is known as capacity adequacy. Assessing capacity adequacy is especially difficult for utilities that primarily use hydroelectric resources to serve load, as many factors can limit the amount of electricity production at hydro plants.

For Tacoma Power the most important factor is the surface elevation of water in each hydro project reservoir during the peak load event. A particular difficulty when assessing surface elevations is that they are constantly changing subject to three moving parts:

1. The quantity of water initially in the reservoir.
2. The volume of water flowing into a project.
3. The amount of water withdrawn from the reservoir to produce power.

> A basic physical principle of hydroelectric generation is that the amount of electricity produced by a given volume of water depends directly on the difference in height between a generation turbine and the surface elevation of the reservoir.

Compounding this difficulty, water is usually withdrawn from a reservoir at a faster rate than natural inflows during a peak load event. As a result, a hydro-based utility's ability to generate electricity diminishes over the duration of peak load events. This phenomenon exposes a very important component of any capacity adequacy assessment – the selection of the time frame over which to assess peak capacity.

To address this timing question, Tacoma Power turned to the NWPCC's "A Resource Adequacy Standard For the Northwest" (Adequacy Standard) issued on April 16, 2008. This adequacy standard calls for Winter and Summer planning reserve margins of at least 23 and 24 percent, respectively.[16] Because Tacoma Power's load peaks during the winter, this analysis focuses on ensuring that the utility has sufficient resources to meet winter time peak load.

The NWPCC adequacy standard defined the *planning reserve margin* as the surplus *generating capability* over the *expected peak load,* averaged over the *sustained peak period,* where:

- The *sustained-peak period* is calculated as the highest load, 6 hours per day over 3 consecutive days (18 hours in total).
- The *generating capability* is the sum of the sustained-peaking capability which includes:
  - Non-hydro resources (including renewable resources), accounting for maintenance and limited by fuel-supply constraints and/or environmental constraints;
  - Firm hydroelectric sustained-peaking capability, based on critical water conditions and assuming that no extraordinary actions are taken to increase peaking capability and,
  - Incremental hydroelectric sustained-peaking capability, which is an additional amount available in water conditions better than critical.
- The *expected-peak load* is the average load over the sustained-peak period, based on normal temperature conditions and adjusted for firm out-of-region sales and purchases and for conservation savings.

Tacoma Power's Resource Operations & Trading unit oversees the day-to-day and hour-to-hour operations of utility resources. As such, staff of this group has unique insight regarding the type and duration of events that could test Tacoma Power's capacity adequacy. They recommended employing two additional peak capacity time frames: 1-hour to test peak loads against maximum resource capabilities; and 72-hours to test Tacoma Power's ability to serve load

[16] Estimates of capacity reserve margins are highly dependent on the calculation methodology. The methodology used in this IRP veers from NWPCC's approach. Therefore, Tacoma Power's calculated capacity reserve margins may not be directly comparable to NWPCC's recommended standards.

over the entire duration of a 3-day cold snap.

This IRP assumes that the cold snap occurs during January 2012. The decision to focus near-term was due to uncertainty regarding operations under Tacoma Power's new Slice contract with BPA (beginning in October 2011). This new contract will give Tacoma some flexibility to determine the timing of power deliveries from BPA. However, the extent of these rights, especially during critical water conditions, is not well developed. As such, this analysis assumed no flexibility associated with power from BPA. Tacoma Power's next IRP should be able to better account for this flexibility and to assess the utility's peak capacity adequacy further into the future.

### *Peak Loads*

The IRP's effort to project peak loads began with identifying the coldest 72-hour period in each year from 1998 to 2008. The median cold period was selected (five periods were colder and five warmer) to conform to the NWPCC's definition that *expected-peak load* is the average load over the sustained-peak period, based on normal temperature conditions. An internally developed econometric model was used to convert these cold temperatures into projected peak loads. The cold temperatures were assumed to occur during the time period(s) of highest retail load: at the beginning of a non-holiday work week, during early morning hours, in mid-January. The projected peak loads were 1003 MW over 1-hour, 948 aMW for the average of the highest 18 hours over three days, and 833 aMW averaged over a continuous 72-hour period.

### *Peak Resources*

The peak resource assessment began with the assumption that project reservoirs were at levels associated with "critical water." Further, the analysis held all resources to normal reserve requirements and regulating margins. Specifically, 5 percent of on-line hydro resources and 5.2 percent of BPA contract resources were held out as operating reserves, 50 percent of the reserves were spinning, and an additional 10 MW of generation was withheld as regulating margin. (The operation of individual resources is discussed in Appendix G.) Under these conditions, Tacoma Power's resources are calculated to deliver 1266 MW of electricity during both a 1-hour and 18-hour period, and 1178 MW during 72-hour period.

### *Capacity Adequacy Results*

Table 2.6 presents the results of this capacity adequacy assessment. Tacoma Power's capacity margin is 26% (1003 MW load and 1266 MW of supply) over the expected 1-hour peak period, 36% during the 18-hour peak period and 41% over the 72-hour peak. The 18-hour figure is comfortably above the 23% figure used in the voluntary Resource Adequacy Standard.

**Table 2.6**
**Peak Load-resource Balance Summary**

| Period | Peak Load | Peak Supply | Peak Load Planning Reserve Margin |
|---|---|---|---|
| 1-hour | 1003 MW | 1266 MW | 26% |
| 18-hour | 948 MW | 1266 MW | 36% |
| 72-hour | 833 MW | 1178 MW | 41% |

### *Capacity Adequacy Stress Test*

The load portion of the capacity adequacy analysis was developed based on weather data from 1998 through 2008. However, in December 2009 extreme low temperatures occurred in Tacoma Power's service territory which resulted in higher utility loads than assessed in the base capacity adequacy calculation.

The IRP stress-tested the capacity adequacy results using actual loads from December 8-10, 2009. This stress test maintained the assumption of critical water levels at Tacoma Power's generating resources. The results, presented in Table 2.7, show that even under these extremely high load assumptions, Tacoma Power remained above the voluntary Resource Adequacy Standard.

Finally, it is important to note that Tacoma Power was not at critical water during the December 2009 cold snap. As a result the utility's actual peak supply was higher than presented in Table 2.7. For example, the actual 1-hour peak generated during that peak event was 1319 aMW. Overall, this stress test enhances confidence that Tacoma Power has the resources needed to deal with expected peak load situations.

**Table 2.7**
**Peak Load-resource Balance Summary**

| Period | Peak Load | Peak Supply | Peak Load Planning Reserve Margin |
|---|---|---|---|
| 1-hour | 1055 MW (8.0ºF) | 1266 MW | 20% |
| 18-hour | 1005 MW (13.9ºF) | 1266 MW | 26% |
| 72-hour | 904 MW (18.0ºF) | 1178 MW | 30% |

## Load-Resource Balance Conclusions

This IRP's load-resource balance assessment indicates that:

- Tacoma Power's current resources, coupled with aggressive conservation, are sufficient to meet expected load over the planning period.
- On an annual basis, supply resources slightly exceed forecast load at critical water. With a median water assumption, Tacoma Power's load-resource balance turns surplus by about 200 aMW.

- The monthly load-resource balance is more complicated. The base analysis found small resource deficits – about 45 aMW – occurring in two out of the 900 months assessed. This finding does not indicate a need for new supply resources. No operating year was deficit over the entire year and, no seasonal resource deficit was evident.
- The capacity adequacy analysis shows that the utility can meet expected peak loads.

Stress-testing reduced the amount of electrical power available to the utility or increased retail load. While the projected number of deficit months increased slightly, they still represented a very small fraction (≤1 percent) of the overall number of months assessed. In every stress test no operating year was deficit over the entire year and a specific month was at most deficit for 3 of the 75 operating years assessed. In other words, projected monthly shortages were rare, of relatively short duration and of limited magnitude.

Furthermore, Tacoma Power has options to deal with such shortages. The utility can use the storage capacity of the Mossyrock reservoir (Riffe Lake) to draw extra power in one month and replace it in a future month. Finally, Tacoma Power can buy power from the wholesale market to cover the shortage.

This assessment of Tacoma Power's load-resource balance presumes that future weather patterns (i.e., precipitation and ambient temperatures) will fall within historical ranges. The IRP is comfortable with this assumption given the wide range of weather conditions encompassed by 75 operating years used in the monthly analysis. However, the load-resource balance assessment could change if weather conditions outside of those covered by this analysis were to occur.

## Least Cost/Least Risk Resource Portfolio

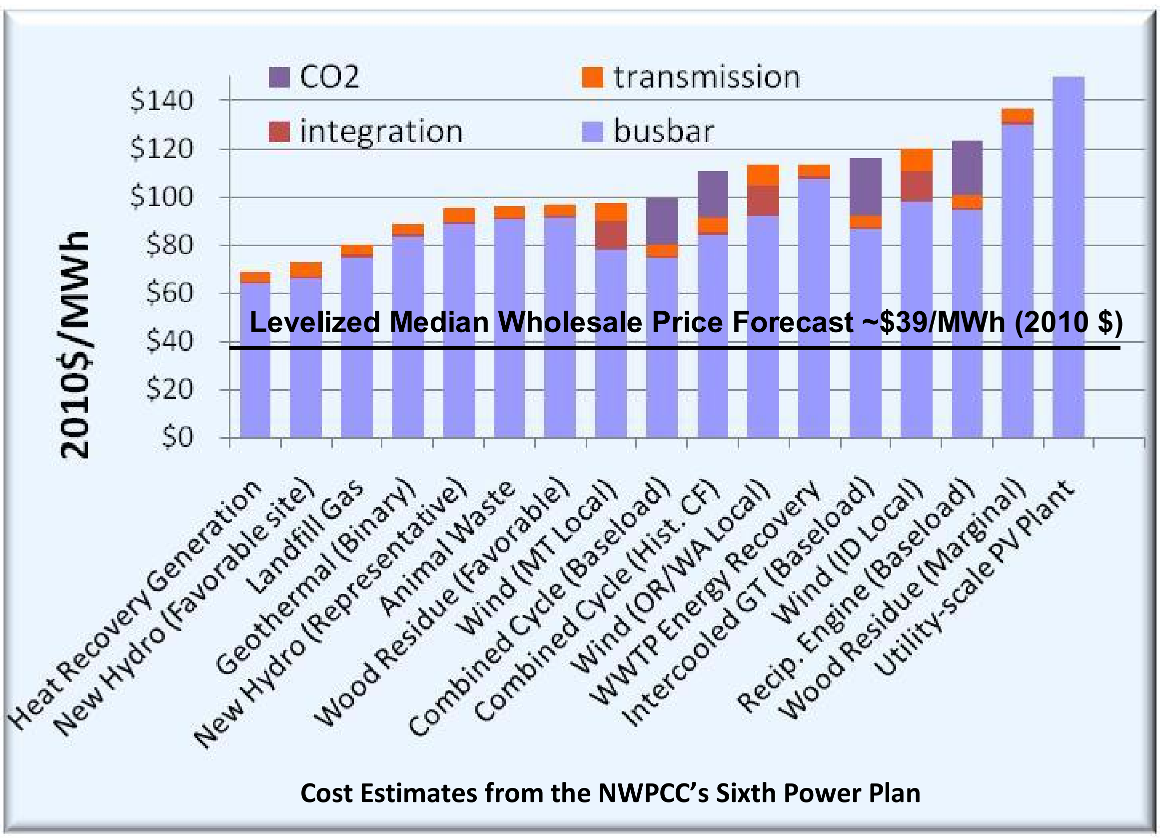
The next step of the integrated resource planning process is to assess commercially available renewable and nonrenewable generating technologies. This is an ongoing task at Tacoma Power. The utility maintains a resource supply database which covers a wide array of potential generation technologies. Through this database Tacoma Power tracks generation technology costs, environmental attributes, technological advancements, and applicability to the region in general and Tacoma Power in particular. This database helps the utility to assess resource opportunities that become available. Also, it is a ready source of information Tacoma Power can draw upon should circumstances change such that the utility needs to actively consider adding new resources. Appendix H summarizes some of the information included in Tacoma Power's resource supply database.

Given Tacoma Power's surplus resource position, the electricity produced by a new resource would be sold in the wholesale market. The utility reviewed the cost projections for potential new generating technology and compared those costs to wholesale market price expectations. Figure 2.11 shows that in all cases, the costs of new resources were higher than forecast market prices. As such, acquiring a new resource would increase utility costs.

The final IRP planning step is to integrate the load forecasts and available generation and conservation resources into a long-range projection of the mix of resources that meets current and projected needs at the lowest cost and risk. This step involves a careful balance of the risks associated with being caught with resource supply deficits, with the risks of acquiring too much electrical power.

Tacoma Power relies almost completely on electricity generated by hydro resources. As such, the amount of power

**Figure 2.11**
**Cost of New Resources in the Pacific Northwest**




the utility has available to serve future retail load is subject to the vagaries of weather. This IRP indicates that extremely dry weather coupled with heavy retail loads could result in a couple of deficit months. This is a rare event, occurring in only one of 75 operating years assessed. Nevertheless, in such a situation, Tacoma Power may need to acquire power from the wholesale market.

The addition of a new resource to the utility's portfolio, while expensive, could eliminate this need. The IRP performed a scoping analysis to illustrate the magnitude of market prices whereby the acquisition of a new resource becomes more attractive than purchasing electricity power in the wholesale market. This scoping analysis assumed:

- The resource is a 20 MW share of a natural gas combustion turbine.
- The resource is called upon to produce 74,000 MWh of electricity, once every twenty years.
    - It would take a 20 MW resource about 150 days of continuous operation to produce the 74,000 MWhs associated with a 50 MW deficit over two months.
    - The assumption that the resource would be needed once every 20 years is "conservative" given that monthly deficits were modeled in only one of 75 operating years.
    - The resource is a "peaking" plant with high operating costs that makes it uneconomic to run in most years.
- Natural gas fuel costs are equal to the median projection by Global Insight (Tacoma Power's supplier of natural gas price forecasts.)

This analysis indicated a "break-even" point for wholesale electricity prices of nearly $700/MWh. In other words, wholesale power prices would have to reach $700/MWh before retail customers would be better served if Tacoma Power acquired the new resource. This analysis ignores other potential risks associated with a natural gas combustion turbine, such as potential GHG emissions regulations and uncertainties about fuel prices. Tacoma Power would also have to develop new skills to operate and maintain a plant completely different than any other in the utility's portfolio.

Based on this scoping analysis, it is reasonable to conclude that acquiring a new natural gas resource will likely impose much higher costs on the utility than would purchasing energy from the wholesale market. As such, Tacoma Power's preferred portfolio is one that refrains from acquiring new generating resources, and instead relies solely on existing resources coupled with aggressive conservation.

# Section Three
# Special Assessments

*In addition to identifying the resource portfolio that minimizes costs and risk, Tacoma Power uses the integrated resource planning process to evaluate other important utility issues. The 2010 IRP investigated three: the strategy to comply with the statutory renewable resource mandates; a preliminary assessment of the potential effect of climate change on Tacoma Power's operations, and the possible impact of electric and hybrid vehicles on the utility's load-resource balance.*

## Renewable Resource Mandates

The Energy Independence Act established renewable resource requirements for utilities with more than 25,000 customers. Beginning in 2012 affected utilities must ensure that the electricity from eligible renewable resources makes up 3 percent of the energy provided to retail customers. The percentage rises to 9 percent in 2016 and 15 percent thereafter. Renewable resources that can apply towards this mandate include: wind, biomass, biodiesel, geothermal, solar, certain hydro resources (tidal, wave, ocean, or incremental hydro), and certain gas resources (landfills, and sewage treatment facilities). Utilities can also use RECs to meet the standard.

> **Renewable energy credits**, or RECs, are essentially the environmental attributes of electricity generated by an eligible renewable resource as defined in 19.285.030 RCW.
> **Traditional hydro generation**, while defined in state law as a renewable resource (19.29A.010 &19.285.030 RCW), is not part of the list of resources utilities can use to comply with the Energy Independence Act's renewable mandates.

This renewable resource mandate complicates utility efforts to achieve the traditional IRP goals of minimizing utility cost and risk – especially for utilities like Tacoma Power who do not need new generating resources. To comply with the 3 percent renewable mandate, Tacoma Power must acquire some combination of 153,000 MWhs from renewable resources and/or RECs (See Table 3.1).

**Table 3.1**
**Tacoma Power's Projected Renewable Requirement**

| Year | Renewable Requirement | Projected Renewable Requirement | |
|---|---|---|---|
| | | aMW | MWh or RECs |
| 2012-2015 | 3% | ~17.5 | ~153,000 |
| 2016-2019 | 9% | ~55.0 | ~482,000 |
| After 2019 | 15% | ~93.0 | ~815,000 |

During the first compliance period, Tacoma Power will draw upon three categories of eligible renewable resources (See Appendix I):

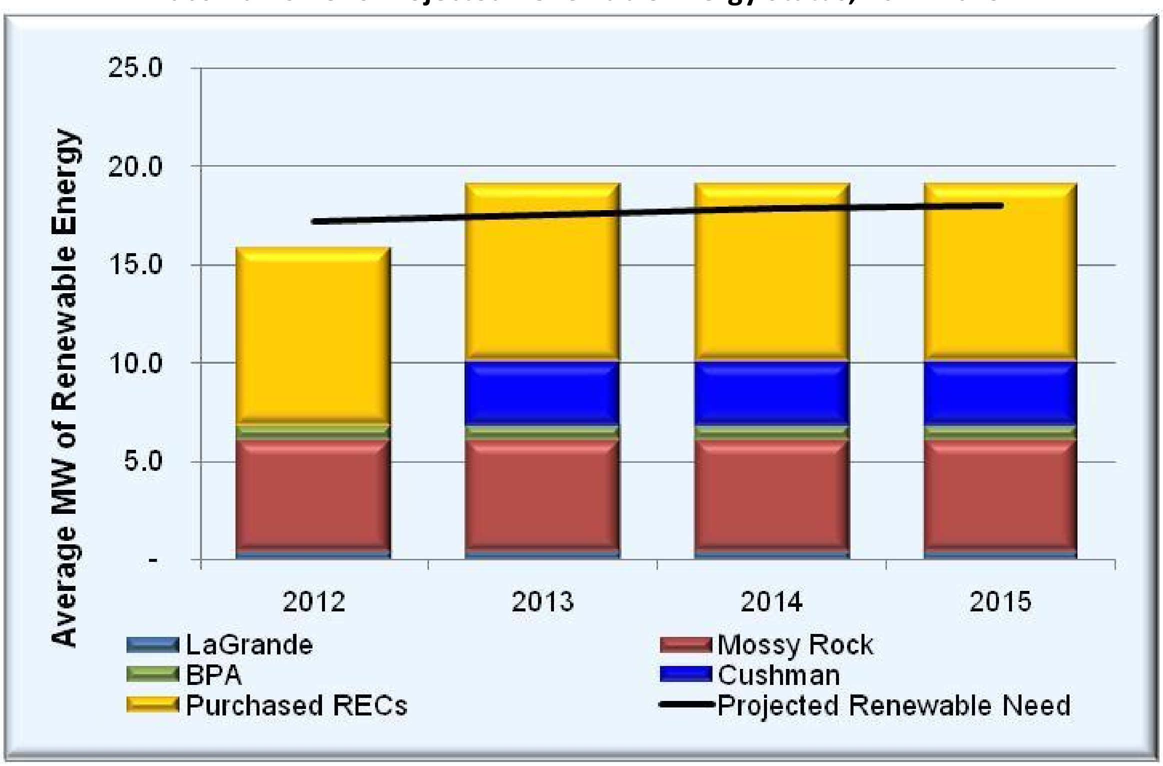
1. Incremental hydro at three projects: (LaGrande ~3,280 MWh, Mossyrock ~41,530 MWh, and starting in 2013, Cushman ~28,260 MWh).
2. RECs from BPA wind resources through the BPA power supply contract (~6,600 RECs through 2015 and ~33,000 thereafter).
3. RECs through an eight year contract with an outside supplier (~79,000 RECs/year from 2012 to 2019).

By 2013, Tacoma Power expects these sources to annually provide around 158,700 of combined MWhs and RECs.

**The Cushman Project**
The Federal Energy Regulatory Commission approved a license amendment allowing Tacoma Power to add a new small powerhouse at the base of Cushman #2 dam on July 15, 2010. Tacoma Power expects this project to be completed in December, 2012. This project's incremental hydro-generation will first be available during the 2013 compliance year. Also, Tacoma Power expects to use sufficient apprenticeship labor to qualify for the 20 percent credit.

While this amount slightly exceeds Tacoma Power's expected need, the utility may need an additional 10,000 to 20,000 MWhs of renewable energy during 2012. Figure 3.1 illustrates the utility's expected renewable resource compliance status during the first compliance period.

**Figure 3.1**
**Tacoma Power's Projected Renewable Energy Status, 2012-2015**



While Tacoma Power is well situated to meet the 2012-2015 renewable mandate, the utility is some 33 aMW short of the 2016-2019 standard. However, any near term efforts to fill this gap would run regulatory risk. During both the 2009 and 2010 legislative sessions, considerable effort was made to amend the Energy Independence Act. Some of the proposed changes would make the regulatory standards more expensive for Tacoma Power:

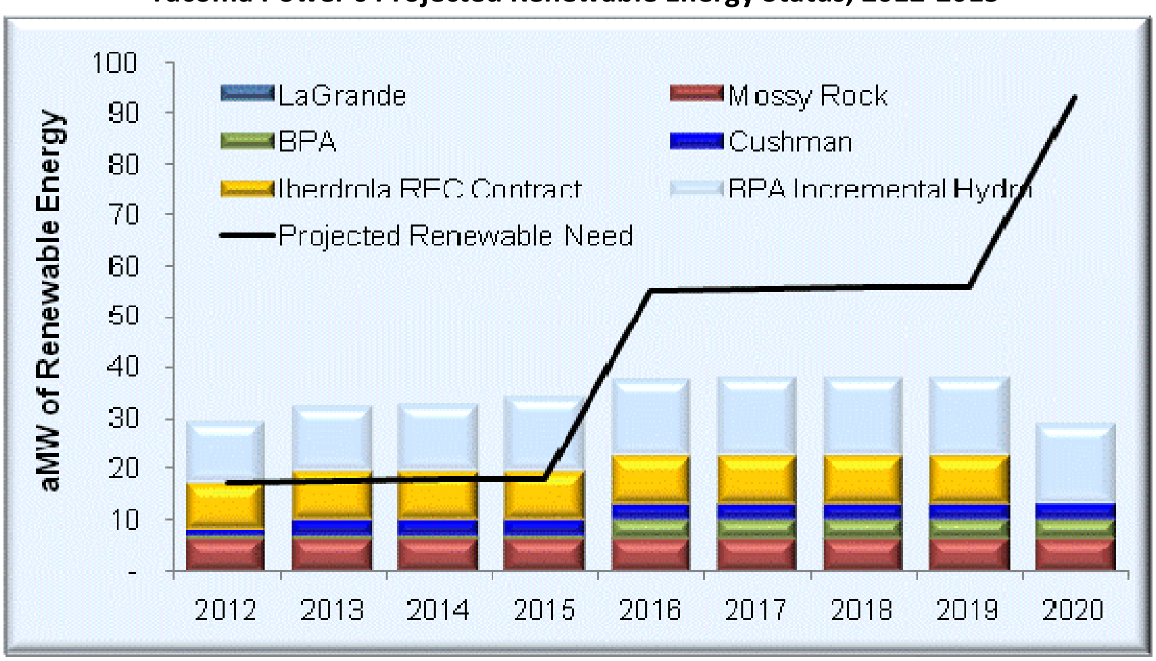
- Increasing the renewable standards by 1.25% beginning in 2016 and adding a new 25% standard in 2025.

While others would ease regulatory costs:

- Adding incremental hydro at BPA projects to the list of eligible resources.
- Allowing utilities to credit conservation acquired in excess of their conservation target towards the renewable target.
- Allowing utilities to bank RECs.
- Exempting utilities that have surplus power from the renewable mandate.

The adoption of any of these amendments could significantly change the regulatory mandate facing Tacoma Power. Figure 3.2 shows the effect of one potential statutory change: allowing Tacoma Power to take credit for our portion of BPA incremental hydro (equipment upgrades and operational changes). This change would move the utility about half-way toward the 2016-2019 9 percent renewable mandate. Further allowing unlimited banking of RECs and incremental hydro MWhs would nearly bring Tacoma Power into compliance with the 2016-2019 renewable mandate.

**Figure 3.2**
**Tacoma Power's Projected Renewable Energy Status, 2012-2015**



Given the uncertain nature of the legislative process and the wide variation in proposed amendments to the Energy Independence Act, determining a precise course of action that minimizes compliance and cost risks is near impossible at this time. Fortunately, the interval between the conclusion of this IRP and the start of the 2016 compliance period will allow Tacoma Power some time to watch legislative efforts evolve, and to respond accordingly.

Finally, assuming no changes to the Energy Independence Act, Tacoma Power projects the need for about 93 aMW of renewable energy/RECs to comply with the 15% renewable mandate that begins in 2020. Approximately 12 aMW should come from existing incremental hydro, leaving the utility 81 aMW short of the target. However, the Energy Independence Act also includes an overall compliance cost cap of 4 percent of a utility's revenue requirement. Tacoma Power expects that it would reach this 4% cost cap well before the utility acquired the full 81 aMW of renewable energy.

## Climate Change

The assessment For this IRP assumed no trends in weather patterns that would change either the volume or timing of stream flows, or temperature induced retail load. This assumption runs counter to the opinion of many individuals, organizations and governments about climate change. For example, the 4th Assessment Report (February 2007) by the Intergovernmental Panel on Climate Change (IPCC)[17] stated that:

> "warming of the climate system is *unequivocal*… The observed climate trends of the 20th century *will continue*, with an expected warming of 0.2ºC per decade…"[18]

Similarly in June 2005 the national science academies of the G8 nations, along with Brazil, China and India, stated that "[t]he projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources…"

On a regional level, the 2nd Public Review Draft of the U.S, Climate Change Science Program's Global Climate Change Impact in the United States (January 2009) asserts that a warmer climate for the Northwest means increases in winter and early spring streamflows and decreases in flow at other times. More specifically:

> "Extreme high and low streamflows also are expected to change with warming. Increasing winter rainfall

[17] The Intergovernmental Panel on Climate Change was established by the United Nations Environment Programme and the World Meteorological Organization.

[18] Alley R., and collaborators, 2007: Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva, Switzerland.

**– NOTE –**

**The following assessment is Tacoma Power's first attempt to consider the potential effects of climate change on utility operations. This assessment requires consideration of the potential changes to both Tacoma Power and BPA resources.**

**To make this assessment, this IRP had to disaggregate global and regional estimates of climate impacts to a local scale. While rapidly evolving, computer models to project regional and local scale impacts are in the initial stages of development. This IRP had to also project how BPA might alter the amount and timing of power generation given the potential changes in river flows. Obviously, Tacoma Power has limited ability to predict future BPA behavior. Therefore, the following analysis should be taken as indicative of the direction of changes that Tacoma Power could face, but not as a projection of future circumstances.**

**Finally, most of this integrated resource plan focused on Tacoma Power's projected status in 2017-18. This section considers the affects of climate change in 2020-25. The slow nature of potential affects from climate change necessitated this model shift.**

> (as opposed to snowfall) is expected to lead to more winter flooding in relatively warm watersheds on the west side of the Cascades. The already low flows of late summer are projected to decrease further due to both earlier snowmelt and increased evaporation and water loss from vegetation. Projected decreases in summer precipitation would exacerbate these effects. Some sensitive watersheds are projected to experience both increased flood risk in winter and increased drought risk in summer due to warming."

As a hydro-based utility, such potential changes interest Tacoma Power. From a planning perspective, the principle issue is to assess how climate change might affect the timing and magnitude of electricity produced by the utility's owned and contracted resources. Tacoma Power undertook two preliminary analyses of the potential implications of climate change. First, the utility retained the consulting firm 3TIER to conduct a preliminary study of potential changes to utility resources on the west side of the Cascade mountains. 3TIER specifically assessed changes to streamflow timing and volume for the Cowlitz and North Fork Skokomish River basins (Cushman Project).

Second, the utility considered the possible changes to contracted resources located east of the Cascades. (Appendix J presents a more complete discussion of these analyses.)

### *Analysis Underpinnings*

In 1996 the IPCC approved a set of 40 climate change scenarios that cover a wide range of the main driving forces of future GHG and sulfur emissions. Each scenario represents a specific quantification of one of four storylines, each containing varying degrees of demographic change and social and economic development, technological change, resource use and pollution management. Of the 40 scenarios, tested three are commonly used in General Circulation Models (GCMs): A2 (high emissions), A1B (medium emissions) and B1 (low emissions). This IRP analysis was based on the "A1B" emissions scenario from the latest IPCC report.

Temperature projections

The "A1B" emissions scenario indicates a warmer future. Initial estimates derived from the difference between 3Tier's analysis and historic hourly temperature data (1970-1999 baseline) suggest monthly temperature increases in 2025 of around 1.0ºC during winter months and 1.6ºC in summer.

Load Adjustments

Table 3.2 shows the potential effects of the predicted increase in temperatures on retail load. Generally, load increases during the summer and falls at other times of the year. The projected annual load decreases by 2.6 aMW.

**Table 3.2**
**Potential Change in Retail Load Due to Climate Change**

| Month | aMW | Month | aMW | Month | aMW | Month | aMW |
|---|---|---|---|---|---|---|---|
| August | 2.26 | November | (3.50) | February | (5.41) | May | (1.39) |
| September | (0.64) | December | (6.42) | March | (3.88) | June | (0.61) |
| October | (2.84) | January | (6.18) | April | (3.96) | July | 1.21 |
| | | | | | | **Annual** | **(2.60)** |

### *West-Side Analysis*

3TEIR assessed the effects of altered climate conditions using the Distributed Hydrology Soil Vegetation Model (DHSVM). This model can predict the extent and magnitude of the changes to watershed hydrology that occur under various climate change assumptions. With this model, 3TEIR projected the impacts of climate change in terms of changes to snowpack, flood frequency probabilities, seasonal reservoir refill volumes, and naturalized average monthly flows.

Cowlitz River Table 3.3 shows the predicted changes in Cowlitz River flows. Essentially, flows shift from a double peak (winter and late spring) to becoming more dominant during the winter under the A1B climate scenario. However, average annual flow was essentially unchanged.

North Fork of the Skokomish River

Table 3.4 indicates that annual Skokomish River flows do not significantly change under the A1B climate scenario. However, the current wintertime peak flows are anticipated to become even more pronounced. (See Figure 3.3)

Planning Implications More dominant winter rainfall and a reduction in spring and summer flows could require the utility to change the way it manages its generating resources. However, given that Tacoma Power is a winter peaking utility, this change in flow patterns could actually better align generation with retail load.

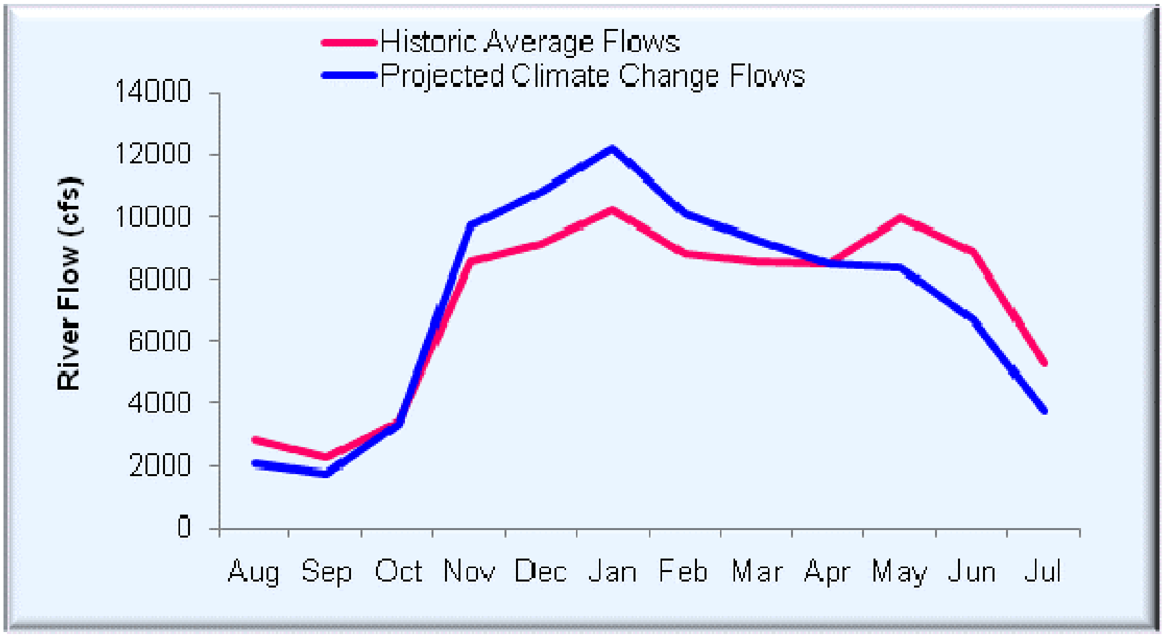
**Table 3.3**
**Cowlitz (Mayfield) Historic and Climate Change Projected Flows**

| Month | Historic Average Flow Rate (cfs) | A1B Average Flow Rate (cfs) | Change in Flow Rate (cfs) |
|---|---|---|---|
| October | 2833 | 2737 | -96 |
| November | 7202 | 8192 | 989 |
| December | 7686 | 9165 | 1480 |
| January | 8718 | 10500 | 1781 |
| February | 7734 | 8924 | 1191 |
| March | 7606 | 8262 | 656 |
| April | 7661 | 7628 | -33 |
| May | 9107 | 7640 | -1467 |
| June | 8145 | 6169 | -1975 |
| July | 4853 | 3456 | -1397 |
| August | 2595 | 1890 | -705 |
| September | 2066 | 1557 | -509 |

**Table 3.4**
**North Fork Skokomish (Cushman No. 1) Historic and Climate Change Projected Flows**

| Month | Historic Average Flow Rate (cfs) | A1B Average Flow Rate (cfs) | Change in Flow Rate (cfs) |
|---|---|---|---|
| October | 618 | 619 | 1 |
| November | 1339 | 1484 | 145 |
| December | 1453 | 1654 | 201 |
| January | 1532 | 1717 | 185 |
| February | 1075 | 1185 | 110 |
| March | 937 | 1000 | 63 |
| April | 840 | 852 | 12 |
| May | 860 | 707 | -153 |
| June | 741 | 544 | -197 |
| July | 405 | 275 | -130 |
| August | 229 | 161 | -68 |
| September | 215 | 169 | -46 |

**Figure 3.3**
**Tacoma Power's Projected River Flow Rates**




### *East-Side Analysis*

Given the importance of the BPA supply contract to Tacoma Power, it is vital to consider the potential effects of climate change on the Federal Columbia River Power System. Tacoma Power used information from the University of Washington's Climate Impacts Group (CIG) to develop a preliminary estimate of the potential effect of an A1B level of climate change on the amount of power delivered through the BPA contract.

This analysis indicates a relatively slight decrease in annual generation of 160 aMW in an average year under the A1B climate scenario. In addition, the analysis found much higher variance in generation around this mean. (See Figure 3.4) The maximum output is projected to increase about 1200 aMW; the 75th percentile increase 60 aMW, the 50th and 25th percentiles decrease around 160 aMW; and the minimum generation decrease about 1440 aMW.

The analysis also indicates much higher variance in monthly power generation. Figure 3.5 shows the projected higher monthly variance. The consequence of this variance could be an increase the probability of both spilling water during wet years and experiencing an operating year that are dryer than the current critical year.

### *Monthly modeling*

Previous analyses discussed in this IRP used 75 operating years of river flow data to estimate Tacoma Power's monthly load-resource balance. However, due to certain data limits, this part of the IRP has only 49 years of river inflow data, 1949-50 through 1997-98.

**Figure 3.4**
**Potential Change in the Columbia River Generation due to Climate Change**

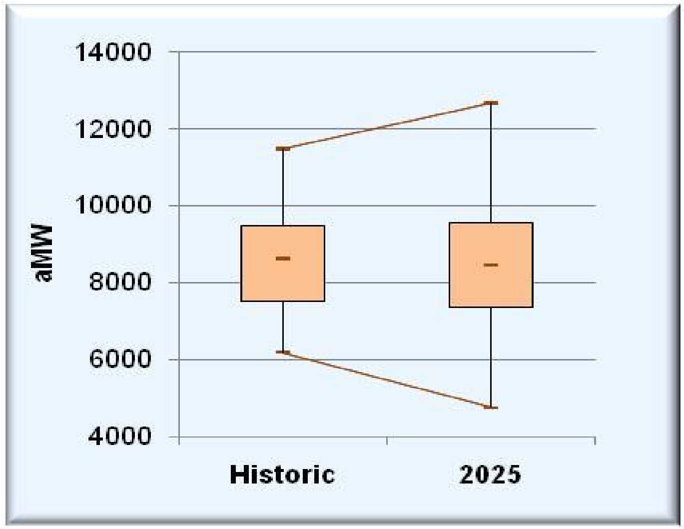
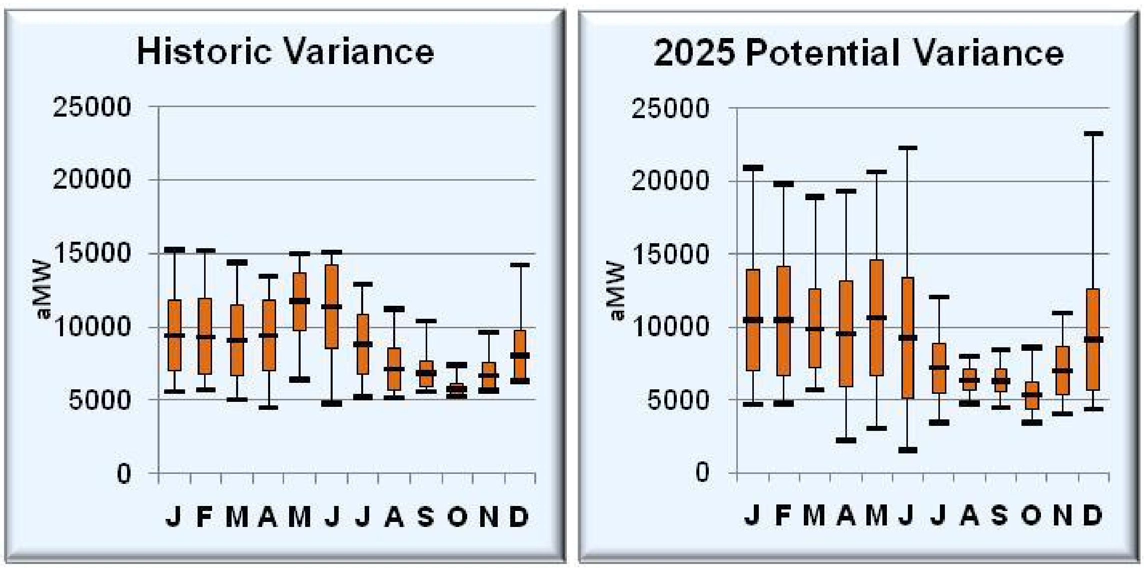



**Figure 3.5**
**Potential Change in Variance of Monthly Columbia River Electricity Generation due to Climate Change**




The monthly model was run with altered load and resource supply figures to develop a preliminary estimate of what effect climate change might have on the utility's resource adequacy. The results indicate one operating year with significant load-resource balance deficits (1976-77) out of the 49 operating years modeled under the A1B climate change scenario.

This assessment is based on preliminary appraisals of the potential effects of climate change on Tacoma Power's load and generating resources. It is a near certainty that the utility's understanding of both these issues will evolve and improve. Since this analysis was performed with projected loads associated with the 2024-25 timeframe, the utility has time to both improve our understanding of the consequences of climate change, and to develop response strategies if necessary.

**We once again remind the reader that modeling regional scale climate change is very challenging. Available computer models to project regional and local scale impacts are in the initial stages of development. Further, estimating the shift in power production resulting from the change in streamflow is difficult.**

**It is not possible to know precisely what changes to Tacoma Power or BPA operational procures would occur under climate change, or due to a new biological opinion. (This assessment assumes no change to operational procedures.) Finally, our extrapolation of demand under climate change assumes no change in base technology assumptions – such as increased adoption of air conditioning. As a result, the present analysis should be taken as indicative of the possible direction of changes facing Tacoma Power, but not as an absolute projection of future circumstances.**

## Electric Vehicles

Since the dawn of the automobile, automakers have toyed with the possibility of using electricity to power cars. Electricity as a transportation fuel has several advantages over gasoline. It is less expensive, more efficient (miles/unit of energy), less polluting and is generated within North America from indigenous fuel sources. However, electric vehicles have always been limited by the batteries used to store electrical energy. In comparison to gasoline fuel, batteries were heavy, expensive, had limited storage capacity and took significant time to recharge. Recent technological advances, many stemming from the personal computer industry, have overcome some of these problems. While still expensive, today's batteries are lighter, recharge quicker, and store more energy.

Several automakers are developing plug-in Hybrid Electric Vehicles (PHEV) and Electric Vehicles (EV) some of which will reportedly begin to ship in late 2010. Manufacturers with electric vehicles under development include:

- ***CHRYSLER LLC*** is testing five different prototype electric-drive vehicles and is said to start selling one model in 2011. The prototypes include a Dodge sports car, a Jeep Wrangler and Patriot, a Chrysler minivan, and a concept sedan.
- ***FISKER AUTOMOTIVE*** is expected to release its Karma plug-in sports sedan in October, 2010. The plug-in can

drive gas-free for 50 miles. Fisker is also developing the Karma S, a convertible expected in 2011, and the NINA line of family oriented vehicles expected in late 2012.

- ***FORD MOTOR CO.*** is planning to produce a number of different PHEV and EV vehicles beginning in 2012. Ford is currently testing these vehicles through fleet partnerships with several utilities.
- ***GENERAL MOTORS*** is moving towards production of the Chevrolet Volt, an extended range electric plug-in vehicle. The Volt will have a lithium-ion battery and electric motor that can take the car 40 miles on a single charge. A gasoline engine will kick in to power a generator to extend the Volt's range beyond the 40 miles. Limited numbers of the Volt are expected to be available in late 2010.
- ***NISSAN MOTORS*** will sell a new all-electric car, the Nissan Leaf, in early 2011. The Leaf will have a range of 100 miles. Nissan is partnering with certain states and utilities to promote and develop electric vehicle charging networks – the I-5 corridor is one target area.
- ***TESLA MOTORS*** is selling the Roadster, an electric sports car which can travel 244 miles on a 3.5-hour charge. The California automaker is developing the all-electric Model S sedan by 2012.
- ***TOYOTA MOTORS*** will start delivery of 150 Toyota Prius plug-in hybrids powered by lithium-ion batteries to US lease and fleet customers in late 2010. The plug-in is expected to operate in a similar fashion to the current Prius vehicle; using both gasoline and electricity to propel the vehicle. Toyota is also developing an all-electric vehicle, the "FT-EV", that is expected to have a range of 50 miles and be available by 2012.

The roll-out of electric vehicles is receiving considerable governmental support. Through the America Recovery and Reinvestment Act, the federal government provided $2.4 billion in grant monies to advance motor vehicle battery technology; another $300 million to replace aging, in-efficient federal fleet vehicles with conventional hybrids, PHEVs and EVs, and up to a $7500 income tax credit to individuals who purchase these types of vehicles. Accompanying these vehicles will be a new infrastructure for charging at home, at work, and around town. By one estimate, nearly one million vehicle charging points will be available in the United States by 2015.

To better understand the potential impact of PHEVs and EVs on Tacoma Power, the IRP developed a spreadsheet computer model to estimate the added retail load caused by the use of electricity as a transportation fuel. Making such an estimate requires assumptions regarding the public's acceptance of a set of technologies that have only recently emerged from the experimental stage:

1. The percentage of new PHEVs/EVs sold.
2. The "mileage" of PHEVs/EVs (kWh/mile).
3. The improvement in vehicle mileage over time.
4. The distance a PHEV/EV can travel with a fully charged battery.

Of these assumptions, the most important is the percentage of new PHEVs/EVs sold, also known as the market penetration. This analysis used two market penetration estimates: an aggressive estimate from studies by the Electric Power Research Institute (EPRI) and the National Renewable Energy Laboratory (NREL);[19] and a base estimate from a National Research Council study.[20] This IRP considers the National Research Council's projected penetration more likely because, among other reasons, they specifically took into account cost differences between PHEVs and vehicles with internal-combustion engines. The National Research Council reasons for being "bearish" on electric vehicles are:[21]

> "The costs of plug-in hybrid electric cars are high -- largely due to their lithium-ion batteries -- and unlikely to drastically decrease in the near future… Costs to manufacture plug-in hybrid electric vehicles in 2010 are estimated to be as much as $18,000 more than for an equivalent conventional vehicle. Although a mile driven on electricity is cheaper than one driven on gasoline, it will likely take several decades before the upfront costs decline enough to be offset by lifetime fuel savings. Subsidies in the tens to hundreds of billions of dollars over that period will be needed if plug-ins are to achieve rapid penetration of the U.S. automotive market…

> "The lithium-ion battery technology used to run [plug-in hybrid electric vehicles that can operate on electricity for 10 or 40 miles] is the key determinant of their cost and range on electric power. Battery technology has been developing rapidly, but steep declines in cost do not appear likely over the next couple of decades because lithium-ion batteries are already produced in large quantities for cell phones and

[19] Aggressive market penetration estimates from "Environmental Assessment of Plug-In Hybrid Electric Vehicles, EPRI, 2007," and "A Preliminary Assessment of Plug-In Hybrid Electric Vehicles on Wind Energy Markets, W. Short and P. Denholm, Technical Report NREL/TP-620-39729, April 2006." However, the penetration rates from those studies were delayed one year.

[20] Transitions to Alternative Transportation Technologies--Plug-in Hybrid Electric Vehicles, National Research Council, 2010.

The National Research Council provides scientific and technical advice to the federal government under a Congressional charter.

[21] From the press release announcing the National Research Council's 2010 study. Accessible at http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12826

laptop computers… While these costs will come down, a fundamental breakthrough in battery technology, unforeseen at present, would be needed to make plug-ins widely affordable in the near future.

"[Under the report's most optimistic assumptions, 6.5 million plug-in hybrids could be sold annually in the United States by 2030, out of total sales of 19.4 million vehicles. Under the more realistic assumptions, 1.8 million plug-in hybrids would be sold that year.] The maximum number of plug-in electric vehicles that could be on the road by 2030 is 40 million, assuming rapid technological progress in the field, increased government support, and consumer acceptance of these vehicles. However, factors such as high cost, limited availability of places to plug in, and market competition suggest that 13 million is a more realistic number, the report says. Even this more modest estimate assumes that current levels of government support will continue for several decades…"

Table 3.6 lists the major assumptions used to estimate the effect of PHEV and EVs on retail load. Table 3.7 presents the projected electricity load from PHEVs and EVs under aggressive, intermediate, and realistic market penetration rates.

**Table 3.6**
**Assumptions Used to Estimate the Effect of PHEVs and EVs on Retail Load**

| | Base | Aggressive | Source |
|---|---|---|---|
| Percent of new vehicles sold in 2025 | | | |
| PHEV | 9% | 46% | See Footnotes 20 & 19, Tacoma Power assumption for EV rates |
| EV | 9% | 18% | |
| The "mileage" of PHEVs & EVs (kWh/mile) in 2011. | PHEV Compact 0.20 | | Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional Power Grids Part 1: Technical Analysis, Northwest Regional U.S., PNNL, November, 2007 |
| | Mid-size 0.30 | | |
| | Mid-SUV 0.38 | | |
| | Large-SUV 0.46 | | |
| | EVs Compact 0.20 | | |
| | Mid-size 0.30 | | |
| | Mid-SUV NA | | |
| | Large-SUV NA | | |
| The efficiency improvement over time, percent/year | 0.5% | 1.5% | Tacoma Power assumption |
| Charge efficiency | 87% | | |
| Discharge efficiency | 85% | | |
| The distance PHEVs/EVs travel under electricity, miles | PHEV 40<br>EV 100 | | |

**Table 3.7**
**Projected Electrical Load Associated with Alternative Electric Vehicle Adoption Rates**

| | Aggressive | | | | Intermediate | | | | Base* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Number of PHEV Vehicles | Number of EV Vehicles | Electric Power VMT (x1000) | aMW | Number of PHEV Vehicles | Number of EV Vehicles | Electric Power VMT (x1000) | aMW | Number of PHEV Vehicles | Number of EV Vehicles | Electric Power VMT (x1000) | aMW |
| 2011 | 302 | 201 | 4,153 | 0.2 | 181 | 131 | 2,575 | 0.1 | 60 | 60 | 997 | 0 |
| 2012 | 843 | 632 | 12,096 | 0.5 | 516 | 411 | 7,603 | 0.3 | 190 | 190 | 3,111 | 0.1 |
| 2013 | 1,641 | 1,095 | 22,254 | 0.9 | 1,017 | 744 | 14,337 | 0.6 | 394 | 394 | 6,420 | 0.3 |
| 2014 | 2,841 | 1,817 | 37,636 | 1.6 | 1,762 | 1,249 | 24,338 | 1 | 682 | 682 | 11,040 | 0.5 |
| 2015 | 4,599 | 2,831 | 59,674 | 2.5 | 2,830 | 1,946 | 38,367 | 1.6 | 1,062 | 1,062 | 17,059 | 0.7 |
| 2016 | 7,439 | 4,145 | 92,606 | 3.9 | 4,488 | 2,841 | 58,566 | 2.4 | 1,537 | 1,537 | 24,526 | 1.0 |
| 2017 | 11,458 | 5,901 | 138,168 | 5.8 | 6,785 | 4,007 | 85,816 | 3.6 | 2,113 | 2,113 | 33,464 | 1.4 |
| 2018 | 16,993 | 8,134 | 199,154 | 8.4 | 9,892 | 5,463 | 121,519 | 5.1 | 2,791 | 2,791 | 43,884 | 1.8 |
| 2019 | 24,712 | 10,871 | 280,906 | 11.8 | 14,144 | 7,223 | 168,357 | 7.1 | 3,576 | 3,576 | 55,808 | 2.3 |
| 2020 | 33,936 | 14,134 | 377,552 | 15.9 | 19,202 | 9,301 | 223,388 | 9.4 | 4,467 | 4,467 | 69,225 | 2.9 |
| 2021 | 44,407 | 17,940 | 486,727 | 20.5 | 25,009 | 11,775 | 286,608 | 12 | 5,610 | 5,610 | 86,488 | 3.6 |
| 2022 | 56,141 | 22,302 | 608,388 | 25.6 | 31,581 | 14,661 | 358,089 | 15 | 7,020 | 7,020 | 107,790 | 4.4 |
| 2023 | 69,110 | 27,223 | 742,075 | 31.2 | 38,910 | 17,966 | 437,657 | 18.4 | 8,709 | 8,709 | 133,239 | 5.5 |
| 2024 | 83,264 | 32,716 | 887,250 | 37.3 | 46,979 | 21,705 | 525,141 | 22 | 10,694 | 10,694 | 163,032 | 6.7 |
| 2025 | 98,544 | 38,774 | 1,043,276 | 43.9 | 55,765 | 25,880 | 620,276 | 26 | 12,986 | 12,986 | 197,277 | 8.1 |
| 2026 | 114,280 | 45,393 | 1,204,471 | 50.7 | 64,936 | 30,493 | 720,236 | 30.2 | 15,592 | 15,592 | 236,000 | 9.7 |
| 2027 | 130,196 | 52,571 | 1,368,612 | 57.6 | 74,354 | 35,542 | 823,879 | 34.5 | 18,513 | 18,513 | 279,146 | 11.5 |
| 2028 | 146,189 | 60,293 | 1,534,906 | 64.5 | 83,969 | 41,021 | 930,786 | 39 | 21,749 | 21,749 | 326,667 | 13.5 |
| 2029 | 162,142 | 68,558 | 1,702,581 | 71.5 | 93,722 | 46,930 | 1,040,550 | 43.6 | 25,302 | 25,302 | 378,519 | 15.6 |

### *Monthly modeling with Electric Vehicles*

Table 3.7 clearly shows that even under the most aggressive assumptions, electric vehicles will add less than 10 aMW to retail load through 2018. Using more realistic EV adoption rates pushes back this date to between 2020 and 2027. Therefore, this analysis considered the effect of EVs on Tacoma Power's load-resource balance in the 2024-25 operating year, a point in time when the additional load could be considerable.

Under the base forecast electric vehicle market penetration, the monthly model indicates a 50 aMW deficit in three months in a single operating year (1976-77). However, the overall year remained resource surplus. Applying the intermediate forecast, the number of deficit months grew to four in the same operating year. The average deficit for these four months was about 70 aMW, and again, the operating year was resource surplus. In the high estimate of electric vehicle market penetration, the number of deficit months increased dramatically. Four operating years had a total of 19 deficit months (4 months in 1940-41, and 5 months in the operating years 1943-44, 1976-77, and 2000-01). The deficit for four of these months exceeded 100 aMW. Moreover, all four years were deficit on an annual basis.

Public adoption of electric vehicles at levels envisioned by EPRI would clearly impose a significant strain on Tacoma Power. Penetration rates at "intermediate" levels would also significantly impact the utility toward the end of the planning period. However, as stated above, this IRP currently expects that market adoption will more likely follow the path predicted by the National Research Council, a level that will not appreciably affect Tacoma Power through 2025. Nevertheless, due to the potential adverse effects, the utility must closely watch the rate at which customers of Tacoma Power adopt electric vehicles.

# Section Four
# Scenario Analysis

*Section Two of this integrated resource plan developed a base case load-resource balance assessment, and then stress-tested the base case results by varying certain important input variables. This section aggregated those stress test variables with other assumptions regarding the effect of climate change, and the demand caused by electric vehicle into three plausible futures: the March of Technology; Slow Growth; and Green Revolution. Each future has a unique set of assumptions. The monthly model was run with inputs that reflect the assumptions associated with each future. The model results for these scenarios were similar to that of the other analyses in this plan. As such, this scenario analysis helps to confirm this IRP's overall conclusions: Tacoma Power does not need new resources for the foreseeable future, but does retain a small risk of becoming resource deficit over a few months in the late spring if the utility experiences a very dry operating year.*

## Introduction

As part of integrated resource planning, Tacoma Power develops plausible alternative futures and assesses how those futures might affect utility operations. These futures consider the social, economic, diplomatic, and technologic forces that could shape Tacoma Power's operating environment. These futures are designed to capture a range of possible load, price and resource impacts relevant to Tacoma Power. The 2010 IRP includes three scenarios: March of Technology, Slow Growth, and Green Revolution. The first two of these scenarios build upon those included in Tacoma Power's 2008 IRP. In the "March of Technology" scenario, the entrepreneurial spirit of America tackles energy sector problems and develops real lasting solutions. The "Slow Growth" scenario presumes economic weakness, lower energy load and prices, and a public less willing to invest in conservation or government regulations limiting the emissions of GHGs. The last scenario, "Green Revolution," revises a scenario included in the 2004 IRP. This scenario envisions strong GHG legislation, high natural gas prices, a vigorous conservation program, and a wholesale move to electric and hybrid-electric vehicles.

The utility projected the effect of these three scenarios with the monthly model to determine Tacoma Power's load-resource balance status under each. Relevant model inputs were updated to reflect each scenario. One significant difference between the base load-resource balance analysis discussed above and this scenario analysis is the timeframe. The base analysis assessed

Tacoma Power's load-resource balance over the 2016-17 operating year – the period with the expected highest load. This scenario analysis assesses the utility's load-resource balance in the 2024-25 operating year. This time period was chosen because it is far enough into the future so that the effects of PHEVs/EVs and climate change could possibly be significant to Tacoma Power's operations.

## Slow Growth

Assumptions:

- Moderate climate regulation change, no climate change effect on utility operations
- Slow economic growth
- Low market prices for natural gas and electricity
- Reduced Conservation
- Slow customer acceptance of PHEVs and EVs
- Load Flat
- Transmission infrastructure sufficient

This scenario finds the United States in a protracted era of sluggish economic growth. Unemployment remains high, as does business and personal bankruptcies. In this environment, Tacoma Power's customers will resist new expenditures for conservation and electric vehicles due to limited financial resources. Moreover, there will be little appetite for new environmental regulations to limit GHG emissions. Regional demand for electricity stagnates which holds down prices of electricity and natural gas.

Tacoma Power suffers along with the rest of the nation in this Slow Growth scenario. Load is flat and the utility earns limited revenues from secondary sales due to low market prices. This creates rate pressures on the utility. Finally, the consequences of climate change begin to show up in energy production.

### *Monthly modeling*

The modeling results for the slow growth scenario do not indicate load-resource balance concerns for the utility. A single month was resource deficit in the operating year 1976-77. The magnitude of that deficit was 58 aMW. The results for this scenario do not indicate the need for new resources.

# March of Technology

Assumptions:

- Technological advances
  - Lower cost of exploration and extraction of natural gas
  - Lower cost of GHG emission controls
  - Lower cost of Electric/Hybrid vehicles
  - Lower cost of conservation
- Moderate climate change expectations and regulation
- Moderate economic growth
- Base market prices for natural gas and electricity
- Increased conservation only partially offsets new transportation sector demand for electricity
- Transmission infrastructure adequate

In this scenario, breakthroughs in a wide array of technologies affect electric utilities. Advancements in extracting natural gas from shale deposits progress, expands supplies and reducing production costs. However, natural gas demand increases as coal generation plants are shuttered in favor of natural gas fired combustion turbines. As a result, wholesale natural gas prices remain steady. In addition, the cost of renewable energy falls, increasing its proportion of energy supplies. As a result of the move towards natural gas and renewable generation, $CO_2$ emissions from the electric utility industry declines, lowering the cost of new regulations limiting GHG emissions. Overall, economic growth in this scenario is assumed to be moderate.

At Tacoma Power, opposing forces prey on base retail load projections. Improved technologies lower the cost and increase the quantity of conservation activities. Conversely, PHEVs and EVs achieve wide acceptance due to reduced battery costs. As a result, the overall retail load grows somewhat. Finally, while climate change is assumed to have a small effect on precipitation and river inflow patterns, operational adjustments and technological improvements limits the changes on utility hydro generation.

### *Monthly modeling*

The modeling indicates two operating years with monthly resource deficits (1940-41 & 1976-77). The deficits associated with the 1940-41 operating year were relatively benign; two months had an average deficit of about 19 aMW. The results associated with the 1976-77 operating year would be more challenging. Four months had deficits ranging from 27 to 107 aMW (average deficit about 66 aMW). However, both years were surplus over the entire year. The modeling results for this scenario do not indicate the need for new resources.

# Green Revolution

Assumptions:

- Aggressive climate change regulation
- Moderate economic growth
- High natural gas prices
- High but variable electricity prices
- Aggressive conservation
- Aggressive adoption of PHEVs and EVs
- Load declines
- Transmission infrastructure adequate

The Green Revolution scenario is one characterized by society having come to the policy conclusion that climate change is real and that it portends unacceptable adverse consequences. This conversion takes about five years and begins in earnest in 2015. As a result, actions taken to counter climate change are in full force by 2025, but will not have yet perceptibly altered the effects of climate change.

In this scenario, stringent controls are placed on GHG emissions. This causes a strong shift away from coal to natural gas, nuclear and renewable generating resources. Demand and prices for natural gas substantially increase. Overall, prices for electricity increase but also become more volatile due to the high proportion of variable generating resources (i.e., wind). Consumers strongly embrace programmatic and behavioral conservation, and electric vehicles to limit carbon emissions.

The effects of these changes at Tacoma Power are significant. Overall, load falls because aggressive conservation and behavioral changes limiting electricity use outweigh the addition of new electric vehicles. The utility's excess hydro generation is sold at a premium due to the absence of any associated $CO_2$ emissions and high wholesale market prices. This extra revenue relieves some of the upward pressure on Tacoma Power's rates.

### *Monthly modeling*

The modeling results indicate a single operating year with load-resource balance issues (1976-77) out of the 49 modeled. However, ten months of that operating year are deficit (averaging about 45 aMW). The overall year was also deficit by about 24 aMW. This result is largely driven by the large reduction in electricity from BPA due to dry water conditions in the Columbia River basin. While this result is clearly concerning, this scenario is based on a preliminary assessment of the potential effects of climate change.

# Conclusions

Overall, the March of Technology and Slow Growth scenarios produced similar results to other analyses in this plan: Tacoma Power does not need new resources for the foreseeable future, but does retain a small risk becoming resource deficit over a few months in the late spring of very dry years.

The Green Revolution scenario indicated the potential for an adverse outcome that could eventually point to a need for new resources around the year 2020. However, this outcome well into the future (2024-25) and is largely driven by the preliminary assessment of the potential effects of climate change.

# Section Five
# Implementation Plan

*This 2010 IRP recommends that Tacoma Power implement the following actions:*

1. *Acquire 12 to 13 aMW of conservation over the 2012-2013 biennium. Increase the 2011-2012 conservation budget to approximately $36 million.*
2. *Develop a renewable resource compliance strategy for the 2016-2019 compliance period as part of the 2012 IRP.*
3. *Enhance utility modeling and assessment capabilities to better account for risk and uncertainties.*
4. *Evaluate operating flexibility and the potential cost of offering integration services for variable output resources.*
5. *Continue to monitor climate science to better assess the potential impacts of climate change on Tacoma Power resource operations.*

A fundamental element of integrated resource planning is the development of a short-term "implementation plan" – near-term actions the utility should take to implement the findings of the IRP. The 2010 IRP's implementation plan has two parts. The first part recommends actions for the utility to begin, and potentially complete, before the publishing of the 2012 plan. The second part covers areas identified for further study that may, or may not be addressed in future IRPs.

## Actions to Implement this Plan

### *Conservation*

This IRP recommends that Tacoma Power continue to aggressively pursue its policy of acquiring all cost-effective conservation. The quantity of energy savings available, coupled with the utility's own generating resources and power contracts, is projected to allow Tacoma Power to maintain a surplus load-resource balance position and to avoid the need to acquire more costly generation resources.

Tacoma Power's 2008 IRP recommended a ten-year conservation potential of 54 aMW. This translated into a conservation target for the 2010-2011 biennium of 10.8 aMW. This target represented a significant increase from the 7.1 aMW of conservation achieved over the 2008 - 2009 period. To achieve this higher target, the utility increased its biennial conservation budget from nearly $15 million (2007-2008) to $30 million (2009-2010). Tacoma Power presently exceeds interim conservation milestones and expects to achieve or exceed its 2010-2011 target of 10.8 aMW.

The 2010 IRP has identified a ten-year conservation potential of 63 aMW for Tacoma Power's service territory. This potential includes BPA conservation programs at Joint Base Lewis-McChord. Excluding this portion, Tacoma Power's recommended ten-year conservation potential is 60 aMW, which translates to a 2012-2013 conservation target of 12 to 13 aMW. The final biennial target will be developed through the conservation market plan which is due this Fall. This conservation market plan will analyze the opportunities for conservation in the utility's service territory and will set forth a plan to deliver conservation to each market sector.

To achieve this higher level of conservation, the IRP recommends an increase to $36 million in conservation spending for the 2011-2012 biennium.

Finally, Tacoma Power investigated the effects of further accelerating the rate of conservation acquisition but determined that the benefits did not justify the additional costs.

### Renewable Energy Credit Acquisition

As noted, conservation is the only new resource Tacoma Power needs to serve load. Nevertheless, the utility is mandated by the Energy Independence Act to serve a portion of retail load with electricity from eligible renewable resources. As a result, Tacoma Power may have to acquire new renewable resources solely for regulatory compliance purposes. The utility would sell the energy produced by any new renewable resource in the wholesale market, presumably at a significant loss.

Tacoma Power currently estimates that it will need approximately 154,000 MWhs per year of renewable energy or RECs to comply with the renewable mandates for the compliance period beginning in 2012 and running through 2015. The 2008 IRP recommended a renewable resource compliance strategy of acquiring RECs to supplement Tacoma Power's own incremental hydro generation. As a result, Tacoma Power entered into a contract to acquire approximately 79,000 RECs per year from 2012 through 2019.

This 2010 IRP reviewed Tacoma Power's inventory of incremental hydro resources and RECs, and concluded that these resources should slightly exceed the annual renewable mandate during the last three years of the 2012-2015 compliance period. However, this review also indicates that Tacoma Power may need to acquire up to 20,000 additional RECs for the compliance year 2012 in order to accommodate the utility's transition to this new requirement.

Given the uncertain nature of the legislative process and the wide variation in proposed amendments to the Energy Independence Act, determining a precise course of action that minimizes compliance cost and risks is near impossible at this time. Delaying the development of a compliance strategy to the 2012 IRP will provide two years to monitor legislative reform efforts, and will still leave approximately three and one-half years to execute the compliance strategy.

## Actions to Prepare for the Next IRP

### *Renewable Portfolio Standards*

This IRP also recommends that Tacoma Power wait until the 2012 IRP to develop a strategy for complying with the 2016 through 2019 increased renewable resource mandate. While the utility is well short of the 480,000 MWhs of renewable resources needed annually for the second compliance period (2016-2019), near term efforts to acquire resources/RECs to fill the shortfall runs some regulatory risk.

During both the 2009 and 2010 Washington state legislative sessions, considerable effort was made to amend the Energy Independence Act. Some of the proposed changes would make the regulatory standards more expansive while others would reduce regulatory costs. Many of the proposed changes would have created large differences in Tacoma Power's compliance targets.

Presuming current mandates remain in effect, Tacoma Power will need an additional 310,000 MWhs of renewable electricity or RECs to comply with the 2016 – 2019 renewable standard. The next IRP will need to assess alternative compliance options and will need to develop a strategy to meet the standard.

### *Enhanced Assessment Capabilities*

After the assessment goals for this IRP were identified, the next step was to determine the appropriate assessment approach. The planning staff determined that "deterministic" modeling was the best approach to assessing Tacoma Power's load-resource balance status. This type of modeling allows the user to assess the consequences of specific future projections.

Stochastic modeling is a different type of analysis that is often considered a superior tool for assessing the relative costs and risks of alternative resource acquisition options. As discussed above, the 2012 IRP will likely face such a question with regard to compliance with the 2016 – 2019 renewable resource mandate. Tacoma Power's choice will be either to acquire all, or part, of an eligible renewable resource. This choice will

A **deterministic analysis** performs a calculation using a fixed set of inputs. The inputs are usually based on an average expectation and some variation from that expectation. **Stochastic analysis** performs the same calculation, but many more times using a distribution of inputs. Stochastic analysis produces a range of outcomes that can be useful when evaluating various options based on multiple criteria such as the cost, cost risk and environmental attribute of alternative power generation alternatives.

require a careful balancing of relative risks and costs to the utility. Stochastic analytic approaches are particularly adept at balancing the costs and risks of new resources.

For the next IRP, Tacoma Power should consider incorporating stochastic analytic techniques. This type of analysis could be especially useful at helping the utility develop its renewable resource compliance strategy.

> In the 2008 IRP, Tacoma Power faced two questions involving cost and risk: 1) the choice between a "Block" or "Slice/Block" contract with BPA, and 2) the choice between a "REC" and "new resource" strategy for compliance with the Energy Independence Act's 2012 through 2015 renewable resource mandate. In the 2008 IRP, Tacoma Power used stochastic analysis to assess these questions.

### *Operating Flexibility*

As a utility with considerable hydro-electric generation, questions have been asked about Tacoma Power's ability to integrate intermittent energy resources such as wind generation. Fueling this question is the expansion of wind resources in the Pacific Northwest, as well as the possibility that Tacoma Power may need in the future to acquire an intermittent renewable resource, such as wind to comply with mandates of the Energy Independence Act. The utility's ability to integrate variable energy resources directly depends on operational flexibility.

To this end, Tacoma Power has begun to assess its operational flexibility. This analysis indicates a limited ability to integrate intermittent resources under current operating paradigms. The 2012 IRP will continue this analysis to identify the operational changes needed to provide various levels of integration capacity (e.g., 10, 25, or 50 aMW), and the opportunity cost of those changes (e.g., the cost of: transferring generation from high value heavy-load hours to low value light-load hours, or other operational changes that reduce generation efficiencies). The analysis could also consider whether the new operating regime would affect utility or system reliability.

### *Climate Change Activities*

There are a myriad of ongoing efforts to address climate change: proposed federal legislation and regulations, the Western Climate Initiative, and bills introduced in the Washington State Legislature. Tacoma Power should actively follow these efforts and participate where appropriate, to give voice to the interests of utility ratepayers. The 2012 IRP should address any of these efforts that succeed prior to its development.

The 2012 IRP should also incorporate BPA findings regarding the effect of climate change on generation variability. Finally, the utility should monitor whether climate effects on the Columbia River system enters into BPA's negotiations with Canada.

# Appendix A

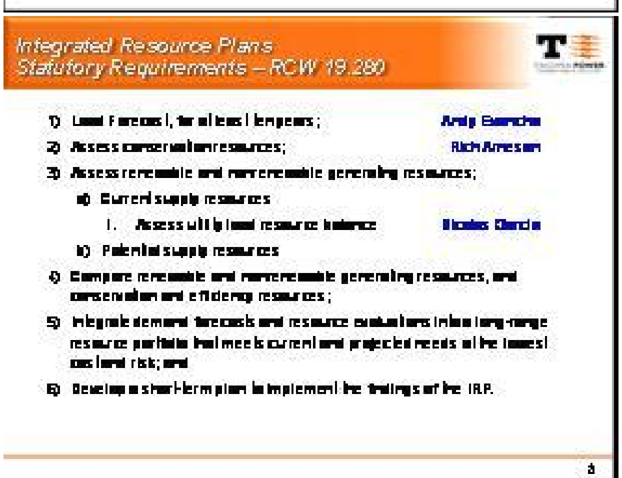
# Stakeholder Meeting Presentations

Tacoma Power held three public meetings to discuss the planning efforts and solicit feedback on this IRP. To maximize public participation, the utility made a special effort to contact representatives of major industrial and military customers, and local environmental and citizens interest groups.

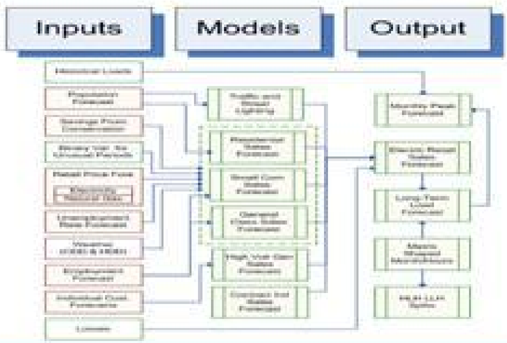
The first meeting was held on March 24, 2010, and described Tacoma Power's approach (e.g., the computer models and important assumptions) to assessing its load-resource balance and initial results from that analysis. The second meeting occurred on May 19, 2010, at which the utility's conservation potential was the principle topic. At the final meeting on July 23, 2010, planning staff reviewed all modeling results and principle IRP conclusions.

Below are the Powerpoint slides from those meeting






## Tacoma Power Forecast Process




5

## Tacoma Power Forecasting Model Structure

**3 Econometric Class Models**

- Residential, Small General & General

**2 Direct Estimates**

- High Voltage General & Contract Industrial

**2 Simple Specifications**

- Street Lights and Traffic Signals

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## Tacoma Power Forecasting Model Structure

Sales are a function of:

- Price
- Economic Activity
- Number of Customers
- Weather
- Price of Substitutes

Structurally adequate for 5 to 10 year analysis

20 year analysis supplemented by

- Scenario Analysis
- Programmatic Conservation Analysis

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## Tacoma Power Forecasting Model Accuracy

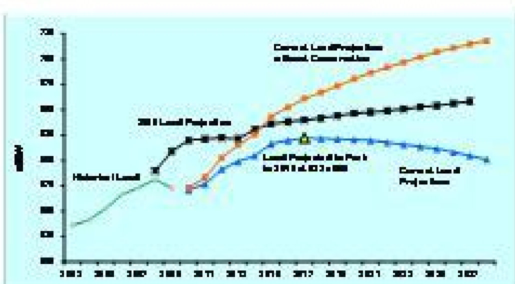
Forecast accuracy is a function of

- Model structure
- Explanatory variable accuracy

Key explanatory variables

- Customer growth
- Price
- Economic activity
- Structural change
  - End Use Saturations
  - Efficiency Trends
  - Housing Stock Size
  - Thermal Integrity

## Tacoma Power's Annual Load-Resource Balance Load Forecast

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## 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 lower than its pro rata share of its ten-year potential."

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## Role of CPAs in Utility Planning

2007 Conservation Potential Assessment

10-year maximum achievable conservation potential of 54 aMW

- Used to determine an aspirational goal of 5.4 aMW in 2010 and 2011
- Used to define and develop program plans and budgets
- Used in 2008 IRP resource planning and load forecasts

2010 Conservation Potential Assessment – Under Development

The 10-year potential to be calculated for WAC 194-37 compliance

- To determine short-term biennium goals/targets and budgets
- To project mid-term conservation planning and load forecasts

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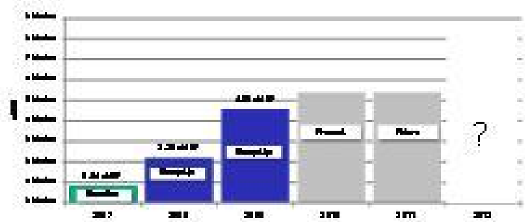
## Conservation Targets Increasing

Conservation target of 4.6 and 4.6 aMW have been set for 2010 and 2011 for I-937 purposes based on the Power Council's conservation calculator

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## Program Portfolio Considerations

- Cost effectiveness
- Customer satisfaction
- Equitable availability of programs
- Regional coordination
- Minimize market risk
- Programs must accommodate Council's RTF measures

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## Positioned to Meet the Goals

- Portfolio of programs to serve customers
- Staffed up to 34
- Marketing in place
- 2009-2010 budget of $31M

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## Bringing Programs to Life Commercial & Industrial

- Expanded Bright Rebates Program
- Custom Retrofit Program
- Energy Smart Gr… Program

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**Questions?**
**Comments!**

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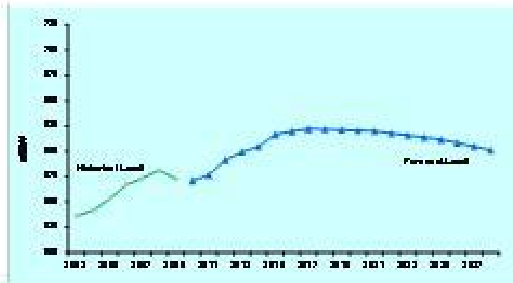
## Tacoma Power's Load Forecast



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## Tacoma Power's Resources


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## Tacoma Power's Resources

| Resource | Facility (Nameplate capacity in MW where appropriate) | Average Energy Production (aMW) | Critical Energy Production (aMW) |
|---|---|---|---|
| BPA Contract | | | |
| | Multiple | [illegible] | [illegible] |
| Owned Projects | | | |
| Cowlitz | Mayfield (162) | [illegible] | 67.1 |
| | Mossyrock (300) | 127.2 | [illegible] |
| Nisqually | Alder (50) | [illegible] | 16.2 |
| | LaGrande (64) | [illegible] | 25.0 |
| Cushman | No. 1 (43) | 16.2 | [illegible] |
| (Skokomish) | No. 2 (81) | [illegible] | [illegible] |
| Wynoochee | Wynoochee (13) | [illegible] | [illegible] |
| Hood St. | Hood St. (0.8) | 0.5 | 0.5 |
| Other Contracts | | | |
| Grand Coulee Project Hydroelectric Auth. | | 27.6 | 27.1 |
| Priest Rapids | | 2.6 | 2.0 |
| Federal Hydro System Diversity Benefit | | | 12.0 |
| Total | | [illegible] | [illegible] |

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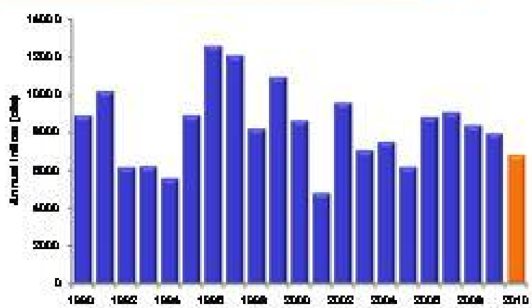
## Average Annual Inflow at Tacoma Power Projects

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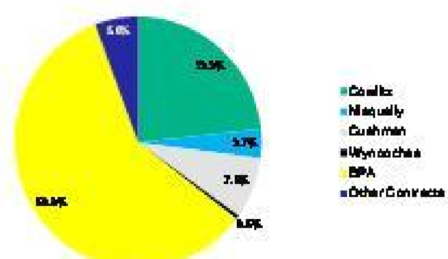
## Tacoma Power Resource Mix - Adverse Water

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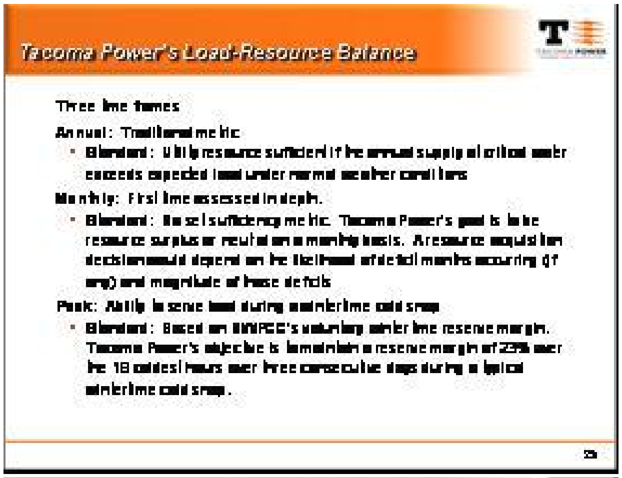
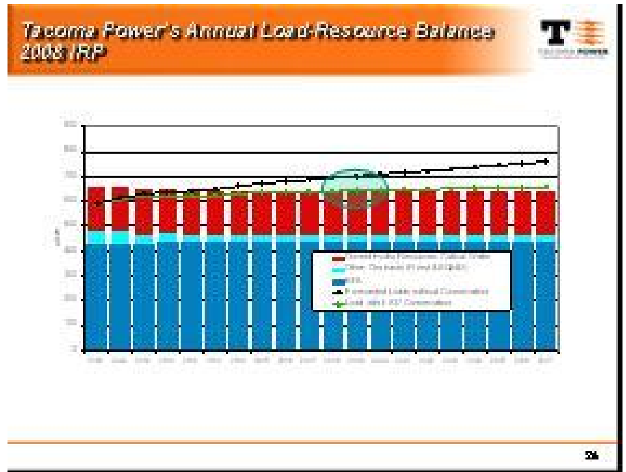
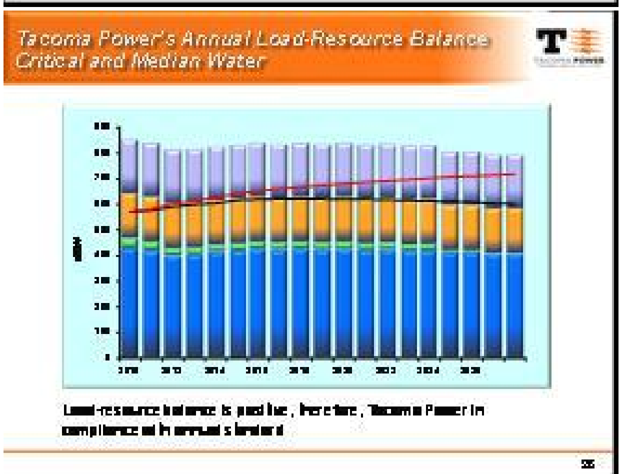
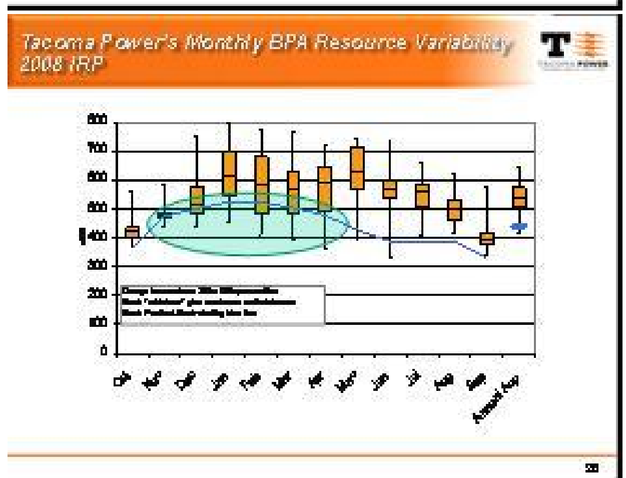
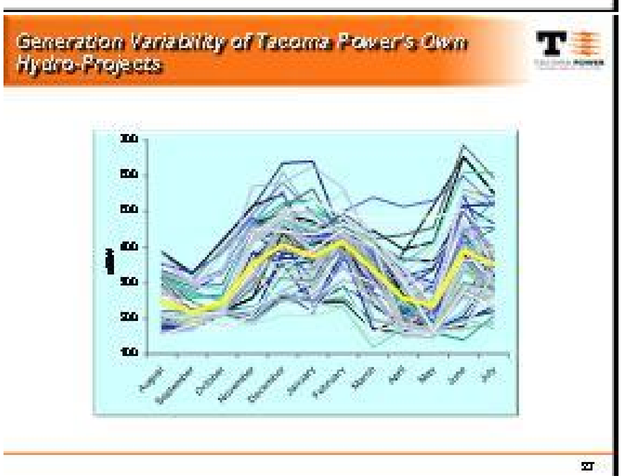
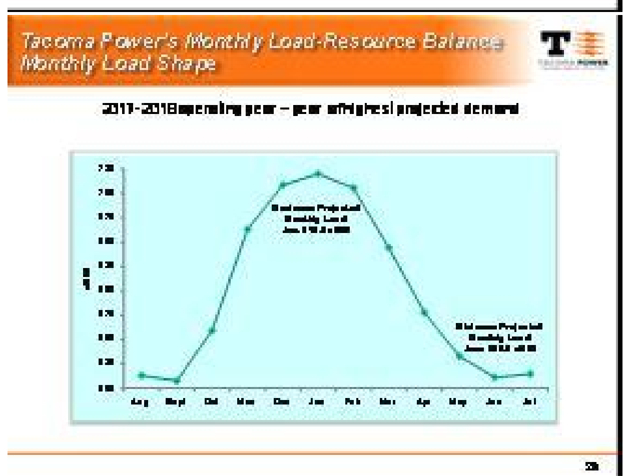

Tacoma Power's Load-Resource Balance
Three time frames
Annual: Traditional metric
Standard: Utility resource sufficient if the annual supply of critical water exceeds expected load under normal weather conditions
Monthly: First time assessed in depth.
Standard: New self sufficiency metric. Tacoma Power's goal is to be resource surplus or neutral on a monthly basis. A resource acquisition decision would depend on the likelihood of deficit months occurring (if any) and magnitude of those deficits
Peak: Ability to serve load during wintertime cold snap
Standard: Based on PNWPCC's voluntary winter time reserve margin. Tacoma Power's objective is to maintain a reserve margin of 23% over the 18 coldest hours over three consecutive days during a typical wintertime cold snap.


Tacoma Power's Annual Load-Resource Balance
2008 IRP


Tacoma Power's Annual Load-Resource Balance
Critical and Median Water


Tacoma Power's Monthly BPA Resource Variability
2008 IRP
800
700
600
500
400
300
200
100
0


Generation Variability of Tacoma Power's Own Hydro-Projects
August
September
October
November
December
January
February
March
April
May
June
July


Tacoma Power's Monthly Load-Resource Balance
Monthly Load Shape

## Tacoma Power's Monthly Load-Resource Balance The Vista LT Model

Selected the Vista LT optimization model because of its ability to deal with variable river flows. The model's basic objective is to maximize the value of the power produced

Vista model inputs include: wholesale power price projections, retail demand, and 76 years of actual river flow data (1928-2003)

Model operating constraints:

- seasonal reservoir elevations: minimum, maximum and target
- generation/transmission capacities, ramping restrictions and forecasted outages

The Vista model produced 75 "annual" projections of "monthly" wholesale transactions (one for each year of river flow)

- sales represent a supply surplus while purchases signal a deficit

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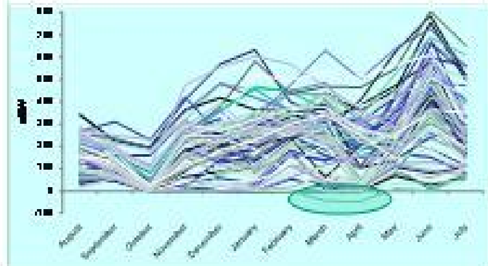
## Tacoma Power's Monthly Power Sales as Predicted by the Vista LT Model Output

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## Tacoma Power's Monthly Load-Resource Balance Low Production Years

Ten driest operating years

Monthly Load-Resource Balance Projections

| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|
| August | 75 | 99 | 47 | 94 | 70 | 295 | 18 | 11 | 64 | 153 |
| September | 67 | 62 | 68 | 75 | 55 | 209 | 59 | 58 | 54 | 119 |
| October | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 18 |
| November | 29 | 0 | 0 | 16 | 10 | 2 | 0 | 16 | 0 | 55 |
| December | 6 | 0 | 0 | 1 | 0 | 0 | 0 | 29 | 0 | 92 |
| January | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 16 | 19 | 5 |
| February | 9 | 59 | 139 | 0 | 0 | 0 | 59 | 88 | 112 | 0 |
| March | 0 | 29 | 71 | 0 | 0 | -45 | 117 | 106 | 49 | 0 |
| April | 0 | 20 | 0 | 17 | 0 | -48 | 156 | 16 | 10 | 2 |
| May | 80 | 107 | 80 | 99 | 69 | 19 | 178 | 168 | 121 | 92 |
| June | 900 | 83 | 60 | 7 | 27 | 0 | 279 | 279 | 129 | 40 |
| July | 155 | 105 | 109 | 79 | 58 | 69 | 161 | 188 | 107 | 98 |

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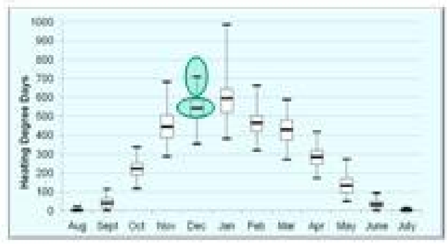
## Tacoma Power's Monthly Load-Resource Balance Range of Heating Degree Days (McCord AFB)

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## Effects of Weather Adjusting Load Forecast

| | Dry Years | | | | | | Cold Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| August | 13 | 52 | 210 | 9 | 61 | 141 | 108 | 91 | 992 | 206 | 242 | 115 |
| September | 96 | 67 | 209 | 57 | 51 | 95 | 106 | 68 | 210 | 94 | 211 | 185 |
| October | 28 | 4 | 0 | 2 | 0 | 91 | 1 | 0 | 186 | 5 | 179 | 5 |
| November | 0 | 9 | 16 | 5 | 0 | 17 | 105 | 296 | 282 | 176 | 274 | 19 |
| December | 12 | 0 | 0 | 6 | 2 | 21 | 94 | 198 | 421 | 240 | 258 | 0 |
| January | 13 | 2 | 0 | 7 | 96 | 19 | 90 | 165 | 968 | 64 | 269 | 0 |
| February | 82 | 17 | 0 | 54 | 121 | 6 | 176 | 928 | 929 | 170 | 999 | 64 |
| March | 2 | 0 | -68 | 104 | 67 | 0 | 920 | 438 | 259 | 909 | 249 | 129 |
| April | 70 | 0 | -8 | 44 | 41 | 2 | 901 | 969 | 417 | 271 | 909 | 94 |
| May | 108 | 74 | 0 | 194 | 146 | 97 | 456 | 471 | 587 | 957 | 418 | 291 |
| June | 21 | 92 | 0 | 959 | 176 | 95 | 561 | 766 | 806 | 510 | 485 | 290 |
| July | 112 | 179 | 52 | 997 | 265 | 207 | 984 | 594 | 647 | 921 | 441 | 280 |

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## Summary of Vista LT results

The weather adjusted results indicate that Tacoma Power has a small risk of experiencing monthly resource deficits

- Resource deficits occurred in 1 of the 75 operating years modeled
- This year had two continuous months of deficit: March and April, and
- The deficits are large enough to likely require wholesale market purchases to make up the shortfall (~50 aMW)

However,

- The overall number of deficit months were small: 2 of 900 (0.1%)
- 75% of operating years had surpluses of at least 160 aMW during March and 30 aMW in April

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## Tacoma Power's Peak Load-Resource Balance

Voluntary sustained-peak capacity standard
- Tests utility ability to serve the 6 highest load hours each day over 3 consecutive days – a total of 18 hours – based on "normal" temps
- Planning Reserve Margin:
  - Winter: 23 percent
  - Summer: 24 percent

Discussions with the Resource Operations & Trading unit staff indicated that Tacoma Power's assessment should focus on three peak periods:
- 1-hour: to test Tacoma Power's maximum energy delivery capability;
- 18-hour: to test towards long-peak the voluntary sustained-peak capacity standard; and
- 72-hour: to test Tacoma Power's ability to meet a longer duration peak event

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## Tacoma Power's Peak Retail Demand

Tacoma Power's 72-hour cold temperature minimums were determined for each year from 1998-2008 – 11 periods in all

To project peak load, these temperature minimums were assumed to occur in a week without any holidays (to maximize demand)

This assumption along with the temperature data were used to project 1-, 18-, and 72-hour peak retail loads for each period

The period with the mid-point loads was used to define the "design" peak load for this analysis

| Period | Peak Demand |
|---|---|
| 1-hour | 1003 MW |
| 18-hour | 946 MW |
| 72-hour | 833 MW |

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## Tacoma Power's Peak Resource Supply

The Peak Resource Supply Analysis was based on the following assumptions:
- Reservoirs began at levels associated with critical water
- Operating regimes would not be violated (e.g., spinning/non-spinning reserve requirements, minimum flow mandates, regulating margins, etc).

Resource Constraints:
- Cowlitz (Mayfield and Mossyrock) Mayfield generation at [illegible] MW with Mossyrock at [illegible] MW – Mossyrock [illegible] 30 MW [illegible] spinning reserve requirements. The Riffe Lake reservoir drafts 2.5 feet per day (7 feet below planned levels, over the 72-hour cold snap).
- Cushman (Cushman No. 1 and No. 2) Cushman No. 1 generation at 40 MW and [illegible]. Cushman No. 2 generation [illegible] 71 MW – [illegible] MW [illegible] to support spinning reserves and to balance [illegible] conditions [illegible] Cushman No. 2 [illegible] Lake Cushman drafts about 1.1 feet per day (3.4 feet below planned levels over 72 hours).
- Nisqually (Alder and LaGrande) Generation [illegible] above minimum flow levels – 13 MW at Alder and 22 MW at LaGrande – due to FERC constraints imposed by FERC license Article 404.
- The Block Portion of the BPA Contract: Assumes that the BPA block contract will deliver 225 MW each hour during January 2012
- The Slice Portion of the BPA Contract: It is difficult to estimate the energy and capacity from the Slice contract during a cold snap. Tacoma Power's Slice share based on BPA's highest 72-hour winter generation from 2005 through 2008
- Other Resources: Tacoma Power's Wynoochee resource was assumed to operate as "fill ing credits." Grand Coulee Project Hydroelectric Authority [illegible] during the winter season. All other resources were assumed to operate at their average level for the month of January.

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## Tacoma Power's Peak Capacity Margin

| Period | Peak Demand | Peak Supply | Capacity Margin |
|---|---|---|---|
| 1-hour | 1003 MW | 1288 MW | 28% |
| 18-hour | 946 MW | 1288 MW | 36% |
| 72-hour | 833 MW | 1176 MW | 39% |

Tacoma Power exceeds the goal of 23 percent planning reserve margin for the 18-hour period recommended by the voluntary regional winter "sustained-peaking capacity" standard

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## Tacoma Power's I-937 Status

Tacoma Power does not need energy resources, but what about "eligible" renewable energy for I-937 compliance?

Tacoma's 2008 IRP Focused on Incremental Hydro & RECs for the first compliance period (2012 – 2015)

| Year | Renew. Mandate | Projected Renew. Need (MWh) | Sources of Eligible Renewables (MWh): Incremental Hydro: LaGrande | Mossy Rock | Cushman | BPA | Bundled REC Contr. | Total Renew. | Remaining Deficit (Surplus) |
|---|---|---|---|---|---|---|---|---|---|
| 2011 | | | | | | | | | |
| 2012 | 3% | 150,771 | 5,280 | 44,898 | 9,324 | 8,606 | 79,000 | 148,045 | (2,726) |
| 2013 | 3% | 153,471 | 5,280 | 44,898 | 29,225 | 8,606 | 79,000 | 168,078 | 15,604 |
| 2014 | 3% | 155,429 | 5,280 | 44,898 | 29,225 | 8,606 | 79,000 | 168,078 | 10,647 |
| 2015 | 3% | 158,171 | 5,280 | 44,898 | 29,225 | 8,606 | 79,000 | 168,078 | 9,905 |
| 2016 | 9% | 481,565 | 5,280 | 44,898 | 29,225 | 99,035 | 79,000 | 165,365 | (287,821) |
| 2017 | 9% | 487,256 | 5,280 | 44,898 | 29,225 | 99,035 | 79,000 | 165,365 | (293,890) |
| 2018 | 9% | 489,459 | 5,280 | 44,898 | 29,225 | 99,035 | 79,000 | 165,365 | (298,072) |
| 2019 | 9% | 490,590 | 5,280 | 44,898 | 29,225 | 99,035 | 79,000 | 165,365 | (298,594) |
| 2020 | 15% | 818,829 | 5,280 | 44,898 | 29,225 | 99,035 | | 116,365 | (702,163) |

Tacoma projects to be some 33 aMW short of the RPS's second compliance period (2016-2019) and may need to acquire renewable resources prior to that time

40

## IRP - Next Steps

Remaining "must do" IRP activities.

3) Assess potential supply resources;
4) Compare renewable and nonrenewable generating resources, and conservation and efficiency resources;
5) Integrate demand forecasts and resource evaluations into a long-range resource portfolio that meets current and projected needs at the lowest cost and risk; and
6) Develop a short-term plan to implement the findings of the IRP.

These should be relatively straightforward since Tacoma Power does not need new energy resources. Therefore, Tacoma Power has the opportunity to focus on certain risk/opportunity scenarios:

a) Climate Change
b) Value of Flexibility
c) Further Evaluate Conservation
d) Electric Vehicles

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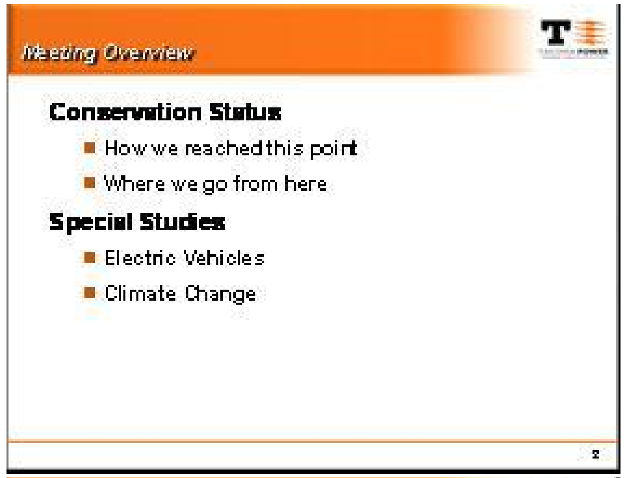
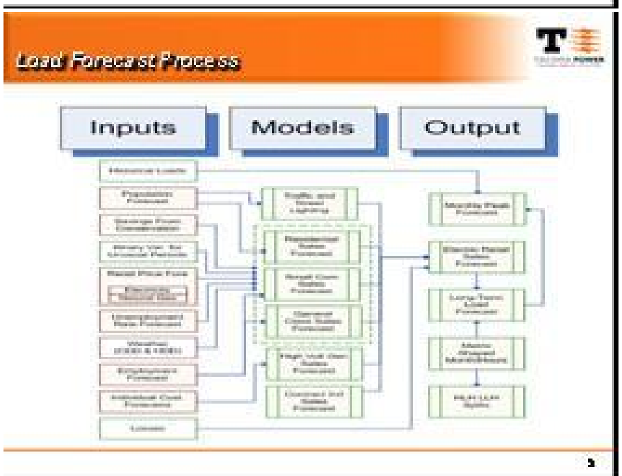
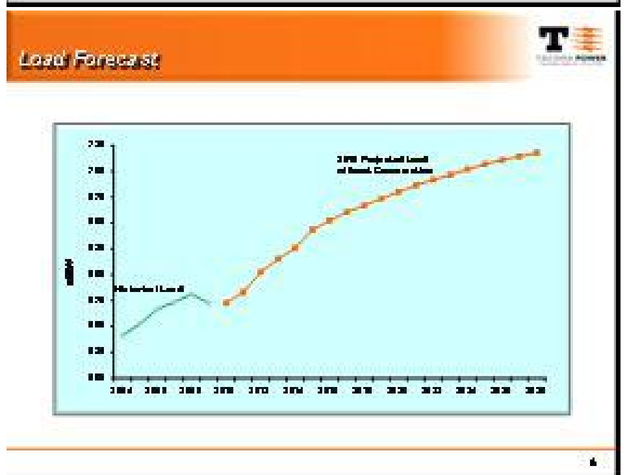
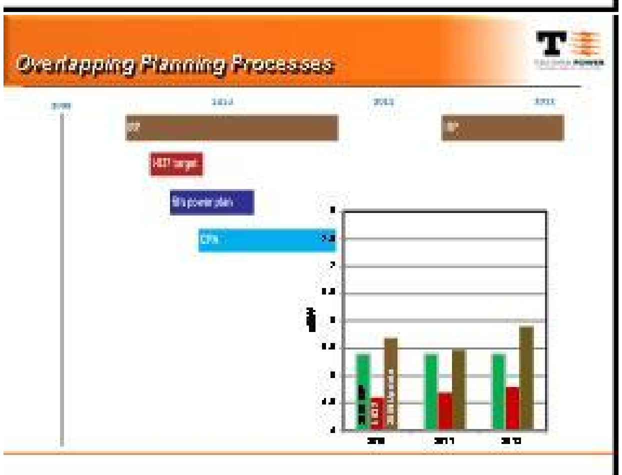
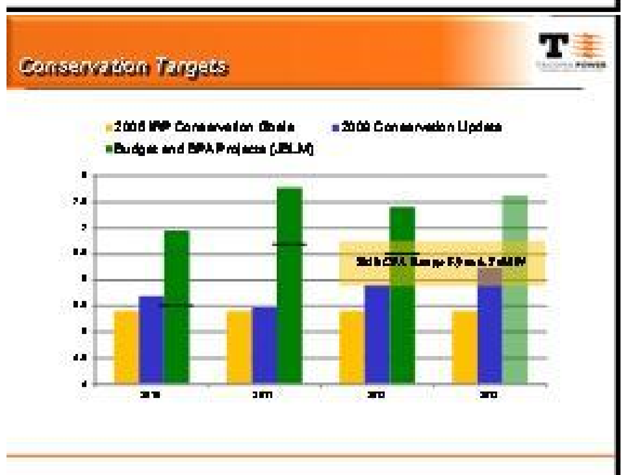
TACOMA POWER
Integrated Resource Planning
Second Meeting of the Public Review Committee
May 13, 2010


Meeting Overview
Conservation Status
How we reached this point
Where we go from here
Special Studies
Electric Vehicles
Climate Change
2

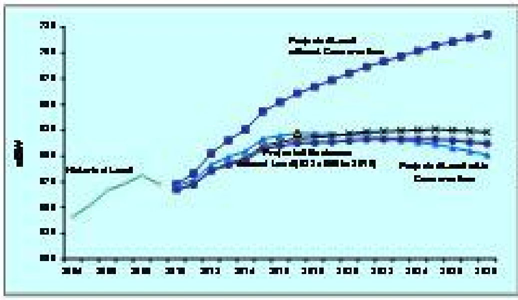

Load Forecast Process
Inputs
Models
Output


Load Forecast


Overlapping Planning Processes


Conservation Targets
2008 IRP Conservation Goals
2009 Conservation Update
Budget and BPA Projects (JBLM)

## Load Forecast



7

## Conservation Planning

*Rich Arneson*

May 13, 2010

## Energy Conservation - State Regulation

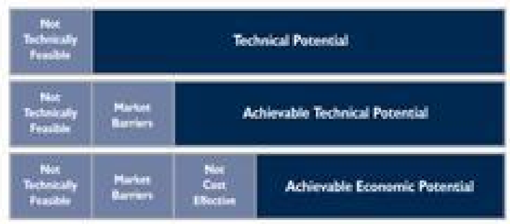
The Energy Independence Act requires qualifying utilities to determine their conservation potential using "methodologies consistent with those used by the Pacific Northwest Electric Power and conservation planning council" (19.285.040(1)(a) RCW)

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."

9

## General Approach to CPA



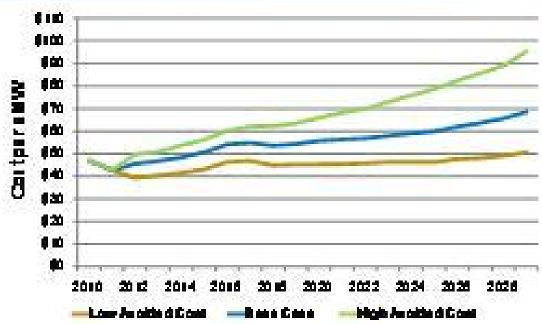

10

## Conservation Scenarios Developed

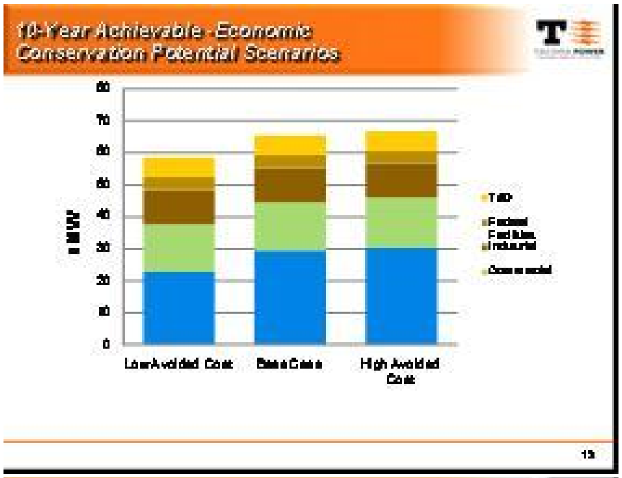
| Avoided Cost | Ramp Type | [illegible] | Impact on Revenue Requirement | 2-Year Cost $ Millions | Conservation Potential (aMW) |
|---|---|---|---|---|---|
| Base Case | Pro-Rata | NA | | | |
| High Case | Pro-Rata | 10% higher cost | | | |
| Low Case | Pro-Rata | 12% lower cost | | | |
| Base Case | Accelerated Early | 20% higher 1-5 year | | | |
| Base Case | Accelerated Late | 20% Lower 1-5 year | | | |

11

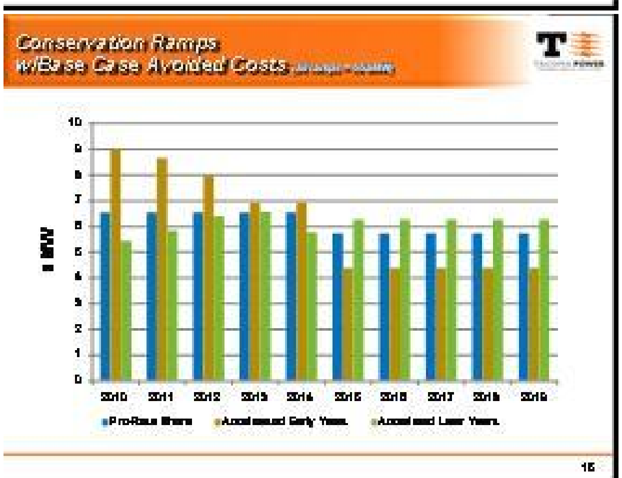
## Forecast Avoided Cost Scenarios

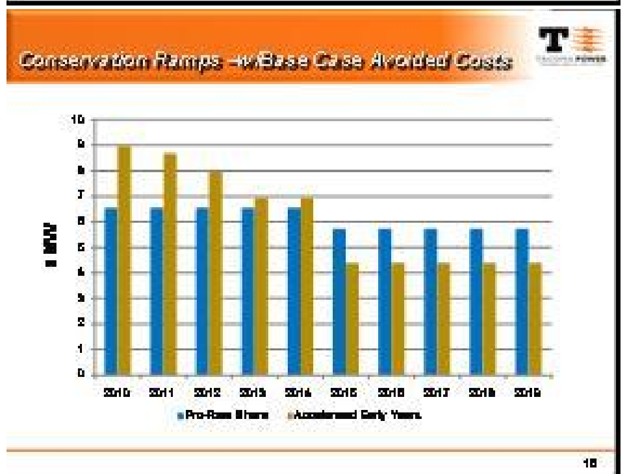



12



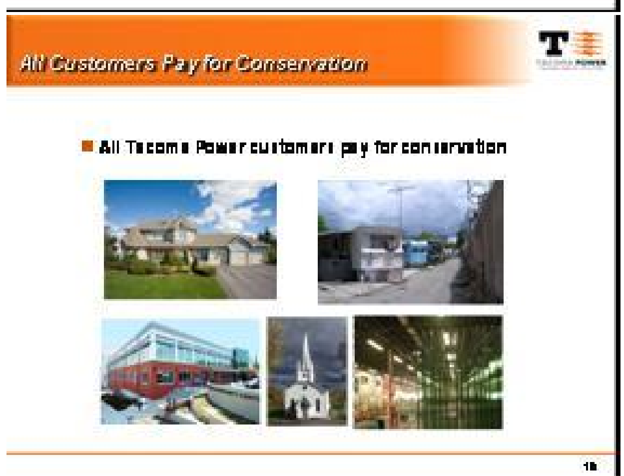






| Avoided Cost | Ramp Type | Relevant change | Impact on Revenue Requirement | 2-Year Cost $ Millions | Conservation Potential (aMW) |
|---|---|---|---|---|---|
| Base Case | Pro-Rata | NA | 5.2% | 15.4 | 66 |
| High Case | Pro-Rata | 10% higher cost | 7.1% | 18.5 | 67 |
| Low Case | Pro-Rata | 12% lower cost | 4.2% | 12.4 | 59 |
| Base Case | Accelerated Early | 20% higher 1-5 year | 5.7% | 17.2 | 66 |
| Base Case | Accelerated Late | 20% Lower 1-5 year | 4.5% | 11.2 | 66 |



## Conservation Status

- Five conservation scenarios
  - Four are consistent with I-937 (one is not – lower ramp rates)
    - The four all provide sufficient conservation acquisition so as to avoid the need for new generation resources
    - Policy call based on:
      - Energy savings
      - Utility costs
      - Bill/Rate impacts (and disparities)
      - Other concerns

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## Special Studies

Nicolas Garcia

May 19, 2010

## Electric Vehicles

| Year | Baseline Case Adoption | | | Intermediate Adoption | | |
|---|---|---|---|---|---|---|
| | EV & PHEV Share of New Vehicles | Number of New EV & PHEV Vehicles | aMW | EV & PHEV Share of New Vehicles | Number of New EV & PHEV Vehicles | aMW |
| 2010 | 0.0% | - | - | 0.0% | - | - |
| 2011 | 0.3% | 120 | 0.0 | 0.8% | 252 | 0.1 |
| 2012 | 0.6% | 380 | 0.1 | 1.4% | 822 | 0.3 |
| 2013 | 0.9% | 788 | 0.3 | 1.9% | 1,486 | 0.6 |
| 2014 | 1.2% | 1,386 | 0.6 | 2.8% | 2,466 | 1.0 |
| 2015 | 1.5% | 2,124 | 0.7 | 3.5% | 3,852 | 1.5 |
| 2016 | 1.8% | 3,076 | 1.0 | 4.5% | 5,882 | 2.4 |
| 2017 | 2.1% | 4,223 | 1.4 | 6.4% | 9,014 | 3.5 |
| 2018 | 2.4% | 5,582 | 1.8 | 8.2% | 10,835 | 5.1 |
| 2019 | 2.7% | 7,162 | 2.3 | 10.5% | 14,448 | 7.1 |
| 2020 | 3.0% | 8,984 | 2.9 | 12.0% | 18,501 | 9.4 |
| 2021 | 3.8% | 11,230 | 3.6 | 13.5% | 23,520 | 12.0 |
| 2022 | 4.6% | 14,040 | 4.4 | 15.1% | 29,323 | 15.0 |
| 2023 | 5.4% | 17,418 | 5.5 | 16.6% | 36,262 | 18.4 |
| 2024 | 6.2% | 21,368 | 6.7 | 18.1% | 43,410 | 22.0 |
| 2025 | 7.0% | 25,872 | 8.1 | 19.6% | 51,780 | 26.0 |
| 2026 | 7.8% | 31,184 | 9.7 | 20.7% | 60,985 | 30.2 |
| 2027 | 8.6% | 37,038 | 11.5 | 21.8% | 71,085 | 34.5 |

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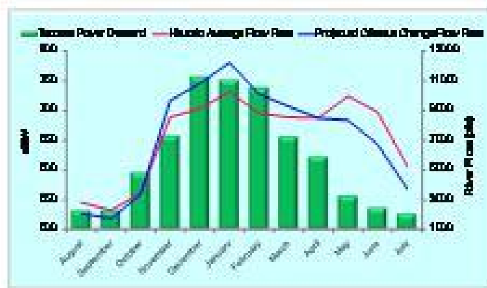
## Climate Change

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TACOMA POWER

## Overview of the 2010 IRP Public Review Committee

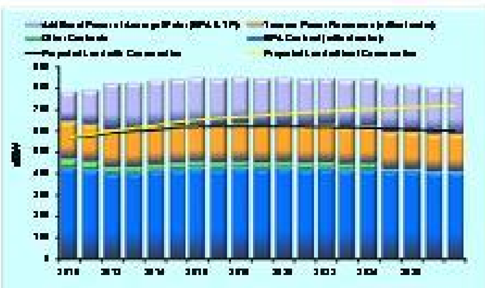
July 23, 2010

### Overview of IRP Assessments

1. Does Tacoma Power need new resources?
   - Load-Resource Balance
     - Annual
     - Monthly
     - Peak
2. Compliance with renewable resource requirements?
3. How much conservation should Tacoma Power acquire?
4. How might electric vehicles affect the utility?
5. What about climate change?

2

### Annual Load-Resource Balance
### Critical and Median Water



3

### Monthly Load-Resource Balance
### The Vista LT Model

Selected the Vista LT optimization model because of its ability to deal with variable river flows. The model's basic objective is to maximize the value of the power produced

Vista model inputs include: wholesale power price projections, retail demand, and 76 years of actual river flow data (1928-2003)

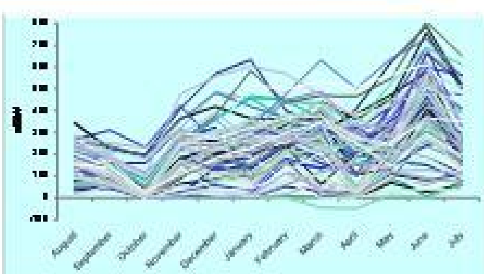
Model operating constraints:
- seasonal reservoir elevations: minimum, maximum and target
- generation/transmission capacities, ramping restrictions and forecasted outages

The Vista model produced 75 "annual" projections of "monthly" wholesale transactions (one for each year of river flow)
- sales represent a supply surplus while purchases signal a deficit

Looked for:
- resource deficits over an entire year
- re-occurring resource deficits over the same month/season

4

### Monthly Load-Resource Balance
### Vista LT Model Results



5

### Monthly Load-Resource Balance
### Summary of Stress Tests

Stress tests varied
- Load growth forecasts
- Conservation acquisition
- Supply from BPA

Re-ran the Vista LT more than 100 times

Results
- No model run produced a resource deficit over an entire year
- In a few model runs, the months of March and April were resource deficit in three of 75 water years

Conclusion: the monthly/seasonal load-resource balance analysis does not indicate a need for additional resources

6

## Monthly Load-Resource Balance Additional Considerations

**Unaccounted Resources**

- Mossyrock rebuild: Engineering estimates project to increase output 4.7 aMW
  - Wicket gates, turbine efficiencies and transformer efficiencies
- Cushman project: Engineering estimates project to add 2.7 aMW
  - New small power house

**Model Benchmarking**

- Compared Vista LT modeling results with that of other computer models Tacoma Power uses to guide generating facility operations
  - Vista LT within 0.4 feet of predictions by the operations models of end-of-month reservoir elevations
  - Vista LT's output predictions were about 5 aMW higher than the operations models

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## Peak Load-Resource Balance

Peak assessment focused on three peak periods:

- 1-hour: test Tacoma Power's maximum energy delivery capability;
- 18-hour: test consistency with voluntary NWPCC standard; and
- 72-hour: test ability to meet a longer duration peak event

Peak retail loads were based on the 72-hour coldest period, each year from 1998-2008

Peak resource supply assumed:

- Reservoirs at levels associated with critical water
- Operating regimes would not be violated (e.g., spinning/non-spinning reserve requirements, minimum flow mandates, regulating margins)

| Period | Peak Demand | Peak Supply | Capacity Margin |
|---|---|---|---|
| 1-hour | 1003 MW | 1266 MW | 21% |
| 18-hour | 948 MW | 1266 MW | 25% |
| 72-hour | 833 MW | 1178 MW | 29% |

8

## Summary of Tacoma Power's Load-Resource Balance

1. **Annual Assessment:** The combination of Tacoma Power's current resources, contracts and conservation acquisitions sufficient to meet the utility's annual retail load for the foreseeable future.
2. **Monthly Assessment:** Of 1500 months modeled, only 2 (one in March and April) had deficits:
   - This is a rare event (0.2%).
   - Moreover, Tacoma Power was resource surplus even in this year.
3. **Peak Assessment:** Tacoma Power has an adequate winter time peak margin.
4. **Overall:** Tacoma Power does not appear to need new resources.

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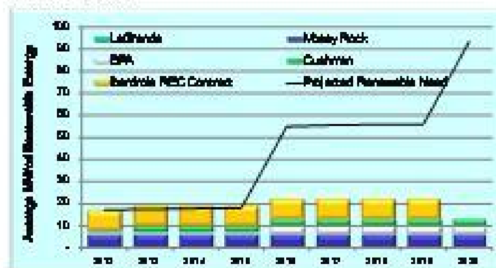
## I-937 Status

Tacoma Power does not need energy resources, but what about "eligible" renewable energy for I-937 compliance?

Tacoma has sufficient incremental hydro & RECs for the 2012 – 2015 compliance period




10

## Conservation Statutory Mandates

Three options for setting conservation targets (WAC 194-37-070)

1) NWPCC Conservation Calculator
2) Modified NWPCC Conservation Calculator
3) Utility Analysis – target setting methodology must be consistent with NWPCC procedures, including:
   (i) Analyze a broad range of energy efficiency measures;
   (ii) Perform a life-cycle cost analysis of measures or programs;
   (iii) Set avoided costs equal to a forecast of regional market prices, which represents the cost of the next increment of available and reliable power supply available to the utility;
   (iv) Analyze the results of multiple scenarios. This includes testing scenarios that accelerate the rate of conservation in the earlier years;"

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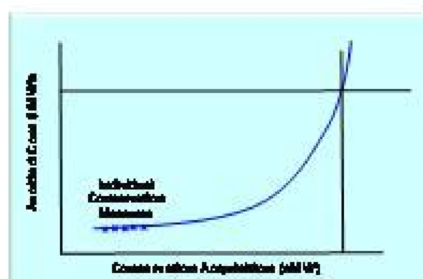
## Conservation Supply Curve

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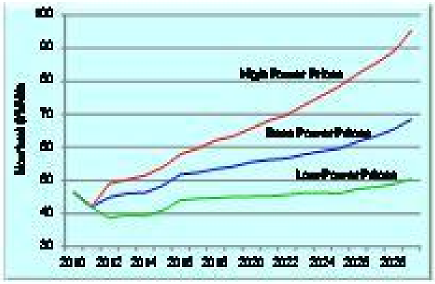
## Conservation Avoided Cost




13

## Effect of Variations in Avoided Cost on Conservation Acquisition

| Conservation 10-year Achievable | Technology Differences |
|---|---|
| Low 56.8 aMW | Includes 213 unique measures. |
| Base 65.5 aMW* | Added measures:<br>•Residential Ductless heat pumps: 5 aMW<br>•Retrofit windows on manufactured homes: 1.1 aMW<br>•Others: 0.8 aMW |
| High 66.9 aMW | Added measures:<br>•Convert homes from electric resistance to Heat Pumps: 0.6 aMW<br>•Residential floor insulation: 0.2 aMW<br>•Commercial refrigerated case lighting: 0.2 aMW<br>•Expand use of other commercial measures: 0.25 aMW<br>•Others: 0.15 aMW |

*Includes federal facility conservation acquired by the Bonneville Power Administration and measures that transition to federal minimum standard. If excluded the potential would decrease to 57.4 aMW

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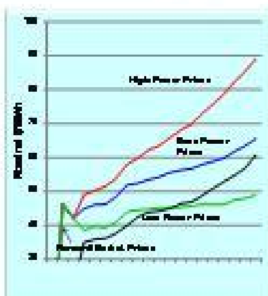
## Conservation Avoided Cost Recommendation

**Base Avoided Cost**

- Believe that it best represents likely future power prices
  - Forecast used median estimate of natural gas prices
  - Compares well with actual forward market prices
- Used in other analyses
  - Budgeting, Load Forecasting, Cushman Powerhouse, etc.

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## Conservation Rate of Acquisition

<u>Requirement</u>: test scenario that accelerates early year conservation

We tested two alternatives to the Base conservation ramp

- 20% higher in early years, 20% lower in later years
- 20% lower in early years, 20% higher in later years


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## Conservation Analysis of Alternative Ramp Rates

| Ramp Scenario | 10-year Conservation Potential (aMW)* | Incremental Revenue Requirement 2010-2012 (% from base) | Incremental Life-Cycle Net Benefits (millions of $) | Compliance with I-937 |
|---|---|---|---|---|
| Base | 57.4 | NA | NA | Yes |
| Back Load | 57.4 | -0.8% | 1.2 | No |
| Front Load | 57.4 | 0.9% | -2.0 | Yes |

*Excludes federal facility conservation acquired by the Bonneville Power Administration and measures that transition to federal minimum standard. If included the potential would increase to 65.6 aMW

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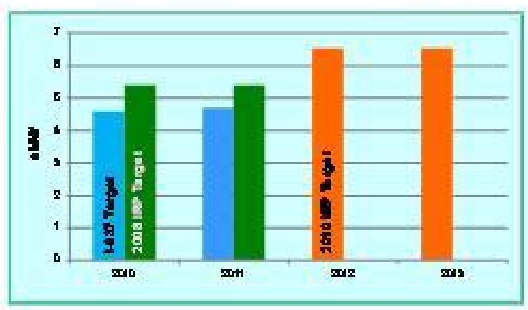
## Conservation Acquisition Targets

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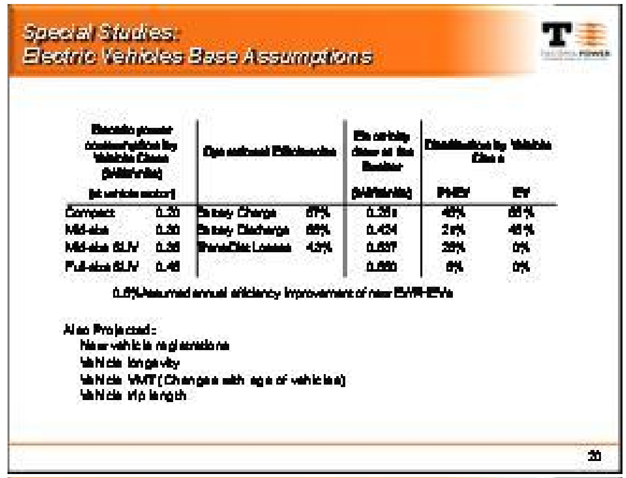
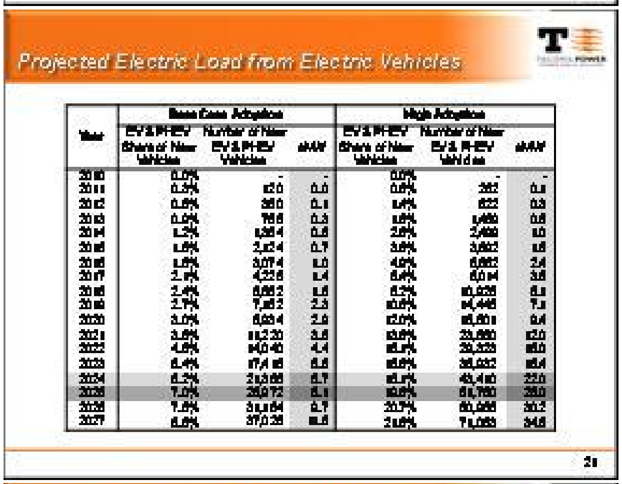
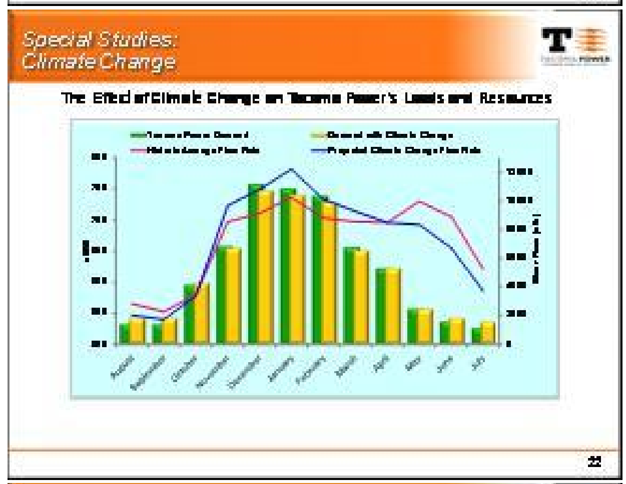
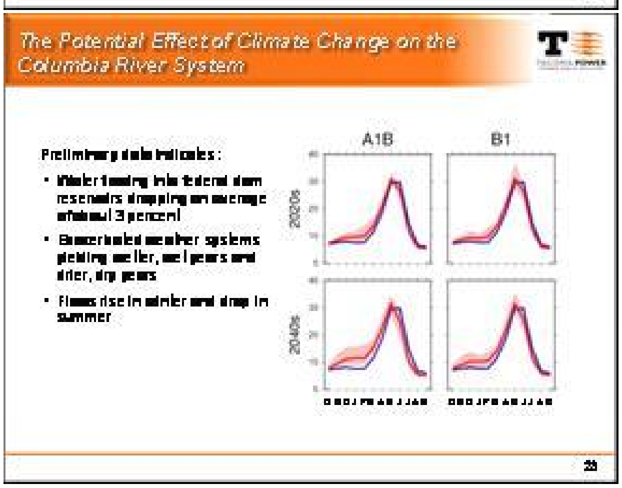
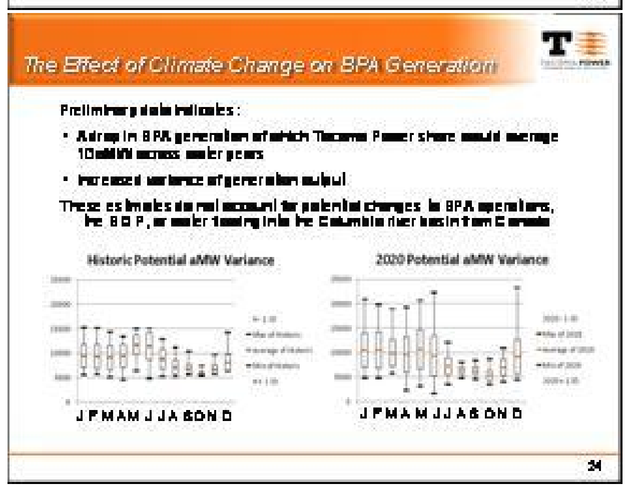
Conservation Dashboard
2010 Aquisition


Special Studies:
Electric Vehicles Base Assumptions
Compact
Mid-size
Also Projected:
20


Projected Electric Load from Electric Vehicles
Base Case Adoption
High Adoption
21

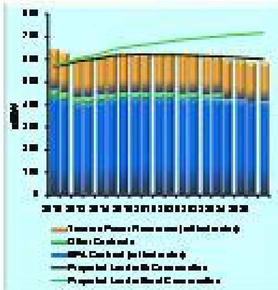

Special Studies:
Climate Change
October
November
December
January
February
March
April
May
June
July
22


The Potential Effect of Climate Change on the Columbia River System
Preliminary data indicates:
A1B
B1
2020s
2040s
summer


The Effect of Climate Change on BPA Generation
Historic Potential aMW Variance
2020 Potential aMW Variance
J F M A M J J A S O N D

## Draft Two-Year Action Plan: Implementing this IRP

- Conservation
  - Acquire 6.5 aMW of conservation in 2011 and 2012. (13.0 aMW total)
- Renewable Portfolio Standards
  - Acquire Renewable Energy Credits to address the small renewable resource deficit expected for 2012
  - Closely follow efforts to amend the Energy Independence Act



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## Draft Two-Year Action Plan: Preparing for the next IRP

- Stochastic Analysis
  - Develop techniques to incorporate the Vista LT model into a larger stochastic analysis of utility load-resource balance. Use the resulting procedures to estimate utility costs and risks associated with different resource portfolios (including conservation).
- Climate Change
  - Follow federal, state and local efforts to establish new regulations to address climate change.
  - Participate in such efforts where appropriate.
- Operating Flexibility
  - Assess Tacoma Power's capacity to integrate variable resources into the grid.
- Renewable Portfolio Standards
  - Develop strategy to address the expected 2016 renewable resource deficit.

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## IRP – Schedule

| Meeting | Date | Topic |
|---|---|---|
| Public Meeting | March 24 | Load Resource Balance |
| Study Session | May 12 | Load Resource Balance |
| Public Meeting | May [illegible] | Conservation, Preliminary discussion of Climate Change and Electric Vehicles |
| Study Session | June [illegible] | Stress Tests, Electric Vehicles & Climate Change |
| Study Session | July [illegible] | Conservation & 2-Year Action Plan |
| Public Meeting | July [illegible] | Discuss results of the Draft Plan |
| | July [illegible] | Include Draft Plan in the PUB Study Session Information Packet |
| Study Session | August [illegible] | Be available to answer question and receive feedback about the Draft Plan |
| | August [illegible] | Mail Draft Final Plan to PUB |
| Study Session | August 25 | Be available to answer remaining question about the Draft Final Plan |
| Board Meeting | August 25 | Submit Resolution Requesting IRP Adoption |

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# Appendix B

# Key Issues Facing Tacoma Power

*Over the spring and summer of 2009, the Tacoma Power's planning staff interviewed mid-level and senior managers at Tacoma Power. The objective of these interviews was to identify major concerns and/or opportunities that the interviewee expects that Tacoma Power might confront beginning in the next few years. The intention is to consider whether to include these concerns and opportunities within the integrated resource planning effort. This Appendix lists, in no particular order, the identified concerns and opportunities.*

1. The effect that the introduction of electric vehicles will have on retail load and utility supply acquisition efforts.
2. How the ongoing economic recession might affect retail electric load and utility resource acquisition efforts over the near-term (next 1-4 years) and long-term (following 5-20 years).
3. The consequence to Tacoma Power of the new voluntary capacity standards issued by the NWPCC. Will those standards change utility operations, resource acquisition plans, or the type of resources considered? Should Tacoma Power develop its own capacity metric to better reflect our particular circumstances?
4. Legislative bills to amend the Energy Independence Act (a.k.a., I-937) have received serious consideration at the state Legislature. How should Tacoma Power deal with the resulting regulatory uncertainty – especially regarding the renewable resource mandate?
5. How should Tacoma Power evaluate potential generation opportunities whose costs vary over time? Should Tacoma Power acquire resources before they are needed to serve load if the cost of those resources is expected to grow?
6. How can Tacoma Power compare in a credible way, current generating technologies with future advancements that could improve performance and/or reduce production costs?
7. What to do if conservation does not achieve the anticipated savings.
8. The new BPA slice/block will likely increasing seasonal and annual volatility of resource supply. How should Tacoma Power incorporate these changes into its resource planning efforts? Should the utility continue to plan to critical water or some other standard?
9. How much risk does Tacoma Power face of experiencing capacity shortfalls during the winter? How should the utility manage this risk?

10. How much operational flexibility do Tacoma Power's generating resources have under various different operating conditions? What is the value of that flexibility?
11. Is Tacoma Power likely to lose some resource flexibility over time due to increasing licensing constraints?
12. The effect of climate change on hydro operations.
13. How to deal with the evolution of retail loads – Tacoma Power becoming more residential based.
14. The effect of national environmental standards – Renewable Portfolio Standards and Cap & Trade Mechanisms to limit GHG emissions.
15. Should Tacoma Power offer Wind Integration services and, if so, how to incorporate these services into operational procedures?
16. Should Tacoma Power strive to increase the "greenness" of its resource portfolio beyond legal mandates?
17. How will the expansion of Smart Grid capabilities affect system operations?
    a. Load management
    b. Communications with customers
    c. Integrated information systems
    d. Minimize losses and lower capital costs
    e. Shorten distribution system outages.
18. Should Tacoma Power partner with other utilities to spread the risk of acquisition of renewable resources?
19. How do the potential changes to the regional transmission system (e.g., expansion and regulation) affect Tacoma Power operations?
20. How the utility deal with uncertain and variable natural gas prices?
21. How best to deal with uncertainty in carbon prices?
22. How can Tacoma Power best use its transmission resources considering "point-to-point" service from BPA, available electricity marketing opportunities, and the expiring "Starwood" contract with PSE? Will conservation impact the Transmission and Distribution system?
23. How will WECC/NERC compliance requirements shift business operations?
24. The effect of infrastructure aging on system operations.

# Appendix C

# White Paper

# Integrated Resource Planning Best Practices

## June 2009

By utility policy and pursuant to state statute, Tacoma Power develops IRPs at regular intervals. Tacoma Power's next IRP is due September 1, 2010.[22] In preparation for the development of this plan, the utility undertook to study five recent IRPs by similarly situated utilities. This study was strictly and solely to better understand how other utilities dealt with issues that Tacoma Power also faces and whether those approaches might provide useful guidance during the 2010 IRP development process. Tacoma Power identified 18 principle topic categories for review. Of particular interest was how other utilities handled issues of forecasting natural gas prices, assessing environmental impacts, considering risk, evaluating energy adequacy and capacity, developing scenarios of the future and conducting the portfolio analysis.

This study proved enlightening. For many topics, these other utilities used similar assessment approaches. However, there were nuanced differences that provide useful information for Tacoma Power to consider as it moves forward with its 2010 IRP. The following pages highlight how these other utilities addressed or dealt with the identified topic areas ***and*** which of these approaches may have relevance to Tacoma Power.

It is important to note that this study did not, in any way, "judge" the quality of these IRPs. Individual circumstances will color an individual utility's response to an issue. As a result, the appropriate and best way to address any issue will likely vary among utilities. The sole goal of this exercise was to gain information that Tacoma Power can use to improve its 2010 IRP. Finally, following representations solely represent Tacoma's understanding of the assessment methods used by these five utilities.

The IRPs studied were prepared by:

| | |
|---|---|
| Seattle City Light (SCL) | 2008 through 2027 (20 years) |
| Avista Utilities (AVI) | 2008 through 2027 |
| Snohomish County PUD (SNO) | 2008 through 2020 (13 years) |
| Puget Sound Energy (PSE) | 2008 through 2027 |
| Chelan County PUD (CHE) | 2008 through 2018 (11 years). |

[22] RCW 19.280.030(1) Utilities with more than twenty-five thousand customers that are not full requirements customers shall develop or update an integrated resource plan by September 1, 2008. At a minimum, progress reports reflecting changing conditions and the progress of the integrated resource plan must be produced every two years thereafter. An updated integrated resource plan must be developed at least every four years subsequent to the 2008 integrated resource plan.

## 1. Major Issues Assessed

SCL – Identify how much additional power the utility needs in the winter (when highest load occurs). Whether to enter into summer-for-winter exchange contracts.

AVI – Describe the Preferred Resource Strategy for meeting customers' future requirements while balancing cost and risk.

SNO – Establish an IRP that ensures enough resources are available, at reasonable cost, to meet future loads and minimize impacts on the environment.

The IRP must contend with the possibility that under high load conditions (caused by an arctic pattern, for example), BPA could drop loads at SnoPUD to maintain reliable operations on other parts of its transmission network.

PSE – Meet the growing energy needs of its customers with the lowest reasonable cost combination of resources – (Note: PSE needs to acquire new power resources.)

CHE – How best to dispose of power and RECs that are surplus to the utility's needs.

**Relevance to Tacoma Power:** Each of these issues is, to a greater or lesser extent, also faced by Tacoma Power, especially:

1. Meeting winter time needs.
2. Meet growing resource needs while balancing cost and risk. (Based on our last IRP, Tacoma Power is likely to be short of power around 2018 assuming critical water.)
3. How best to address a surplus load-resource balance.

## 2. Policy Directives

SCL – Goal of "Net Zero" GHG emissions – must offset emissions from any new resource.

Comply with I-937's renewable resource requirements as well as multiple other local/state/federal statutes, regulations and standards.

AVI – Manage rate variability, as well as limit customer costs. The IRP is a resource evaluation tool rather than an acquisition plan.

SNO – Cost-effective conservation is the preferred resource to meet load growth;

Use BPA power and renewable energy to meet loads not served by conservation;

To the extent possible, locate new resources in the utility's service area; and

Ensure that the Preferred Plan allows the utility to meet I-937 requirements.

PSE – Identify resource solutions that are cost effective and environmentally sound.

CHE – Develop a strategy to identify preferred new long-term resources (i.e., the amounts, types and timing) to reliably and cost-effectively meet the future customer needs.

Show how different candidate resource strategies would affect future performance of the overall portfolio in terms of reliability, cost, risk and environmental impacts.

**Relevance to Tacoma Power:** The Policy Directives most relevant to Tacoma Power are:

1. Comply with I-937's renewable resource requirements and all other local/state/federal environmental statutes, regulations and standards.
2. Limit rate variability and customer costs.
3. Consider reliability, cost, risk and environmental impacts in resource evaluations.

## 3. Organization

SCL – Chapters: Load Forecast; Existing Resource Portfolio; Policy Direction; Resource Choices; Portfolio Analysis; Key Findings and Conclusions; and, Public Involvement.

AVI – Includes list of acronyms; key messages (one page); table of Technical Advisory Committee meeting dates and agenda items; a graphical representation of the Modeling Process; and discusses differences between the current and past preferred resource portfolios.

Each chapter begins with "highlights."

SNO – Includes a detailed description of conservation programs and the planning environment.

PSE – Devotes an entire chapter to Planning Environment: Changing Environmental Regulations, Regional Transmission Constraints, Resource Costs and Availability, Financial Considerations. Also, load forecasting is discussed in detail.

Reported on efforts to implement previous action plan.

Includes chapter on delivery system planning (local infrastructure): expansion, retrofit/replacement, regulations (NERC/WECC), modernization (smart grid).

CHE – Chapters on Planning Environment, Load, Resources, Portfolio Modeling and conservation programs. Includes the Washington State Electricity Utility Integrated Resource Plan Cover Sheet, a required submittal to CTED.

**Relevance to Tacoma Power:** Good ideas for organizing Tacoma Power's IRP include:

1. Begin with a one page list of key messages.
2. Discuss in detail the utility's planning environment: Changing Environmental Regulations, Regional Transmission Constraints, Resource Costs and Availability, Financial Considerations, and efforts to implement the previous IRP.
3. Detail the differences between the current and past preferred resource portfolios.
4. Discuss delivery system planning (local infrastructure): expansion, retrofit/replacement, regulations (NERC/WECC), modernization (smart grid).
5. Include the CTED Integrated Resource IRP Cover Sheet.
6. Include a list of acronyms and table on public outreach meeting dates and agenda items.
7. Discuss how the recommendations of the previous IRP were implemented.

## 4. Public Process

SCL – Stakeholder committee representing residential, commercial and industrial customers, resource developers, environmental organizations, and energy-related government agencies guided resource planning efforts with comments and suggestions. Met 5 times.

AVI – 3 stakeholder groups:

- Utility planning, (provide input concerning the IRP studies, resource data, modeling efforts, and critical review of the modeling results);
- Critical IRP stakeholders (environmental advocates and government agencies); and,
- Regional planning entities (the NWPCC and the WECC).

PSE – 2 work groups: an IRP Advisory Group and Conservation Resources Advisory Group. Held a total of 13 public meetings (8 IRPAG and 5 CRAG)

CHE – Website with information. Five public meetings were held with Board during the planning, development and approval of the IRP.

**Relevance to Tacoma Power:**

1. Hold 3 to 5 meetings with a committee of retail customers (residential, commercial and industrial), environmental organizations, resource developers and government agencies.
2. Have a web site.

## 5. Load Assessment

AVI – Aurora.

SCL – Aurora, Electric Market Model, average load, hourly load through 2027, and 1 hour peaks calibrated for their hydro.

PSE – Peak loads calculated on an hourly basis, and projected for normal and extreme winter temperatures. The extreme peak design temperatures were based on a 1 in 20 year expected occurrence (5% exceedance probability) developed from distributions of 30 years of minimum temperatures during the on-peak hours.

CHE – Used a regression equation with temperature at time of peak as the independent variable to project the load change per degree temperature. Monthly peak temperature distributions were developed from 1995-2006 peak temperature data.

Load: Residential Regression - Population and per capita income; Commercial Regression –population and sales; Industry – individually estimated.

SNO – End use model, Conway Pederson model for demographics, hookup/growth linkages. They have their own estimates of demand elasticity.

**Relevance to Tacoma Power:** Ideas for load assessment include:

1. Define a peak design temperature. Perhaps the 95% temperature.
2. Develop load factors for extreme weather.
3. Use regression analysis to specify parametric means and stochastic distribution.

4. Use hourly loads to estimate potential for hydro storage.

## 6. Energy Prices

SCL – Natural gas prices forecasts from Global Energy Decisions, Inc. (renamed "Ventyx"). Ventyx developed a probability distribution of expected long term Henry Hub gas prices with a stochastic analysis. Used the 75th percentile of this distribution, plus basin differentials, for the high gas price scenario.

Assumed a wind integration cost of $7.82.

SNO – Forecast market electric prices with Aurora. Projected REC prices based on the actual nationwide average REC cost ($6.29 in 2007). Inflated future REC costs with a 2.5% inflation rate and expected cost escalations as I-937 requirements come into effect. Added REC prices to the hourly wholesale prices produced by Aurora. Unclear how natural gas prices were forecast.

PSE – Future natural gas prices based on long-run fundamentals forecasts. For the years 2008 through 2011, used forward market price information and thereafter applied long-run reference forecast.

Assumed a $CO_2$ charge of $7 per ton starting in 2012, increasing 5% per year thereafter.

Forecasted electric market prices for each scenario using the AURORA model. Each forecast was different due to the specific economic, marketplace, and load assumptions of each scenario.

Assumed wind integration costs at $5.90 in 2007, escalating at 2.5% per year.

AVI – Natural gas prices the single most important modeling assumption in the NW – sets market price in about three-quarters of all hours. Blended NYMEX forward prices with a consultant's forecast. NYMEX weighting at 50% in 2008 and decreased by 10% annually through 2012. Estimated basin differentials (Henry Hub versus western pricing points) using an average of recent basin differentials.

Studied the western interconnect (Aurora model) to understand the regional electric market. Monte Carlo-style analysis varied hydro, wind, load and gas price data over 300 iterations. The simulation results collectively formed the Base Case market prices.

Modeled coefficient of variance as a function of other variables such as $CO_2$ penalties.

Assumed $CO_2$ values of $8.94 per ton in 2015 increasing to $14.34 per ton in 2027.

CHE – Used electricity price forecasts from the NWPCC (based on the Aurora model). Primary interest is in potential price of energy and RECs to sell.

**Relevance to Tacoma Power:** Ideas related to determining energy prices:

1. Use Aurora to project future electricity prices.
2. Supplement resource cost estimates with the value/cost of RECs/$CO_2$.
3. Combine forward market prices and consulting firm projections to project natural gas prices.

4. Taylor prices to the expected conditions/scenario assumptions.
5. Value wind integration costs.

## 7. Resource Identification and Assessment

SCL – Gathered basic information for each generation resource including: resource technology and fuel; current status and outlook; and, resource characteristics (dispatchability, transmission requirements and environmental attributes).

Included Seasonal Exchanges and Capacity Purchases in the list of potential resources.

AVI – Wind variability is modeled in a manner similar to hydroelectric resources. A single wind generation shape is developed for each area. This generation shape is smoother than individual plant characteristics and closely represents how a large number of wind farms across a geographical area would operate. The Monte Carlo model randomly draws a capacity factor from the distribution for each hour of each month.

Account for declines in the hydro resource due to expiring mid-Columbia contracts.

SNO – The conservation identification process parallels that used by the NWPCC. Identified technically feasible, economic and achievable resources using the eQuest model and engineering judgment.

PSE – Noted that resource alternatives are limited.

CHE – Long on power. Resource assessments solely focused on meeting I-937 obligations. Included conservation potential and wholesale value of power.

**Relevance to Tacoma Power:** Ideas related to assessing potential resources:

1. Include seasonal exchanges in the list of potential resources (SCL).
2. Consider transmission and environmental attributes of candidate resources (SCL).
3. Possibly use AVI's approach to modeling the value of our potential to firm wind.

## 8. Treatment of Demand Response and Energy Efficiency

SCL – The conservation cost assessment methodology changed in two significant ways from the previous IRP: 1) accounting for the cost of accelerating conservation; and 2) I-937.

AVI – Base Case market prices were used to analyze potential conservation initiatives and supply-side resources.

Focused on 5 areas of conservation: energy efficiency (risk and capacity valuations – from load shapes and capacity avoided costs); load management (demand response); transmission and distribution efficiencies; analytics; and communications.

Reviewed potential responses to "outlier" events: July heat wave and short term price escalations.

PSE – Demand response focused on avoided peak rather than annual energy requirements.

CHE – Incorporated the CPA values.

**Relevance to Tacoma Power:** Ideas related to conservation:

1. Discuss in some detail differences in methodology from the previous IRP.
2. Compare conservation resources side-by-side with supply-side resources.
3. Understand how conservation effects utility operations.
4. Review the potential effect of conservation during extreme weather events.

## 9. Environmental Assessment

SCL – Subjectively evaluated the environmental attributes of potential resources.
Preliminary assessment of the potential impact of climate change on hydro operations.

AVI – Assessed the utility's carbon footprint (tons per MWh).
A group meets regularly to discuss climate change information and legislative activities (includes Environmental Affairs, Governmental Affairs and Resource Planning.

SNO – No explicit environmental analysis of resource alternatives. However, an implicit analysis occurred through the development of the prioritized menu of resource options. Environmental outcomes were part of the basis for one of their scenarios.

PSE – Compared the cost of its two most favorable portfolios under "green world" and "business as usual" scenarios. Made a qualitative judgment for the probabilities of each scenario occurring which led to the identification of the least costly portfolio.
Discussed potential environmental and system effects caused by climate change.
Discussed as part of the Planning Environment section of their IRP and in Appendix C.

CHE – Did not model costs associated with air emissions in its portfolio scenarios because of the uncertainty surrounding future regulations for air pollutants and any associated costs.
Assessed how conservation acquisition would be affected if the assumed cost of RECs were added to the avoided energy costs.

**Relevance to Tacoma Power:** Environmental assessment issues most relevant to Tacoma Power are:

1. Assume $CO_2$ values when comparing resource portfolios.
2. A modification of PSE's approach. Compare the cost of the most favorable portfolios under all scenarios, not just "green world" and "business as usual." Assign relative likelihoods for each scenario.

## 10. Energy Adequacy

SCL – Did not assess annual energy adequacy, instead focused on reliability during January. Used a 95% reliability standard. This level corresponds to the average of the second and third worst operating years. Assumed it could purchase 100 aMW of short-term electricity from the wholesale power market. No summer adequacy issue.

AVI – Used "confidence interval planning": Historical data indicates that a 90% confidence of serving load is the optimal criterion based on variability of load and hydro generation. (10% chance that load and hydro variability will exceed the planning criterion).

SNO – Annual load-resource balance compared base case load forecast (without conservation) with hydro resources at critical. Also looked at seasonal (monthly) shape of loads and resources and stated that deficits and surpluses are made up in market.

PSE – Did not find anything on annual (or monthly) energy adequacy. PSE analyzed winter capacity, perhaps because they are much more thermal based.

CHE – Utility is long throughout the planning horizon (sales contracts will be expiring). The utility has a positive annual LRB in every year of the planning horizon. Made no analysis of capacity adequacy (does not have an hourly model).

**Relevance to Tacoma Power:** Consider confidence interval planning.

## 11. Portfolio Development

SCL – Constructed candidate portfolios based on certain assumptions, (e.g., peak load need, future energy prices, availability of 100 aMW in the spot market, owned/contracted resources, resource costs, performance) and the following objectives:

- Minimize the resources needed to meet 95% of resource adequacy in winter and I-937 requirements by acquisition of conservation up to $60/MWh.
- Minimize costs by early use of low cost resources (exchanges and capacity purchases).
- Meet resource adequacy requirement and I-937 requirements.
- Use scalable resources when possible (e.g., wind, geothermal, combustion turbines).
- Ensure sufficient summer generation to meet proposed seasonal exchanges.
- Avoid resources in the early years that require new transmission.

AVI – Used a proprietary "Preferred Resource Strategy Linear Programming Model" to identify a preferred portfolio based on simulated market prices, forecasted capacity and energy needs, resource values and a goal of limiting power supply cost volatility.

SNO – Developed a resource portfolio for six scenarios based on the following process:

- Identify the cost effective conservation programs and the timing for the savings.

- Fill the residual need according to the prioritized resource menu: a) BPA; b) Small Hydro; c) Biomass/Landfill Gas; d) Tidal/Geothermal; and, e) Wind. Not sure how these resources were prioritized.

PSE – Developed 12 principle portfolios to provide insight into the effect of different levels of renewable energy in the portfolio, the cost and risk of different fuel choices, and the sensitivity of the timing of these key decisions.

CHE – Long on power. Used the Excel based "Resource Portfolio Strategist" model (Cadmus) to assess the existing portfolio and I-937 obligation.

**Relevance to Tacoma Power:** Prefer to use computer optimization model to select preferred portfolio.

## 12. Risk Assessment

SCL – A primary goal is to illustrate the tradeoff between risk and other criteria such as cost and reliability. Forms of risk evaluated include:

- Load uncertainty due to weather, economic conditions and other factors.
- Generation plant output variability, (e.g., hydropower year-to-year and month-to-month and wind hour-to-hour and day-to-day).
- Wholesale electricity and natural gas prices.
- The cost of complying with environmental regulations, particularly CO2 emissions.

AVI – Risk is measured by the volatility of annual power supply expenses, driven by variations in natural gas costs, loads, emission uncertainty, hydro conditions and forced outages. The Base Case assumes 30% natural gas (NG) price volatility to capture projected market risk.

Used a multi-variable Monte Carlo approach to quantitatively assess risk around an expected mean outcome. Stochastically modeled four futures: Base Case, Volatile Gas, Unconstrained Carbon and a High Carbon Charges.

Modeled coefficient of variance as a function of other variables such as $CO_2$ penalties.

SNO – Developed a probability distribution of costs for each portfolio using 70 years of historical BPA hydro system generation data. Risks characterized by each portfolio's range of cost outcomes (span between the 90th and 10th percentile) in the year 2016.

Compared the cost of the Preferred Plan with one relying on conservation, BPA, and the short-term wholesale power market.

PSE – Portfolios were exposed to 100 Monte Carlo trials. The results were graphed "average costs v. average of 10 highest costs" and "average costs v. annual cost volatility."

CHE – Focused on three risk categories:

- Short-term addressed by probability distributions: e.g., Weather effects on electricity usage and Stream flows (the amount and timing of hydroelectric generation).

- Long-term addressed by scenario forecasts: e.g., FERC licensing requirements affect on hydroelectric production costs.
- Other: New conservation and renewable requirements created by Washington state initiative; and, uncertain load growth.

Used Resource Portfolio Strategist model to assess various load and hydro scenarios, and varied conservation ramp rates. Based on assumed correlations between key variables, the model ran through 500 Monte Carlo iterations to develop a 5% confidence interval.

**Relevance to Tacoma Power:** Issues of risk most relevant to Tacoma Power are:

*Risks to assess:*

1. Load uncertainty due to weather, economic conditions and other factors.
2. Generation output variability, (e.g., hydropower year to year and month to month).
3. Wholesale electricity and natural gas prices.
4. The cost of environmental regulations, particularly $CO_2$ emissions control.

*Approach to dealing with risk:*

5. For known/expected distributions, utilize Monte Carlo analysis to quantitatively assess risk around an expected mean. Use sensitivity testing for pure unknowns.
6. Compare "average costs" to some high cost outcomes (e.g., 90$^{th}$ percentile costs)
7. Real interest rates (discussed by SNO but no variance) and real investment cost trends.
8. Avista displays its underlying distributions in public review overheads. We should compare our assumed distributions with theirs.

## 13. Scenario Planning

SCL – "What if " scenarios: High load growth; Prolonged recession; Impact of climate change on power purchases and sales (assumptions from NWPCC's 5th Regional Power Plan); PHEV; high NG prices; high renewable resource costs.

AVI – Seven scenarios were developed: high and low natural gas prices; varying regional load growth (based on high and low economic forecasts – 80% confidence interval); and, shifting all passenger automobiles to electricity from petroleum fuel. Also studied the possible impacts of climate change on retail load – but was not an official scenario.

SNO – Developed six planning scenarios: base case, low and high load growth, growth and consequences (prosperity and limited environmental concerns), bleak house (significant national and local problems), and tech goes nano (vibrant new industry). Developed six portfolios under each scenario.

PSE – Six scenarios: Current Trends; Green World; Robust Growth; Technology Improvement; Escalating Costs; and Low Growth. For each scenario developed unique assumptions for economic conditions, regional power profiles and energy prices: resource and emissions costs, heat rates, load growth, gas prices, PTC, RPS, and build constraints.

CHE – Base Case; low bookend (low load growth/hydro costs/ramp rates), high bookend (high load growth/hydro costs/ramp rates).

**Relevance to Tacoma Power:** Potential ideas for scenarios to include:

1. Prolonged recession
2. Impact of Climate change on power purchases and sales and spring/summer hydro.
3. Significant expansion of plug-in vehicles.
4. Volatile natural gas prices.
5. High renewable costs
6. Imposition of a carbon cap-and-trade mechanism
7. Change I-937 to allow above market conservation a one-for-one to trade-off of the renewable requirement.
8. Develop unique assumptions for each scenario: resource costs, heat rates, local and regional load growth, gas prices, emissions costs, PTC, RPS, and build constraints.

## 14. Portfolio Analysis Methodology

SCL – Phase 1. Evaluated the identified resource portfolios using the Aurora model for:

- Reliability. The degree portfolios relied on market purchases over 20 years to meet the 95% winter time resource adequacy metric.
- Cost. The net present value of both capital and operating costs (includes transmission costs) over 20 years. Resource cost information came from DOE, NWPPC, the California Energy Commission, and Northwest Utility IRPs.
- Risk. The portfolios' exposure to uncertainty about hydro generation, level of load, fuel prices and the market price of power, (buying or selling).
- Environmental impact. Carbon dioxide emissions were assigned costs. Total GHG and other air emissions (NOx, SO2, mercury and PM) over 20 years.

In Phase 2, lessons from the first phase informed the construction of a second set of resource portfolios, to improve performance. An Aurora analysis identified the preferred portfolio. Scenarios further assessed the Phase 2 portfolios.

A strength of this approach is the ability to test each portfolio's handling of variability in hydro-generation and volatility of fuel and wholesale power prices.

AVI – Used the proprietary linear programming PRiSM computer model to identify the optimal resource mix to meet capacity and energy needs. The PRiSM model has four basic inputs: resource shortages for peak load and energy, existing resource portfolio costs and volatility. The model projects capital costs for potential new resources over 300 Monte Carlo iterations. The model identified an efficient frontier of portfolios. Judgment used to balance risks and costs to select the preferred portfolio.

SNO – Used a self developed model to estimate the cost of six resource portfolios. Qualitatively considered lead-time and implementation as well as cost when selecting the Preferred Plan. (e.g., advanced the start date of a new geothermal resource – prior to need – to provide insurance against higher than expected loads.)

From this evaluation, a Preferred Plan was formed, which considers cost, reliability, risk, and operational constraints.

PSE – Used the Aurora model to evaluate and rank by cost the 12 portfolios against the six scenarios. Narrowed the field to two portfolios by screening out portfolios for reasons of cost, technology availability (carbon sequestration), environmental concerns (coal without sequestration) and resource implementation timing (absence of power bridging contracts). Compared the costs of the final two portfolios under the "green world" and "base case" scenarios. The final choice was based on a judgment of the probability of these two scenarios actually occurring.

CHE – The utility has a surplus LRB and eligible renewable resources so did not model new supply resources. Instead, the existing portfolio was stressed with three load forecasts, varying hydroelectric costs, and an increased conservation ramp rates. These stress-tests were evaluated using four explicit and one implicit criteria:

- reliability (positive annual average load/resource balance);
- cost (11-year NPV);
- risk (variability in the NPV of the net portfolio cost);
- environmental impacts (qualitative analysis of air emissions);
- the potential impact on wholesale power sales (implicit).

The analysis was done on the Cadmus Excel-based *Resource Portfolio Strategist model*. This model has Monte Carlo simulation and scenario analysis capabilities that quantify costs, risks and correlations between key variables, such as load and market prices (NG and electric), hydro availability, conservation, wind availability, and forced outages.

**Relevance to Tacoma Power:** Issues of Portfolio Analysis most relevant to Tacoma Power are:

1. Clearly articulate the resource evaluation criteria that include reliability, cost, risk and environmental impact.
2. Use computer model to estimate costs and risks.
3. Professional judgment an important part of selecting the preferred portfolio.
4. Important to scenario test the performance of the preferred portfolio.
5. The Cadmus DSM model (End Use Forecast) is being used for our CPA and may work well with the Resource Portfolio Strategist model.

## 15. Capacity Adequacy / Reserve Margins (methods and metrics)

SCL – A winter peaking utility – focused on the January load-resource balance. The adequacy metric: a 95% confidence level of meeting January loads. This includes periods of low generation due to drought conditions (1 in 20 years) and high load due to cold winter temperatures.

AVI – Planning reserves set at 10% of one-hour system peak load plus 90 MW (approximately 30 MW of Colstrip because of cold weather coal handling problems plus 60 MW due to river icing). This amounts to roughly a 15% planning reserve margin during the peak load hour.

Historical data indicates that the use of a 90% confidence interval based on the monthly variability of load and hydroelectric generation results in a 10% chance of the combined load and hydro variability exceeding the planning criteria.

SNO – To assess how the Preferred Plan would position the utility to meet peak loads, compared the maximum capability of utility resources under blended water conditions to the single highest hourly load forecast for each year.

PSE – Peak loads driven by temperature-dependent heating load. The peak load forecast – the highest load hour of the year – considers both the customer base and amount of power used at 13 degrees Fahrenheit. 13ºF represents a one in 20 year occurrence (5% exceedance probability) based on 30 years of temperature data during the on-peak hours.

CHE – Did not analyze capacity adequacy.

**Relevance to Tacoma Power:** Capacity and Reserve Margin Issues most relevant to Tacoma Power are:

1. Consider seasonal/monthly load-resource balance.
2. Define a confidence level for meeting loads.
3. Consider resource decrement during extreme weather.

## 16. Two-year action plan

SCL – Conservation Resources - Pursue accelerated conservation.

Generation Resources - Pursue full BPA contract rights; Complete a power purchase agreement with a landfill gas supplier; Investigate future capacity versus energy needs.

Market Resources - Investigate and acquire seasonal exchanges and/or capacity contracts to offset near-term reliability risk.

Other New Resources - Pursue cost-effective distributed generation opportunities; Update costs information for new commercially available resources; investigate the availability and costs for geothermal, solar, and demand response. Acquire as appropriate.

Transmission - Continue to participate in the development of Columbia Grid; provide comments to the U.S. DOE and FERC on important transmission issues.

Future IRPs - Refine modeling approaches, assumptions, and forecasts; research the impacts of climate change on generation and river ecology.

AVI – Research renewable energy (wind and others), demand management (transmission and distribution system efficiency) and emissions, modeling enhancements, transmission modeling and research (ColumbiaGrid and other forums), and conservation.

SNO – ŏ Implement all cost-effective energy conservation measures. *Pursue "stretch" goals.*

- Negotiate long-term contracts for renewable resources.
- Actively pursue development of geothermal power resources.
- Continue research and development of tidal energy systems.
- Evaluate and, where appropriate, pursue small-scale hydroelectric opportunities.
- Where appropriate, encourage customer-ownership of small-scale resources.
- Participate in regional transmission planning forums.
- Monitor emerging technologies and demand-side resource options.

PSE – Work to significantly increase demand management programs, meet renewable resource obligations, and opportunistically fill resource needs with purchased power agreements and/or NG fueled power plants.

CHE – *Conservation Resources*

- Continue to develop conservation potential; refine demographic data by customer class.
- Study available cost-effective energy efficiency measures and programs. Produce conservation business plan. Implement conservation programs, which comply with requirements of the Washington State RPS.
- Evaluate conservation potential using automated metering technologies and rate design.
- Look for economies of scale in conservation efforts.
- Develop a system for tracking conservation achievements.

*Resource Planning*

- Begin evaluations of post 2011/2012 contracts (when current contracts expire).
- Track the development of the NWPCC's Sixth Power Plan: conservation potential; wholesale market price forecasts; new resources and costs; and, resource adequacy.
- Follow the NWPCC's development of resource adequacy standards.
- Continue to track environmental legislation, including cap and trade programs.
- Update incremental hydro generation estimates to comply with state RPS requirements.
- Research potential methods of performing IRP analyses in more granular time periods.

- Revise and update model inputs as new information becomes available.
- Research and evaluate the potential effects of plug-in hybrid and/or electric cars.

**Relevance to Tacoma Power:** These Action Plans describe activities to implement the identified preferred portfolios. While important, Tacoma Power's focus is on research/information needs for our next IRP.

## 17. Transmission Planning

SCL – May need new or upgraded transmission facilities to transmit power from any additional resources to its service area, or to balance its power supply surpluses and deficits in regional power markets. (Identifies same constraints as PSE).

AVI – Transmission costs modeled using Avista's proprietary PRiSM model that matches different generating resources with company-specific resource requirements. Cost estimates based on engineering judgment. The Estimated Resource Integration Costs evaluated 50 MW, 100 MW, 250 MW and greater than 400 MW generation sizes (nameplate) at 23 different locations. The study looked at 10 generic project areas outside of, and nine areas within, the company's service territory.

PSE – Physical and contractual limitations and lack of coordination within the regional transmission system constrains PSE's ability to acquire generation outside its service territory. Transmission path constraints affecting PSE's ability to import electricity include: I-5 corridor, west through the Columbia River Gorge, across the Cascades, and Montana to the NW. Discuss the transmission needed to acquire new resources.

SNO – Under high load conditions there is a likelihood that BPA would need to drop loads in Snohomish County to maintain reliable operations on other parts of its transmission network.

**Relevance to Tacoma Power:** Need to determine whether Tacoma Power will need additional transmission to deal with the altered resource profile brought about by being a BPA slice customer.

## 18. Model Selection Notes

Aurora – Multiplier based model - Load forecast month-by-month, average and peak loads for a 20 yr outlook.

Genesis – a hydro /resource/load and resource balance model developed at BPA.

RPM – a portfolio cost and risk model that selects preferred resource options.
The NWPCC made adjustments to a vendor model. Availability is unclear.
This model would require substantial training and adjustment

NWPCC Conservation Model – The in house model available through RTF.

Model Energy 20/20 – For modeling resource response to policy change. For example, can help to assess whether to provide firming for wind, whether to focus on long term or short term conservation, what is the risk from the BPA slice contract and how could that risk effect the operation of our hydro resources? What should we do with spinning reserve?

Portfolio Strategist is an excel based portfolio model which uses multiple Resource and Market inputs (for 8 periods per month) and generates cost and system balancing outputs. It allows stochastic analysis for up to 20 variables.

# Appendix D
# Load Forecasting Procedures

Tacoma Power releases a new retail load forecast each year, usually in July. The load forecast available for this IRP was finished in July, 2009. That forecast estimated retail sales over twenty years and included both annual and monthly sales projections.

Generally, Tacoma Power forecasts have predicted retail load with reasonable accuracy. Up through 2007, the load predictions have typically been within 1.5 percent of actual weather adjusted customer load. The 2008 weather adjusted actual load deviated from the forecast load by less than 3.0 percent. The majority of this error is attributable to the economic recession that drove loads below the 2008 forecast.

Tacoma Power works to refine its modeling methodology and techniques with each forecast. For example, to account for unusual market conditions such as the current recession as well as the turbulent market conditions that occurred in 2000-2001.

The utility's load forecast methodology generally follows a three step process. First, the loads associated with individual customer classes are projected using a variety of techniques assuming no conservation. Next, the load for each class is adjusted to account for the cumulative reductions associated with conservation. Finally, the projected class specific loads are adjusted for losses and aggregated into a single utility wide load forecast.

## Class Specific Load Forecasts

### *Residential Service, Small General Service and General Service Classes*

Tacoma Power uses econometric models to project retail sales for the Residential Service, Small General Service, General Service customer classes. The econometric models relate retail sales to economic, demographic and weather-related phenomena using untransformed variables and generalized least squares techniques. The explanatory variables include estimates of unemployment and employment, energy prices, heating and cooling degree-days, population and conservation. Also incorporated are binary variables to explain the effects of the current recession.

Customer growth, both residential and commercial/industrial, was based on estimates of population and employment activity for Pierce County by Global Insight and Puget Sound Economic Forecaster. Projections for the Pierce County unemployment rate were also from the Global Insight Spring forecast. The average unemployment for the 20 year forecast period is about 6.5 percent, peaking in 2010 at 10.8 percent and trending down thereafter.

For this forecast, real prices (prices adjusted for inflation) were expected to grow by 10 percent in 2011and then slow to 1 percent per year from 2015-2020, 0.3 percent per year from 2021-2025, and 1 percent per year from 2025-2029. Retail rate estimates for the near term are based on Tacoma Power's financial model and longer term (post-2015) estimates are based on Energy Information Administration projections.

Heating and cooling degree-days are based on the most recent 10-year average of actual weather data – though cooling degree-days do not have a large effect on the model's explanatory power.

### *High Voltage General Service and Contract Industrial Service Classes*

Tacoma Power directly forecasts retail electrical sales for its seven High Voltage General Service class customers (includes Joint Base Lewis-McChord), and its two Contract Industrial Service class customers. These forecasts are based on direct conversations with representatives of each customer regarding business climate expectations, production expansion/contraction, changes in operations and production processes, as well as observation of historical consumption. Overall retail sales to the High Voltage General class are projected to grow from 51 to 65 aMW from 2010 through 2017 and then stay stable thereafter. Similarly, sales to the two Contract Industrial customers are expected to grow from about 55 aMW in 2010 to about 65 aMW by 2021 and then level out. Load growth in these sectors is mitigated somewhat by conservation programs.

### *Street Lighting and Traffic Signals*

Sales for street lighting and traffic signals are estimated by observation using a trending analysis. Private off-street lighting is a small class and sales are expected to follow underlying residential growth rates.

### *Forecast Results – Annual Load*

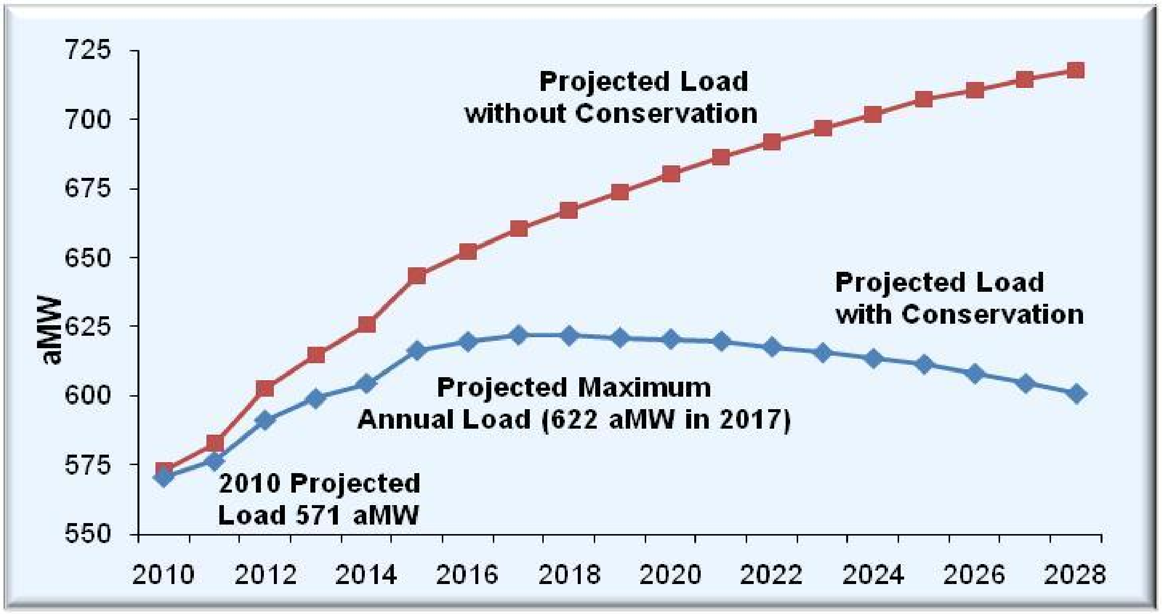
Table D1 shows projected sales and annual growth rates for Tacoma Power's four largest retail classes (several customer classifications are not shown): Residential Service, Small General Service, General Service, and High Voltage General Service sectors. Electricity sales across these classes are expected to experience relatively healthy growth through 2015 as the region and the city of Tacoma emerges from the current economic recession. However, after 2015, class specific load growth begins to diverge. The General Service class continues to grow, albeit at much slower rates. The High Voltage General Service and Small General Service classes plateau around 2017. And the Residential class begins a steady and significant decline in consumption. The reductions experienced by the Residential class result from a combination of high real prices and aggressive utility conservation.

In aggregate, Tacoma Power's retail load is projected to increase about 1.2 percent annually until it reaches its zenith of 622 aMW in 2017. In the later years of the planning period the projected reductions from the residential class overwhelm increases from other classes and bring about a slow but steady decline in the utility's overall retail load. As a result, the load projected for 2028 is about 20 aMW lower than that in 2017. (See Figure D1). It is important to note the importance that conservation plays in this projection. Without conservation, Tacoma Power's retail load would be approximately 120 aMW greater at the end of the planning period.

**Table D1**
**Projected Sales and Inter-Year Growth Rates for Select Retail Sectors**

| | Residential | | Small General Service | | General Service | | High Voltage General Service | |
|---|---|---|---|---|---|---|---|---|
| | aMW | % Δ | aMW | % Δ | aMW | % Δ | aMW | % Δ |
| 2010 | 208 | -- | 36 | -- | 193 | -- | 51 | -- |
| 2011 | 206 | -1.0% | 35 | -1.4% | 196 | 1.6% | 53 | 2.9% |
| 2012 | 211 | 2.6% | 36 | 2.6% | 200 | 2.4% | 53 | 1.3% |
| 2013 | 213 | 1.2% | 37 | 2.6% | 204 | 2.0% | 54 | 0.7% |
| 2014 | 215 | 0.6% | 38 | 1.4% | 208 | 1.6% | 54 | 0.3% |
| 2015 | 216 | 0.4% | 38 | 1.2% | 211 | 1.5% | 60 | 12.1% |
| 2016 | 215 | -0.1% | 39 | 0.4% | 212 | 0.6% | 63 | 4.5% |
| 2017 | 214 | -0.4% | 38 | 0.2% | 213 | 0.6% | 65 | 3.3% |
| 2018 | 213 | -0.5% | 38 | 0.1% | 214 | 0.4% | 65 | 0.2% |
| 2019 | 212 | -0.7% | 38 | 0.0% | 215 | 0.4% | 65 | 0.2% |
| 2020 | 211 | -0.6% | 39 | 0.1% | 216 | 0.3% | 66 | 0.2% |
| 2021 | 209 | -0.7% | 39 | 0.5% | 216 | 0.3% | 66 | 0.1% |
| 2022 | 207 | -1.0% | 39 | 0.4% | 217 | 0.2% | 66 | -0.1% |
| 2023 | 205 | -1.0% | 39 | 0.3% | 217 | 0.2% | 66 | -0.1% |
| 2024 | 203 | -1.0% | 39 | 0.3% | 217 | 0.2% | 65 | 0.0% |
| 2025 | 201 | -1.0% | 39 | 0.3% | 218 | 0.2% | 65 | 0.1% |
| 2026 | 198 | -1.3% | 39 | -0.1% | 218 | -0.1% | 65 | 0.0% |
| 2027 | 195 | -1.3% | 39 | -0.1% | 217 | -0.1% | 65 | 0.0% |
| 2028 | 193 | -1.4% | 39 | -0.1% | 217 | -0.2% | 65 | -0.1% |

**Figure D1**
**Tacoma Power's Projected Annual Load**




## *Load Forecast Accuracy*

Tacoma Power has a strong track record of accurately projecting retail load. Comparing past forecasts with actual load indicates a forecast error of less than 2.0 percent. Even the most recent forecast, which was made at the onset of the economic recession which drove down retail load, was within 3.0 percent of actual loads.

## *Forecast Results – Monthly Load*

Tacoma Power's monthly load forecasts are based on an apportionment of annual loads. The methodology assumes normal monthly weather patterns. The monthly distribution curve for the 2017-18 operating year – the year with the highest anticipated load – is presented in Figure D2. This figure clearly shows that Tacoma Power is a winter peaking utility.

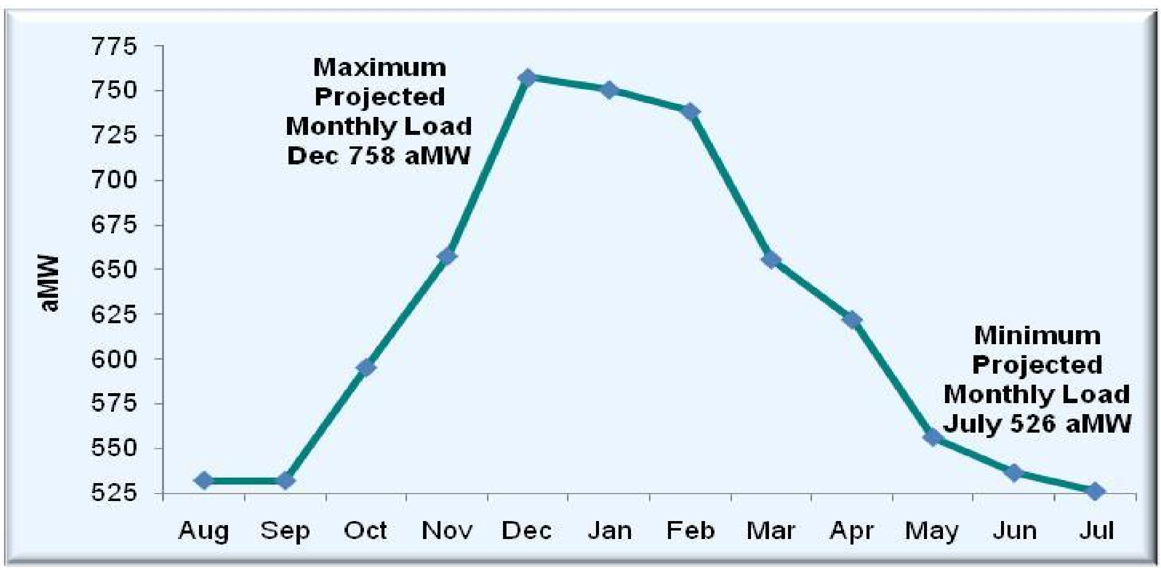
## *Forecast Results – Peak Load*

For this IRP, Tacoma Power projected its peak load over three period durations: 1-hour, 18-hour, and 72-hour. These expected peak loads were developed based on the historic temperatures experience over the last 11 years (1998-2008) and time-indicator variables (i.e. month, day of the week, holidays). For each year from 1998 through 2008, the 72-hour period with the coldest temperatures was identified, a total of eleven "cold snaps." The Resource Adequacy standard developed by the NWPCC defines *expected-peak load* as "based on normal temperature conditions." To conform to this definition, Tacoma Power selected the cold snap with the median temperatures as the basis for the expected peak load (five periods were colder and five warmer). This selection simulates a "typical", or "every other year" type of cold snap.

Peak hourly loads were estimated using a simple linear regression model. The regressions were based on a historical data set from January 1, 2008, to July 1, 2009 to capture the effects of the current recession on load. The model estimated the load for each hour separately using a total of 24 equations and data sets. A comparison of actual loads with the model forecast showed a mean average percentage error of 5.9%.

The most important model input was the median cold snap temperatures identified above. However, the highest retail load is not necessarily associated with the coldest hour. Other factors such as time of day, and day of week are also important – load on a winter morning will be higher at 9:00 am than at 3:00 am even if temperatures in the early morning are lower. The regression model was run assuming the low temperatures occurred at the beginning of a non-holiday work week in mid-January. This is the time of year that Tacoma Power usually experiences its largest retail load.

**Figure D2**
**Tacoma Power's Projected Monthly Load for 2017-18 Operating Year**




The results of the regression model were a projected 1-hour peak load for Tacoma Power of 1003 MW, and 18- and 72-hour loads of 948 MW and 833 MW, respectively.

Report

# Conservation Potential Assessment (2010–2019)

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*[**Note**: For the purpose of brevity, the appendices associated with the Cadmus Conservation Potential Assessment (2010-2019) were not included in this IRP. These appendices are available from Tacoma Power.]*

# Executive Summary

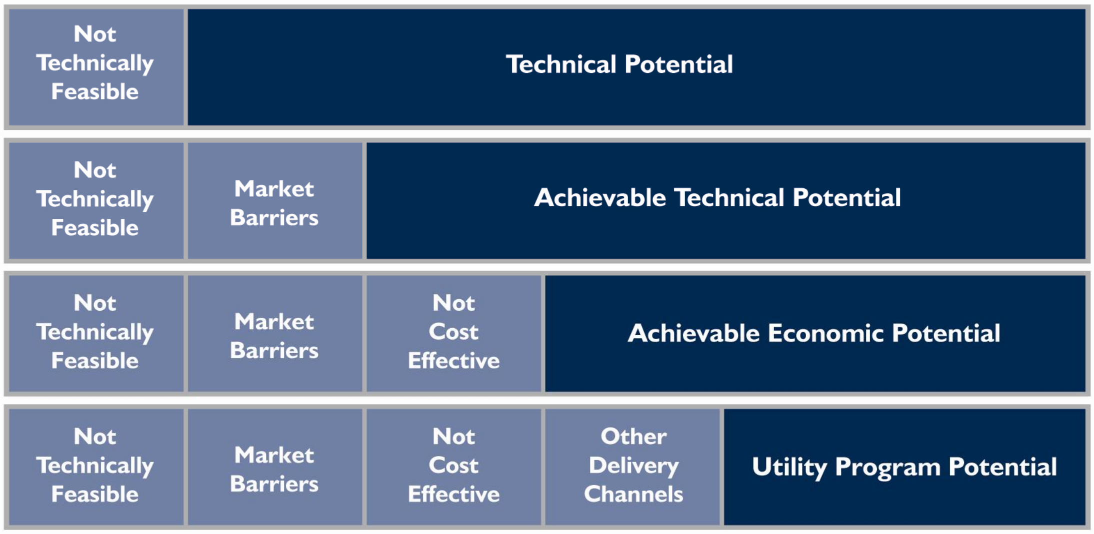
## Overview

This Conservation Potential Assessment (CPA) summarizes the results from an independent study of potentials for electric demand-side management (DSM) resources in Tacoma Power's service area from 2010 to 2019. The study was commissioned by Tacoma Power as part of its biennial integrated resource planning (IRP) process, and is intended to be used to assist Tacoma Power in setting its 2012–2013 planning targets. The study, building on previous efforts, incorporates improvements over the 2006 assessment regarding the assessment's 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). Methods used to evaluate technical potentials and cost-effectiveness drew upon utility industry best practices, and were consistent with the Council's methodology in its assessment of regional conservation potentials in the Northwest.[23] This study estimated the potential for the residential, commercial, and industrial sectors. Independently, Tacoma Power's Transmission and Distribution department is developing a potentials assessment for savings for that sector.

Figure 1 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 that technical potential will never be installed due to market barriers—the resulting potential is the achievable technical potential. The next level down, achievable economic potential, is determined by adding a cost-effectiveness screen, based on the utility's avoided cost. Only measures with a benefit-to-cost ratio, based on the total resource cost test greater than one, 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.

[23] Methodology is described in the link given: 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 2019ĉs forecasted baseline electric sales and potential by sector. Study results indicate 84 aMW of technically feasible electric energy-efficiency potential will be available by 2019, the end of a 10-year planning horizon. Once market constraints have been accounted for, this translates to achievable potential of 71 aMW. If all this potential proved cost-effective and realizable, it would amount to 56 aMW, a 9 percent reduction in 2019 forecasted retail sales, and a 57 percent reduction of load growth from 2010 to 2019. All the results shown are at the meter.

**Table ES-1. Energy Conservation Potential by Sector (aMW in 2019)**

| Secto | Baseli Sales | Technical Potential | Achievable Technical Potential | Achievable Economic Potential | Achievable Econon Potential as % of Baseline |
|---|---|---|---|---|---|
| Residenti | [illegible] | 4 | 3 | 2 | 1 |
| Commerc | [illegible] | 2 | 1 | 1 | |
| Industrial | [illegible] | 1 | 1 | 1 | |
| Federal | | | | | |
| **Total** | [illegible] | | | | |

Table **ES-2** presents the distribution of potential by jurisdiction for each sector.

**Table ES-2. Achievable Economic Potential by Sector and Jurisdiction (aMW in 2019)**

| Jurisdiction | Residential | Commercial | Industrial |
|---|---|---|---|
| Eatonville | 0.01 | 0.00 | -- |
| Federal Way | 0.05 | 0.01 | -- |
| Fife | 0.42 | 0.84 | 1.09 |
| Fircrest | 0.54 | 0.08 | 0.00 |
| Graham | 1.27 | 0.16 | 0.01 |
| Lakewood | 1.41 | 0.77 | 0.03 |
| Milton | 0.01 | 0.01 | -- |
| Puyallup | 1.02 | 0.22 | 0.08 |
| Roy | 0.70 | 0.01 | 0.00 |
| Silver Creek | -- | 0.00 | -- |
| Spanaway | 2.79 | 0.33 | 0.66 |
| Steilacoom | 0.01 | 0.20 | 0.02 |
| Tacoma | 16.4 | 8.93 | 9.61 |
| University Place | 2.60 | 0.71 | 0.00 |
| Not Assigned | 0.01 | 2.54 | -- |
| **Total** | **27.3** | **14.8** | **11.5** |

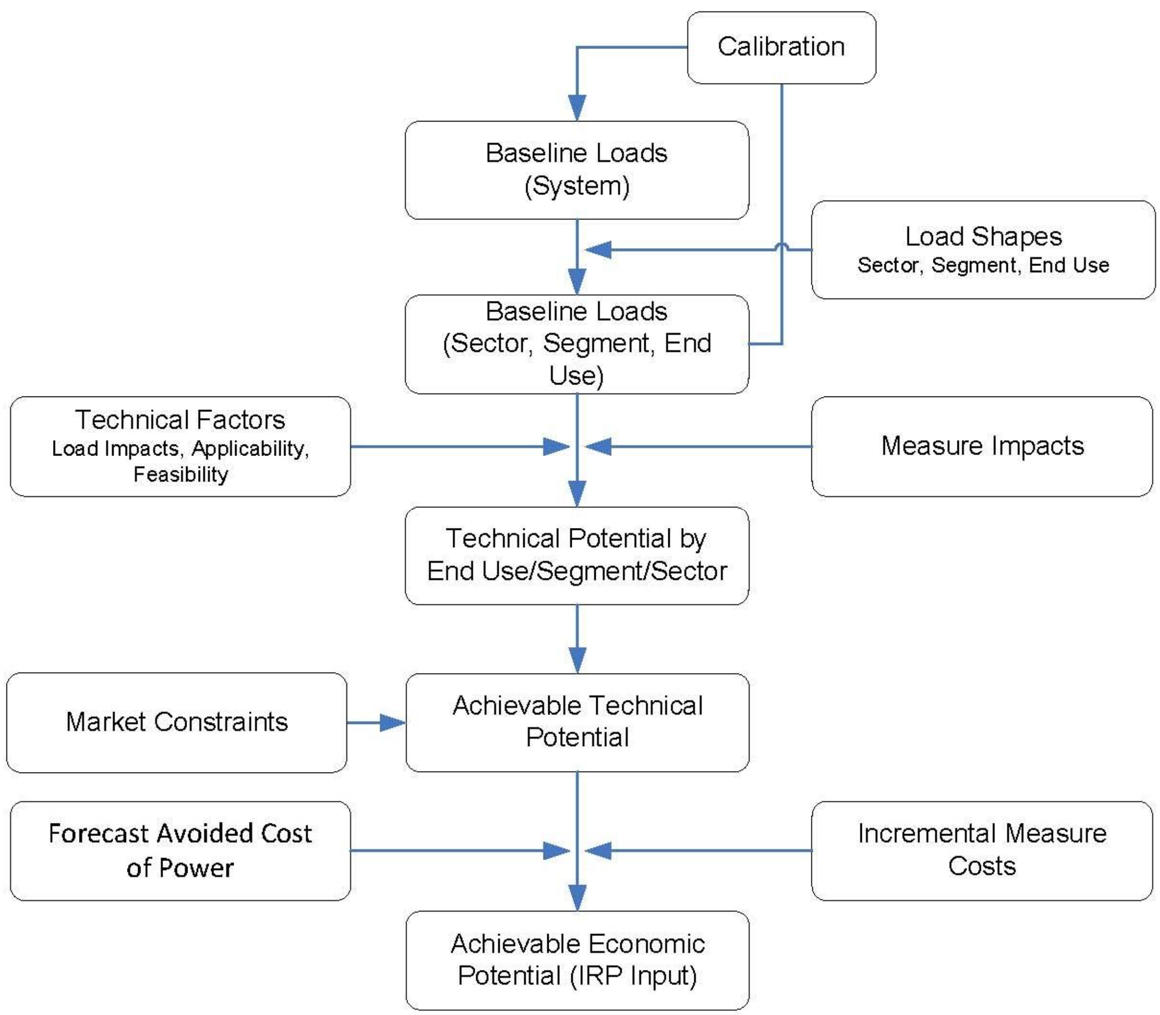
Note: Distribution of potential by jurisdiction is based on 2008 sales

# General Approach and Methodology

DSM resources analyzed in this study differ as to technology, availability, type of load impact, and target consumer markets. Analysis of their potentials, required customized methods addressing the unique characteristics of each resource. These methods still derived from the same conceptual framework and the general analytic approach.

The general methodology can best be described as a hybrid ñtop-down/bottom-upò approach. As illustrated in Figure 2, it begins with the current load forecast, decomposes this into its constituent customer-class and end-use components, and examines the effects of a range of DSM and practices on each end use, accounting for fuel shares, current market saturations, technical feasibility, and costs. These unique impacts are aggregated to produce estimates of resource potentials at the end-use, customer-class, and system levels.

**Figure 2. General Methodology for Assessment of Demand-Side Resource Potentials**



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

- **Develop a baseline forecast:** A baseline forecast was created, based on end-use consumption estimates, and calibrated to Tacoma Powerõs 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 Powerõs climate and customers were analyzed to accurately depict energy-efficiency potential over a 10-year planning horizon. This list was based on that developed by the Council for the 6th Power Plan. When expanded by customer segment, end use, and vintage, this list totaled over 59,700 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 marginal efficiency shares in development of the base-case forecasts.

    - Technical potential assumes all resource opportunities may be captured, regardless of their costs or market barriers. For demand-side resources, such as energy efficiency and fuel conversion, technical potentials further fall into two classes: ñinstantaneousò (retrofit) and ñphased-inò (lost-opportunity) resources.

    - Achievable technical potential is defined as the portion of technical potential that might be assumed to be achievable in the course of the planning horizon, given market barriers that may impede customer participation in DSM programs. Assumed achievable potentials levels are meant to serve principally as planning guidelines. Ultimately, actual levels of achievable opportunities will depend on: customersô willingness and ability to participate in the demand-side programs; administrative constraints; and availability of an effective delivery infrastructure. Customersô willingness to participate in demand-side programs also depends on the amount of incentive offered.

    - Achievable economic potential is defined as the portion of achievable technical potential that is cost-effective, using the utilityõs 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 are classified into the following four categories:
***Existing retrofit*** represents retrofit opportunities in existing construction. Examples of such measures include: shell improvements (insulation, weather-stripping, etc.); and early equipment replacement. This potential is considered a ñretrofitò as it occurs in existing building stock, and, theoretically, is available for acquisition any time during the study.

- 
- ***Existing equipment replacement*** 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 the opportunity to upgrade is missed, it must wait until new equipment burns out.
- ***New construction improvements*** represent potential specific to retrofit 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 Tacomaós new construction forecast, and missed efficiency upgrades will typically need to wait until installed technologies must be replaced.
- ***New construction equipment efficiency*** refers to efficiency equipment upgrades in new construction. These include efficient end-use equipment above existing efficiency standards for new construction homes. Similarly to new construction retrofit opportunities, this potential will be driven by the new construction forecast, and efficient equipment will need to be installed as part of the construction process.

The methodology used for estimating technical energy-efficiency potential has been based on standard industry practices, and is consistent with methodology used by the Council in its assessments of conservation potentials for the 6$^{th}$ Northwest Regional Power Plan. Electric energy-efficiency technologies and measures considered in this study include those used in the 6$^{th}$ Power Plan. As described in Section 2, ramp rates used to determine achievable potential for retrofit opportunities are consistent with rates the Council currently uses for calculating achievable potentials in the 6$^{th}$ Power Plan. A detailed discussion of the methodology for estimating energy-efficiency potential is presented in Appendix A.
This study used energy codes and appliance standards in effect at the end of 2009. Impacts of the 2009 Energy Code, expected to be implemented in the first quarter of 2011, have not been included in this study.
In compliance with rules established in Chapter 194-37 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. The results of the electric conservation potential reported here will provide the basis for compliance with requirements of WAC Chapter 194-37.

### *Organization of the Report*

This report is organized in five sections, with each presenting results of a sector: combined, residential, commercial, and industrial. The final section presents potential from alternative economic forecasts. Additional technical information, descriptions of data, and their sources are included in this documentós appendices.

# Energy-Efficiency Potentials

## *Scope of Analysis*

This assessmentøs primary objective was to develop accurate estimates of available energy-efficiency potential, which are essential for Tacoma Powerøs 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. 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 were analyzed. In addition, potential was distinguished by jurisdiction.

In addition, Tacoma Power serves two large federal facilitiesô McChord Air Force Base and Fort Lewis (now known as Joint Base Lewis-McChord [JBLM]). The Bonneville Power Administration (BPA), in coordination with Tacoma Power and Puget Sound Energy, has recently completed a comprehensive energy audit of these federal facilities. The audit results, provided in Appendix B, determined achievable economic potential of 2.8 aMW for these facilities. Given the availability of these data, this study does not provide a separate assessment of potential for these federal facilities.

The study includes a comprehensive set of energy-efficiency electric measures applicable to the climate and customer characteristics of Tacoma Powerøs service territory. This list is based on measures used in the Counciløs 6$^{th}$ 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 304 *unique* electric energy-efficiency measures (Table 1). Considering all permutations of these measures across all customer sectors and segments, customized data had to be compiled and analyzed for over 59,700 measures.

**Table 1. Energy-Efficiency Measure Counts by Sector**

| Sector | Measure Counts: Unique | Measure Counts: Permutations |
|---|---|---|
| Residential | 157 | 4,380 |
| Commercial | 98 | 36,644 |
| Industrial | 51 | 18,762 |

This study used the 2006 Washington State energy code for new construction as a baseline. In addition, Federal standards, as of January 1, 2010, were incorporated, consistent with those used by the Council for the 6$^{th}$ Power Plan.[24]

Part of Tacoma Powerøs load can be attributed to facilities for which potential has not been calculated. These include: power sales to port cranes, refrigerated containers temporarily

[24] See Table 4-1 of the 6th Power Plan.

stored at port, certain industrial accounts that have closed during the year, and the wholesale power to the City of Ruston. This portion of the load constitutes 16,000 MWh annually. The remainder of this section is divided into three parts:

- A brief description of the methodology 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 2019 forecasted baseline electric sales and potentials by sector. Study results indicate 84 aMW of technically feasible electric energy-efficiency potential will be available by 2019, the end of the 10-year planning horizon (not including federal facilities). This translates to an achievable technical potential of 71 aMW. The achievable economic potential is 56 aMWð a 9 percent reduction in 2019 forecasted retail sales, and a 57 percent reduction of load growth from 2010 to 2019. All the results shown are at the meter. The 61 aMW translates to a reduction of approximately 2,500,000 metric tonnes of $CO_2$, which would otherwise be released into the atmosphere.[25]

**Table 2. Summary Conservation Potential by Sector (aMW in 2019)**

| Sector | Baseline Sales | Technical Potential | Achievable Technical Potential | Achievable Economic Potential |
|---|---|---|---|---|
| Residential | 238 | 46.5 | 39.5 | 27.3 |
| Commercial | 228 | 23.3 | 19.8 | 14.8 |
| Industrial | 136 | 14.0 | 11.9 | 11.5 |
| Federal Facilities* | 42 | NA | NA | 2.8 |
| **Total** | **644** | **84** | **71** | **56** |

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

This conservation potential assessment remains neutral regarding the acquisition approach required. Some technologies will require ñupstreamò encouragement, which most utilities, on their own, are unable to fulfill. However, groups within the region may be able to acquire these savings on behalf of the utility. As a result, these actionable potentials have been included. In addition, these savings are based on forecasts of future consumption, absent utility program activities. While consumption forecasts account for past savings Tacoma Power has acquired, estimated potential is inclusive ofð not in addition toð 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 three percent of the total achievable economic potential. The potentials, by acquisition type and sector, are shown in Table 3.

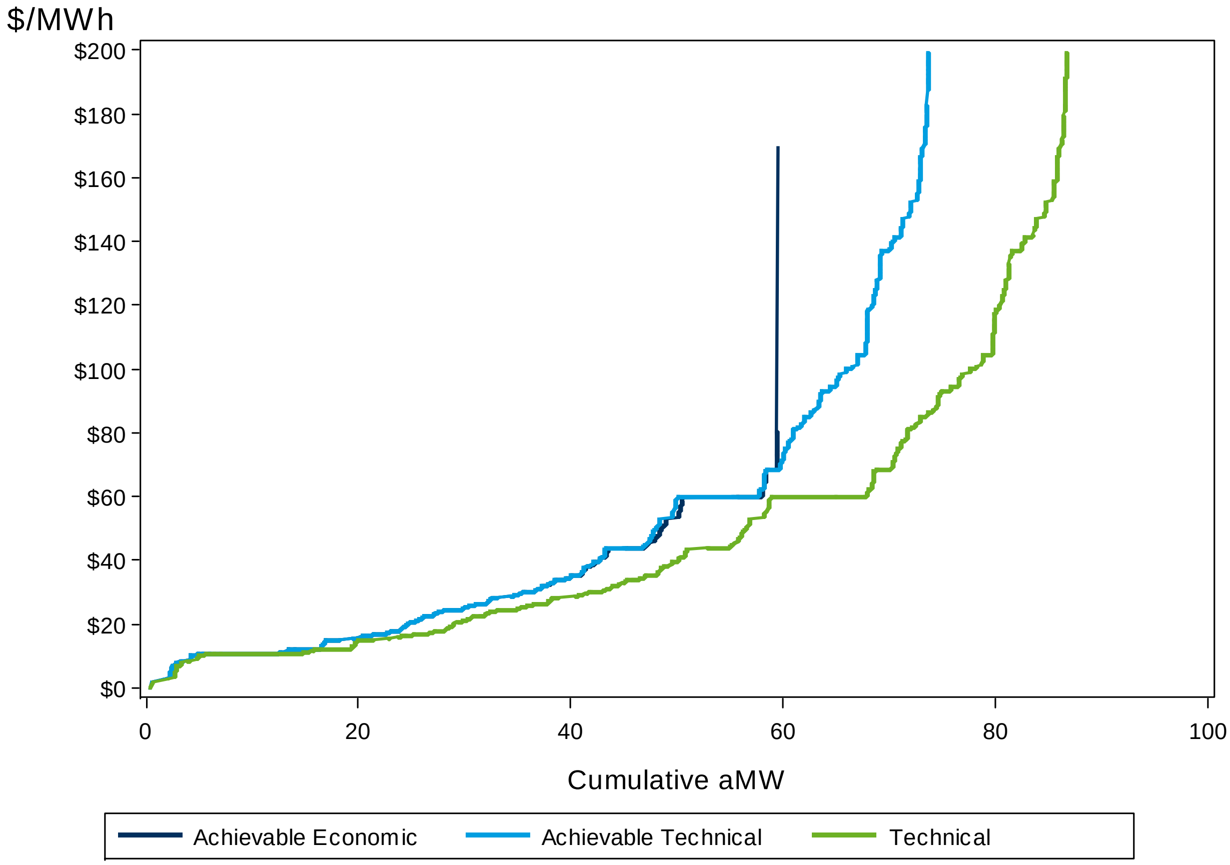
[25] Estimating 0.9 lbs $CO_2$ per kWh of electricity generated by a new combined-cycle gas turbine and an average measure life of 10 years.

**Table 3. Achievable Economic Potentiality Acquisition Type (aMW in 2019)**

| Sector | Existing Construction Retrofit | Existing Construction Equipment Replacement | New Construction Improvements | New Construction Equipment Efficiency | Total |
|---|---|---|---|---|---|
| Residential | 25.5 | 0.71 | 0.90 | 0.11 | 27.3 |
| Commercial | 14.2 | 0.11 | 0.52 | 0.00 | 14.8 |
| Industrial | 11.5 | -- | -- | -- | 11.5 |
| **Total** | **51** | **0.8** | **1.4** | **0.1** | **54** |

A supply curve of these resources, based on levelized costs, is shown in Figure 3. This curve represents the universe of measures evaluated for this study, and their relative contribution to potential. Note that achievable economic potential shows the effect of quantifiable non-energy benefits, allowing for measures with a cost well above the levelized avoided cost (around $60/MWh) to pass the Total Resource Cost economic screen.

**Figure 3. Supply Curve by Potential Type**



### *Alternative Scenarios*

In addition to base case results shown, the assessment included a study of three alternate scenarios.

- High avoided cost scenario.
- Low avoided cost scenario.
- Technology progress—an accelerated ramp rate where acquisitions in the first five years increases by 20 percent and decreases in the second five years.

Results of the high and low avoided cost scenarios are shown in Table 4. The total 10-year potential remains the same as the base case for the technology progress scenario, as only the ramp rate is affected.

**Table 4. Achievable Economic Potential under Alternate Scenarios (aMW in 2019)**

| Sector | Low Avoided Cost | Base Case | High Avoided Cost |
|---|---|---|---|
| Residential | 25.4 | 27.3 | 28.1 |
| Commercial | 14.7 | 14.5 | 15.2 |
| Industrial | 11.5 | 11.5 | 11.5 |
| **Total** | **51.6** | **53.5** | **54.8** |

# Residential Sector

Residential customers in Tacoma Powerôs service territory are expected to account for approximately 40 percent of baseline electricity retail sales by 2019. 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, LED interior lighting). Potential by segment are given in Table 5; results are given at the meter.

**Table 5. Residential Sector Potential by Segment (aMW in 2019)**

| Segment | Technical | Achievable Technical | Achievable Economic | Achievable Economic as % of Total |
|---|---|---|---|---|
| Single Family | 32.3 | 27.4 | 17.7 | 65% |
| Multifamily | 8.9 | 7.6 | 6.4 | 24% |
| Manufactured | 5.4 | 4.6 | 3.2 | 12% |
| **Total** | **46.5** | **39.5** | **27.3** | **100%** |

Achievable economic potential would result in reduction of approximately 1,300,000 metric tonnes of generated $CO_2$. As shown in Table 5, single-family homes represent 65 percent of the total achievable economic electric potential for the residential sector, followed by multifamily and manufactured homes (24 percent and 12 percent, respectively). The main driver of these results is each home typeôs proportion of baseline sales, 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, which increases their relative share of the potential. Conversely, low 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. Further detail on these factors is provided in Appendix A.

In addition to potential from the traditional energy-efficiency measures above, potential exists from solar water heaters and photovoltaics (PV). Using equivalent assumptions of the Council in the 6$^{th}$ Power Plan, the 10-year achievable PV technical potential in Tacoma Powerôs territory is: 0.735 aMW for PV; and 7.16 aMW for solar water heaters. Both these measures have a levelized cost of more than $250/MWh, and do not pass the economic screen.

Tacoma Power maintains a comprehensive customer database, which has been used in this study to identify sales and customers by detailed market segments as well as to provide greater detail on location and historical program participation. Table 6 provides detailed information regarding electric sales and dwellings for the 13 distinct jurisdictions, plus an unincorporated area, comprising the Tacoma Power service territory. Conservation potential for Tacoma will follow a similar distribution by jurisdiction, a helpful factor to consider for developing programs, targeting participants, and building implementation strategies. Of particular importance will be homes in Tacoma eligible for weatherization, but which have yet to participate in a weatherization program. Additional details regarding savings associated with specific measures, assessed within each end use, are provided in Appendix C.

**Table 6. Residential Statistics by Jurisdiction**

| Jurisdiction | 2008 Sales (MWh) | Dwelling Units | Eligible Weatherization Dwellings |
|---|---|---|---|
| Tacoma | 1,166,548 | 85,511 | 17,914 |
| Spanaway | 198,017 | 14,515 | 1,087 |
| University Place | 185,021 | 13,562 | 1,778 |
| Other* | 123,514 | 9,054 | 981 |
| Lakewood | 99,861 | 7,320 | 1,148 |
| Graham | 90,466 | 6,631 | 466 |
| Puyallup | 72,147 | 5,289 | 567 |
| **Total** | **1,935,573** | **141,882** | **23,940** |

* Other category includes jurisdictions with fewer than 4,000 dwellings: Fircrest, Fife, Roy, Federal Way, Steilacoom, Milton, Eatonville, and unincorporated jurisdictions
Note: Distribution of dwelling units based on 2008 sales

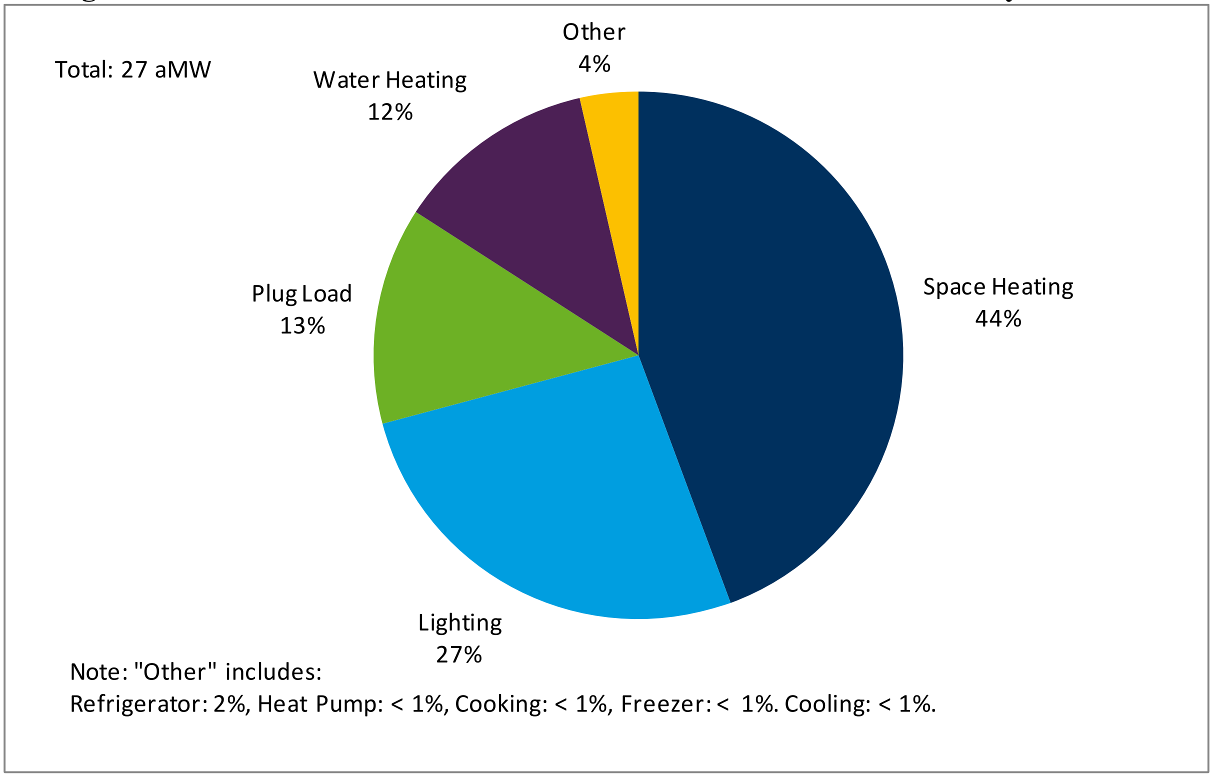
Figure 4 shows total achievable economic potential by end use category. Note that baseline sales are totaled across Tacomaôs territory. Although baseline sales for plug loads are greater than space heat, this does not imply, in a given home, space heating usage is less than all plug loads. Rather, only about half the homes in Tacomaôs territory have electric space heating, but all homes have plug loads; so total sales account for these fuel share and saturation distributions.

Space heating represents the largest portion (54 percent) of achievable economic potential. This end use includes heating savings from weatherization measures as well as 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).[26]

While this study has accounted for expected impacts of new lighting standards outlined in the 2007 Energy Independence and Security Act (EISA), lighting still represents the second largest portion (27 percent) of achievable economic potential. Plug loads represent approximately 13 percent of achievable economic potential, and include non-refrigeration appliances, such as televisions, computers, and clothes washers. Water heating accounts for 12 percent of achievable economic potential, while the remaining end uses represent approximately 4 percent. The refrigerator end use (accounting for 2 percent of the potential) only encompasses savings from replacing old refrigerators with ENERGY STAR or better units. Refrigerator decommissioning (refrigerator recycling) is not included as a standalone measure as no widget is installed. However, savings from this activity are recognized. The Regional Technical Forum (RTF) currently estimates savings of 904 kWh per unit, at a benefit-cost ratio greater than one. Detailed sales and potentials by end use are presented in Table 7 Further information on data sources used to calculate these potentials is provided in Appendix A.

[26] 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 are treated separately because of complications around heating and cooling savings associated with heat pumps

**Figure 4. Residential Sector Achievable Economic Potential in 2019 by End Use**




The economic potential in this assessment includes measures only recently becoming widely commercialized, including ductless heat pumps and heat pump water heaters. Together, they account for approximately 7 percent of the Tacoma Power residential achievable economic potential. Acquiring these savings will require aggressive program activity.

**Table 7. Residential Sector Potential by End Use (aMW in 2019)**

| End Use | Baseline Sales | Technical | Achievable Technical | Achievable Economic |
|---|---|---|---|---|
| Space Heating | 53.7 | 26.5 | 22.5 | 12.1 |
| Lighting | 34.7 | 8.5 | 7.2 | 7.2 |
| Plug Load | 57.0 | 5.2 | 4.4 | 3.6 |
| Water Heating | 30.1 | 4.9 | 4.1 | 3.4 |
| Refrigerator | 13.1 | 0.6 | 0.5 | 0.5 |
| Heat Pump | 9.0 | 0.2 | 0.2 | 0.2 |
| Cooking | 14.4 | 0.3 | 0.3 | 0.2 |
| Freezer | 5.3 | 0.2 | 0.1 | 0.1 |
| Cooling | 2.7 | 0.1 | 0.04 | 0.04 |
| Dryer | 11.2 | 0.2 | 0.1 | -- |
| HVAC Auxiliary | 6.8 | -- | -- | -- |
| **Total** | **237.8** | **46.5** | **39.5** | **27.2** |

Within the space heating end use, 0.3 aMW of achievable economic potential derives from conversion of baseboard heating to ductless heat pumps, and 0.1 aMW from the conversion of electric forced-air furnaces to air-source heat pumps; the remainder (11.7 aMW) derives from weatherization measures.

It is important to note the achievable economic potential estimate presented in this study represents the total potential that can be realized in Tacoma Powerօs service area. These savings may, in part, be realized by Tacoma Power through its programs, but savings will come 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).

Figure 5 and Table 8 show achievable economic potential by vintage and measure type, grouped in the following manner: existing retrofit, existing equipment replacement, new construction improvements, and new construction equipment efficiency. These distinctions are important in terms of timing resource availability and acquisition, as only certain portions of potential can be accelerated. Though program planning is outside this studyօs scope, these considerations remain vital for setting accurate annual program and portfolio goals.

Retrofit resources in existing construction accounted for the vast majority of achievable economic potential (94 percent), with equipment measures in existing construction representing 2 percent of achievable economic potential. Due to this studyօs relatively short timeframe, with low expected housing starts, new construction potential composed less than 4 percent of the total achievable economic potential.

**Figure 5. Residential Sector Achievable Economic Potential in 2019 by Acquisition Type**

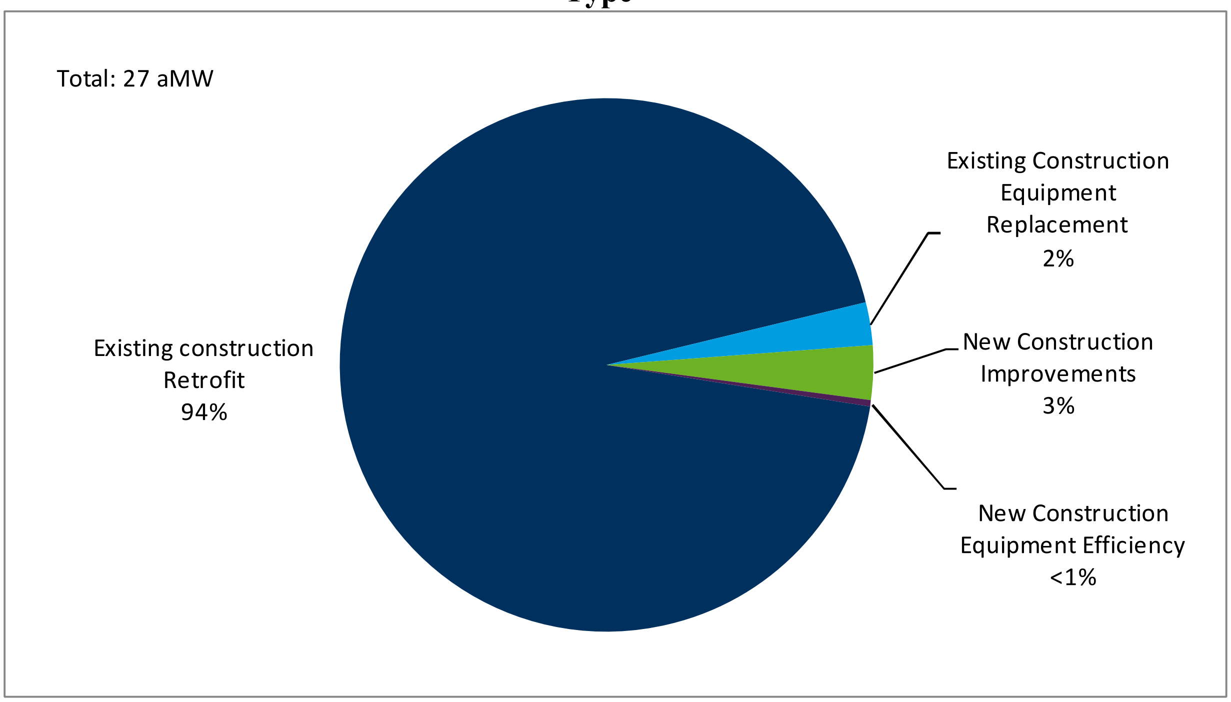


**Table 8. Residential Sector Achievable Economic Potential by End-Use and Acquisition Type (aMW in 2019)**

| End Use | Existing Construction Retrofit | Existing Construction Equipment Replacement | New Construction Improvements | New Construction Equipment Efficiency | Total |
|---|---|---|---|---|---|
| Space Heating | 11.79 | -- | 0.29 | -- | 12.8 |
| Lighting | 7.1 | -- | 0.12 | -- | 7.22 |
| Plug Load | 3.37 | -- | 0.24 | -- | 3.61 |
| Water Heating | 3.13 | -- | 0.23 | -- | 3.36 |
| Refrigerator | -- | 0.41 | -- | 0.07 | 0.48 |
| Heat Pump | -- | 0.14 | -- | 0.02 | 0.16 |
| Cooking | 0.14 | -- | 0.01 | -- | 0.15 |
| Freezer | -- | 0.12 | -- | 0.02 | 0.14 |
| Cooling | -- | 0.04 | -- | 0 | 0.04 |
| **Total** | **25.5** | **0.7** | **0.9** | **0.1** | **27.2** |
| **Percent of Total** | **94%** | **2.6%** | **3.3%** | **0.4%** | **100%** |

Effective and flexible conservation programs will be critical to capturing lost opportunity potentials constituted by the equipment replacement and new construction categories (1.7 aMW). In addition, for the new construction potential, this analysis was based on the 2006 Washington State Energy Code. However, the recently adopted 2009 energy code will create a new baseline, which will result in reduced potential for these categories. For Tacoma Power, the effect of the new codes on new and major remodel conservation will reduce these results, requiring a separate study to accurately quantify the change in potential.

# Commercial Sector

Data sources used to determine the commercial sector potential include: Tacoma building classification (approximately 94% of the power sales), Commercial Building Stock Assessment,[27] and the Councilôs 6th Power Plan. Based on resources included in this assessment, electric achievable economic potential in the commercial sector is expected to be just under 15 aMW over 10 years, corresponding to a 7 percent reduction of forecasted 2019 commercial consumption. The potential break-out by segment is provided in Table 9. Note the table includes ñMisc Classifiedò and ñMisc Unclassifiedò segments. The Misc Unclassified segment is composed of customers with unknown segments. The Misc Classified segment is composed of customers where the segment is known, but they do not readily fit into given named segments (for example, an account classified as an assisted living center). Potentials for both these segments are treated similarly.

**Table 9. Commercial Sector Potential by Segment (aMW in 2019)***

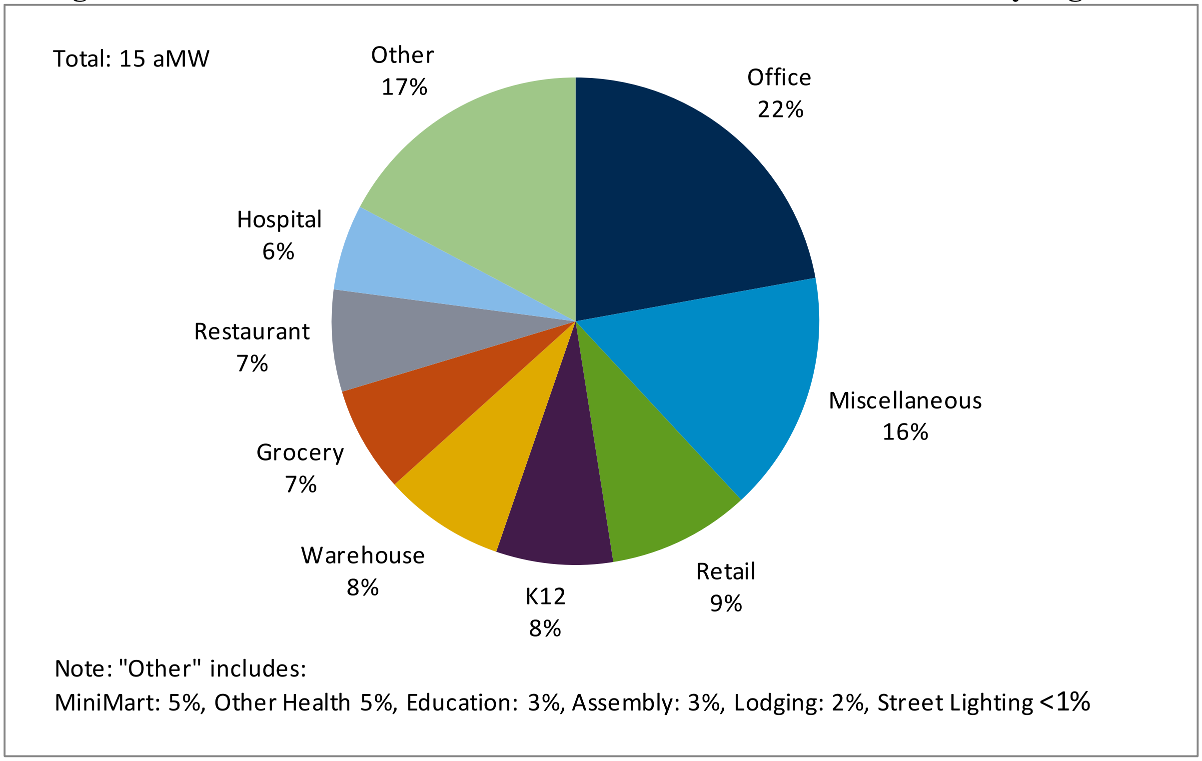
| Segment | Technical | Achievable Technical | Achievable Economic | Achievable Economic as % of Total |
|---|---|---|---|---|
| Office | 6.1 | 5.2 | 3.3 | 22% |
| Misc Classified | 2.7 | 2.3 | 1.5 | 10% |
| Retail | 2.3 | 2.0 | 1.4 | 9% |
| Warehouse | 1.6 | 1.3 | 1.2 | 8% |
| K12 | 1.8 | 1.5 | 1.2 | 8% |
| Grocery | 1.4 | 1.2 | 1.0 | 7% |
| Restaurant | 1.3 | 1.1 | 1.0 | 7% |
| Misc Unclassified | 1.4 | 1.2 | 0.9 | 6% |
| Hospital | 0.9 | 0.8 | 0.8 | 6% |
| Other Health | 1.1 | 0.9 | 0.7 | 5% |
| MiniMart | 1.0 | 0.8 | 0.7 | 5% |
| University | 0.7 | 0.6 | 0.5 | 3% |
| Assembly | 0.6 | 0.5 | 0.4 | 3% |
| Lodging | 0.5 | 0.4 | 0.3 | 2% |
| Street Lighting | 0.09 | 0.08 | 0.01 | <1% |
| **Total** | **23.4** | **19.9** | **14.8** | **100%** |

*Note, numbers may not sum to total due to rounding.

The 14.8 aMW of achievable economic potential would result in a reduction of approximately 600,000 metric tonnes of generated $CO_2$. As shown in Figure 6, combined offices, misc classified/ unclassified buildings (labeled together as miscellaneous), and retail represent just under half of the available economic potential (22 percent, 16 percent, and 9 percent, respectively). Acquiring the savings potential in the miscellaneous segments, representing approximately 6,500 accounts (50% of all accounts, and 18% of the commercial load), will require nimble program design as there are great variety and unique requirements for this sector. Hospitals, comprising 6% of the potential, are composed of less than 35 known accounts and thus will require active engagement with decision makers to acquire the savings.

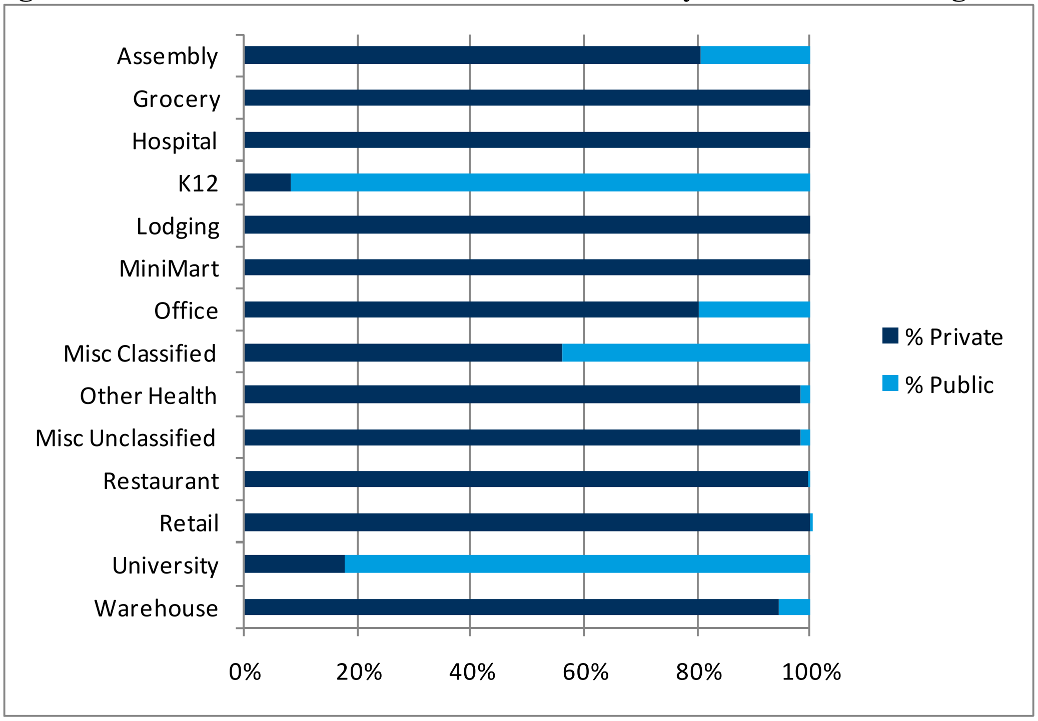
[27] The 2007 CBSA data was parsed to include buildings in and near Tacoma power territory.

**Figure 6. Commercial Sector Achievable Economic Potential in 2019 by Segment**




Within each segment, the buildings are private or public sector. The public sector includes state, county, city, and federal buildings not included as federal facilities. Approximately 80 percent of the achievable economic potential is within the private sector, primarily in the office and retail segments.

**Figure 7. Distribution of 2008 Commercial Sales by Institution and Segment**




Lighting efficiency represents, by far, the largest portion of achievable economic potential in the commercial sector (75 percent), followed by refrigeration (10 percent) and plug loads (7 percent), 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. Included in the lighting potential is an estimate of Tacomaĉs street lighting segment. The measures considered in this analysis consisted of the replacement of high pressure sodium lamps upon burnout with LEDs of various wattages. In 2019, approximately 0.09 aMW of technical potential and 0.08 aMW of technical achievable potential are available. Achievable economic scenario results in less than 0.01 aMW of potential. Table 10 shows the distribution of baseline sales and savings across end uses.

**Figure 8. Commercial Sector Achievable Economic Potential by End Use**

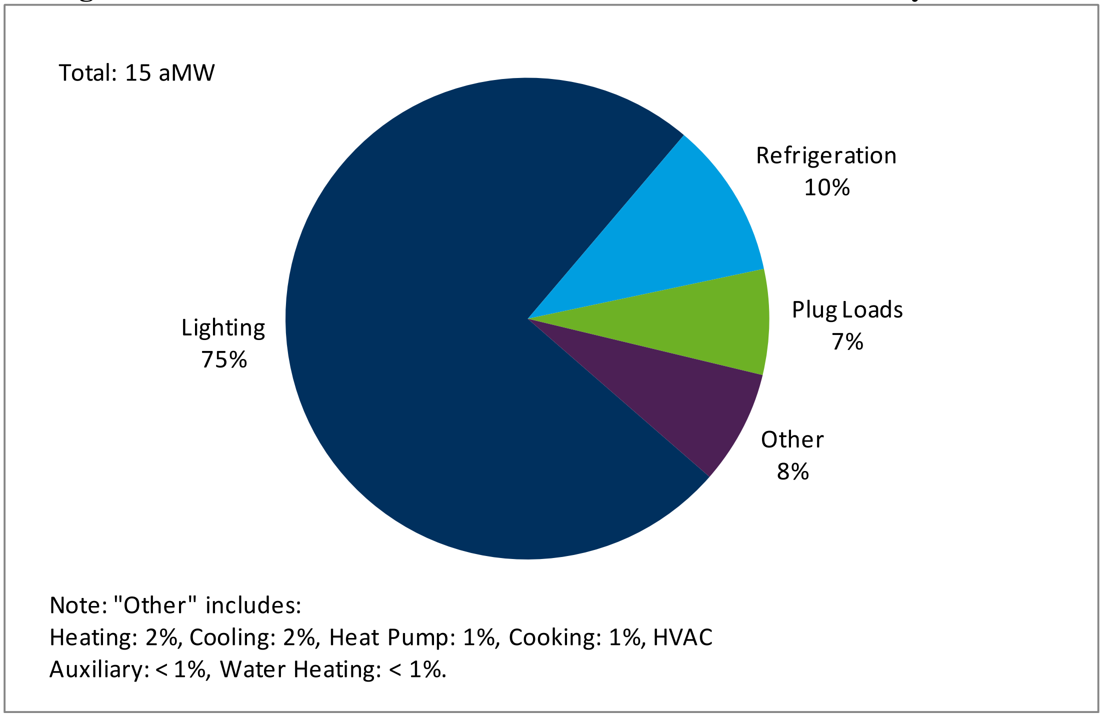



**Table 10. Commercial Sector Energy-Efficiency Potential by End Use (aMW in 2019)**

| End Use | Baseline Sales | Technical Potential | Achievable Technical Potential | Achievable Economic Potential |
|---|---|---|---|---|
| Lighting | 78.9 | 14.6 | 12.5 | 11.1 |
| Refrigeration | 15.6 | 2.1 | 1.8 | 1.6 |
| Plug Loads | 46.4 | 2.3 | 1.9 | 1.0 |
| Heating | 12.2 | 1.1 | 1.0 | 0.4 |
| Cooling | 14.8 | 0.8 | 0.7 | 0.3 |
| Heat Pump | 13.2 | 1.1 | 0.9 | 0.2 |
| Cooking | 3.8 | 0.2 | 0.2 | 0.2 |
| HVAC Auxiliary | 34.1 | 1.0 | 0.8 | 0.1 |
| Water Heating | 8.8 | 0.01 | 0.01 | 0.01 |
| **Total** | **227.7** | **23.3** | **19.8** | **14.8** |

Additional details regarding savings associated with specific measures assessed within each end use are provided in Appendix C.

Figure 9 summarizes existing, major remodel, and new construction commercial buildingsô potential. Many economic measures are available to 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, low new construction potential.

**Figure 9. Commercial Sector Achievable Economic Potential in 2019 by Acquisition Type**

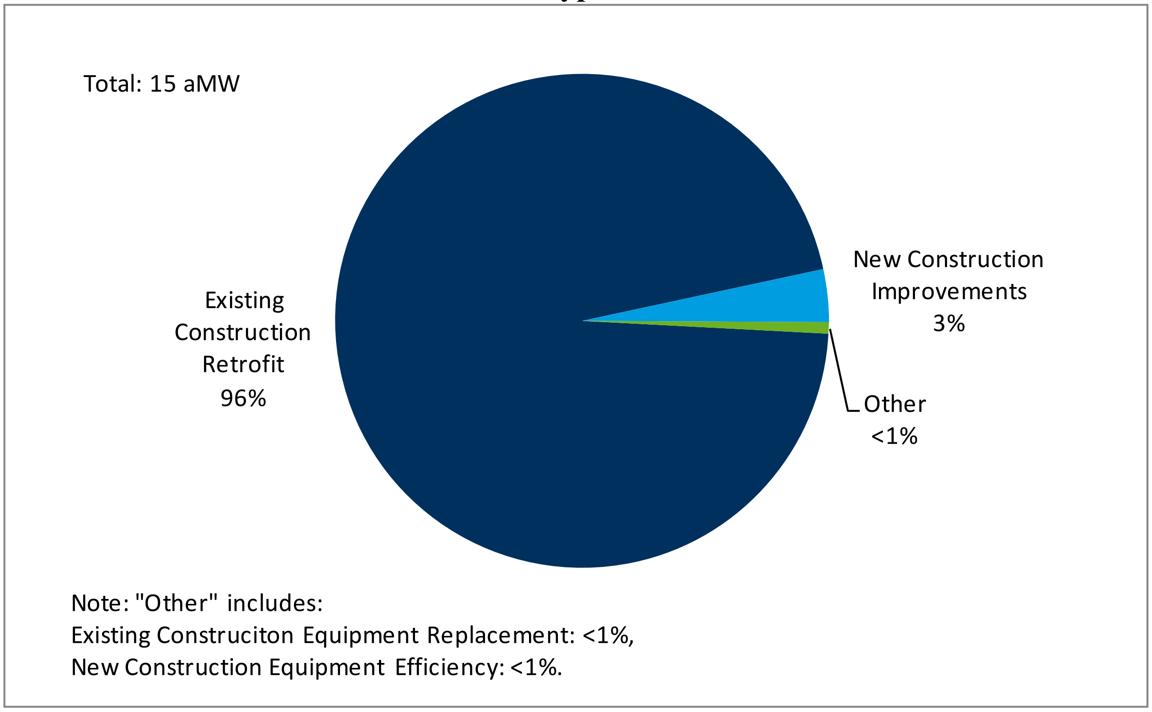


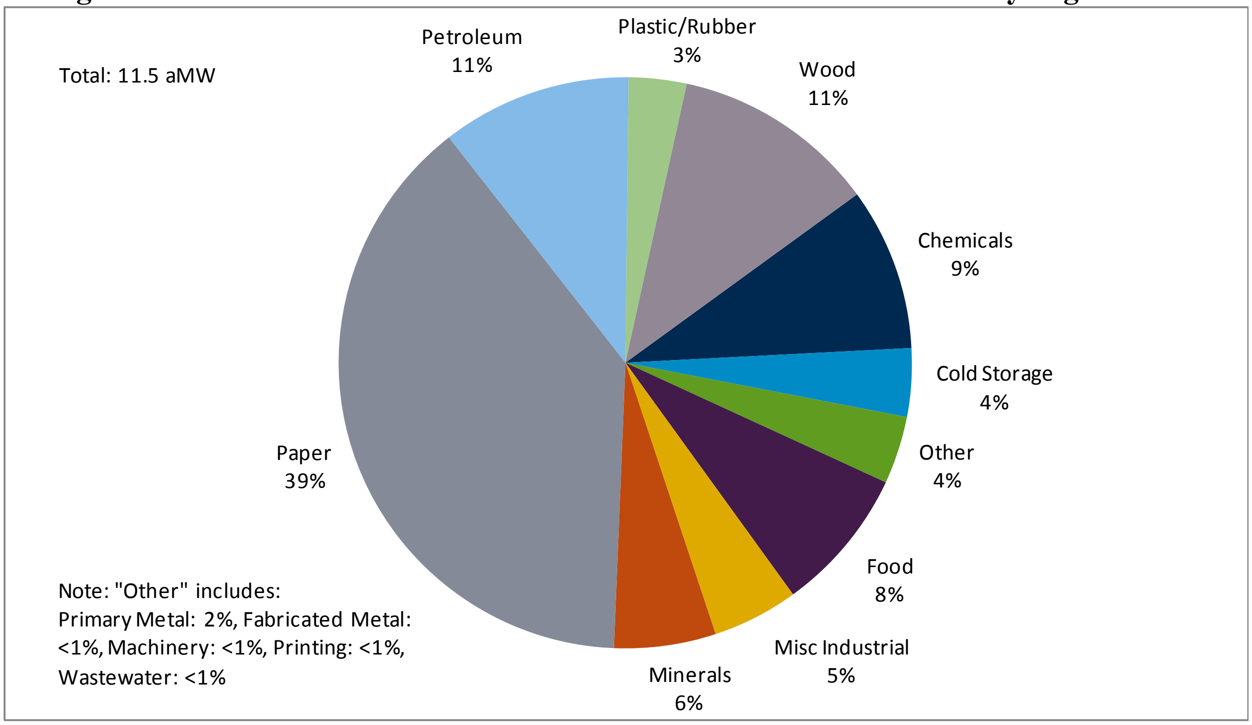

**Table 11. Commercial Sector Achievable Economic Potential by End-Use and Acquisition Type (aMW in 2019)**

| End Use | Existing construction Retrofit | Existing Construction Equipment Replacement | New Construction Improvements | New Construction Equipment Efficiency | Total |
|---|---|---|---|---|---|
| Cooking | 0.14 | -- | 0.02 | -- | 0.16 |
| Cooling | 0.20 | 0.09 | 0.01 | 0.00 | 0.30 |
| HVAC Auxiliary | 0.08 | -- | 0.02 | -- | 0.1 |
| Heat Pump | 0.15 | 0.02 | 0.03 | -- | 0.2 |
| Heating | 0.35 | -- | 0.01 | -- | 0.36 |
| Lighting | 10.79 | -- | 0.30 | -- | 11.1 |
| Plug Loads | 0.99 | -- | 0.06 | -- | 1.05 |
| Refrigeration | 1.50 | -- | 0.06 | -- | 1.6 |
| Water Heating | 0.01 | -- | -- | -- | 0.01 |
| **Total** | **14.2** | **0.1** | **0.5** | **0.00** | **14.8** |
| **Percent of Total** | **96%** | **0.7%** | **3.4%** | **0.00%** | **100%** |

# 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 11.5 aMW over the 10-year planning horizon, corresponding to a 9 percent reduction of forecasted 2019 industrial consumption.

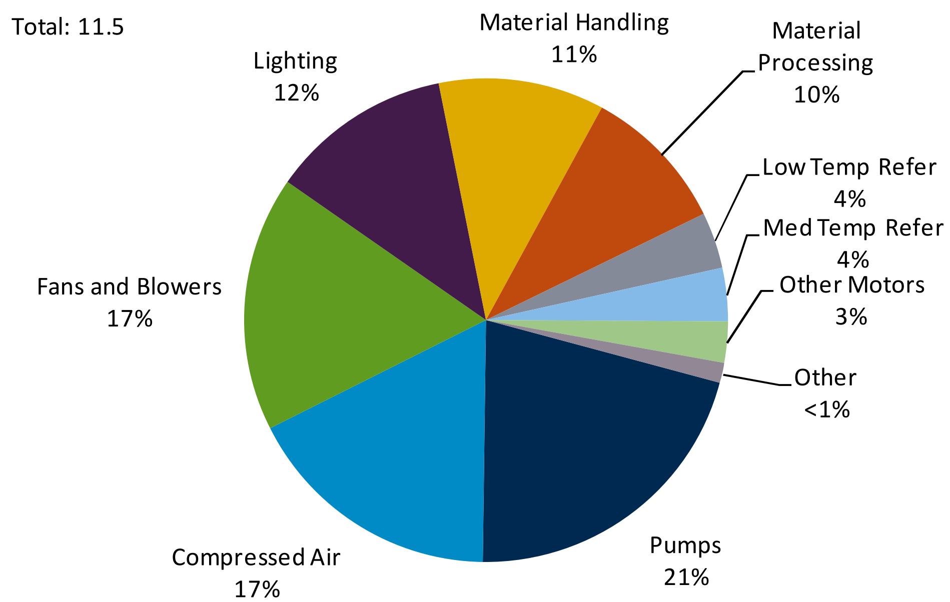
**Figure 10. Industrial Sector Electric Achievable Economic Potential by Segment**




Most industrial sector achievable economic potential is composed of low-cost measures. Energy management measures account for more than half (around 6.1 aMW) of the potential across all end uses. These measures, primarily operation and management strategies that differ from the hardware components typically promoted in programs, and capturing these savings may require a unique approach.

By end use, the majority of electric achievable economic potentials in the industrial sector (56 percent) are attributable to efficiency gains in motor system improvements (mainly air compressors, fans, and pumps). Lighting is the next most significant source of savings (12 percent). Material processing and handling, together, constitute 21 percent of the potential. A small amount of additional potential exists for other motors, process improvements, and other facility improvements (Figure 11 and Table 12). Details of measures are included in Appendix C.

**Figure 11. Industrial Sector Electric Achievable Economic Potential by End Use**




Note: "Other" includes:
Miscellaneous <1%, Melting and Casting <1%, Drying and Curing <1%, Heat Treating <1%, Pollution Control <1%, HVAC <1%, Heating <1%.

**Table 12. Industrial Sector Energy-Efficiency Potential by End Use (aMW in 2019)**

| End Use | Baseline Sales | Technical Potential | Achievable Technical Potential | Achievable Economic Potential |
|---|---|---|---|---|
| Pumps | 27.2 | 3.02 | 2.57 | 2.42 |
| Compressed Air | 13.0 | 2.35 | 1.99 | 1.99 |
| Fans and Blowers | 14.1 | 2.31 | 1.96 | 1.96 |
| Lighting | 7.52 | 1.64 | 1.40 | 1.40 |
| Material Handling | 15.1 | 1.82 | 1.55 | 1.27 |
| Material Processing | 27.0 | 1.33 | 1.13 | 1.13 |
| Low Temp Refer | 2.41 | 0.51 | 0.43 | 0.43 |
| Med Temp Refer | 1.64 | 0.48 | 0.41 | 0.41 |
| Other Motors | 4.80 | 0.37 | 0.32 | 0.32 |
| Pollution Control | 1.31 | 0.07 | 0.06 | 0.06 |
| HVAC | 3.64 | 0.07 | 0.06 | 0.06 |
| Miscellaneous | 12.4 | 0.02 | 0.01 | 0.01 |
| Melting and Casting | 0.65 | 0.02 | 0.01 | 0.01 |
| Heating | 3.28 | 0.00 | 0.00 | 0.00 |
| Drying and Curing | 1.99 | 0.00 | 0.00 | 0.00 |
| Heat Treating | 0.16 | 0.00 | 0.00 | 0.00 |
| **Total** | **136** | **14.0** | **11.9** | **11.5** |

The 11.5 aMW translates to a reduction of approximately 450,000 metric tonnes of $CO_2$. All industrial conservation potential is considered existing construction retrofit. Additional

details regarding savings associated with specific measures assessed within each end use are provided in Appendix C.

# Alternative Scenarios

This chapter presents additional achievable economic potential scenarios that consider high and low avoided cost scenarios by sector.

## *Residential*

Table 13 presents potentials by end use for alternative achievable economic scenarios, compared to the base case. These scenariosôprimary impacts occur where measures with total resource costs (TRCs) near 1 are adjusted above or below the cost-effectiveness threshold. For the residential sector, most affected measures are in the space heating end use. For these measures, the high avoided cost scenario results in approximately a 0.8 aMW increase in potential from the base case, due primarily to a few weatherization measures that become cost effective. The low avoided cost scenario results in a 1.8 aMW decrease in potential from the base case due primarily to ductless heat pumps no longer being cost effective.

**Table 13. Residential Sector Potential by End Use for Alternative Achievable Economic Scenarios (aMW in 2019)**

| End Use | Low Avoided Cost | Base-Case | High Avoided Cost |
|---|---|---|---|
| Space Heating | 10.3 | 12.1 | 12.9 |
| Lighting | 7.2 | 7.2 | 7.2 |
| Plug Load | 3.6 | 3.6 | 3.6 |
| Water Heating | 3.4 | 3.4 | 3.4 |
| Refrigerator | 0.5 | 0.5 | 0.5 |
| Heat Pump | 0..2 | 0.2 | 0.2 |
| Cooking | 0.2 | 0.2 | 0.2 |
| Freezer | 0.1 | 0.1 | 0.1 |
| Cooling | 0.04 | 0.04 | 0.04 |
| Dryer | -- | -- | -- |
| HVAC Auxiliary | -- | -- | -- |
| **Total** | **25.4** | **27.2** | **28.1** |

## *Commercial*

Table 14 presents potentials by end use for the alternative achievable economic scenarios, compared to the base case. Primary impacts of these scenarios occur where measures with TRCs near 1 are adjusted above or below the cost-effectiveness threshold. For the commercial sector, very few measures are affected by this change in avoided costs. Most affected measures are in the lighting, refrigeration, and cooling end uses for the high avoided cost scenario. For the low avoided cost scenario, the minor shift is spread across lighting, cooling, = heat pumps, and HVAC auxiliary end uses. For these measures, the high avoided cost scenario results in approximately 0.41 aMW increase, while the low avoided cost scenario results in a 0.14 aMW decrease from the base case.

**Table 14. Commercial Sector Potential by End Use for Alternative Achievable Economic Scenarios (aMW in 2019)**

| End Use | Low Avoided Cost | Base-Case | High Avoided Cost |
|---|---|---|---|
| Lighting | 11.1 | 11.1 | 11.3 |
| Refrigeration | 1.6 | 1.6 | 1.7 |
| Plug Loads | 1.0 | 1.0 | 1.0 |
| Heating | 0.4 | 0.4 | 0.4 |
| Cooling | 0.2 | 0.3 | 0.3 |
| Heat Pump | 0.2 | 0.2 | 0.2 |
| Cooking | 0.2 | 0.2 | 0.2 |
| HVAC Auxiliary | 0.1 | 0.1 | 0.1 |
| Water Heating | 0.01 | 0.01 | 0.01 |
| **Total** | **14.7** | **14.8** | **15.2** |

## *Industrial*

In the industrial sector, no changes occurred due to shifts in avoided cost. In other words, no measures had a marginal TRC.

# Appendix F

# Tacoma Power Resources

*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 has contractual interest in the output from two projects – Priest Rapids and Grand Coulee Project Hydroelectric Authority.*

Tacoma Power is at a significant advantage relative to most other electric utilities. The electricity that Tacoma Power supplies to retail customers is virtually all generated by hydro-electric resources obviating most GHG emission risk. And, these resources are expected to be sufficient to meet retail load under critical water conditions over the 18 years assess by this IRP. This obviates most fuel price risks (e.g., 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 does, on occasion, purchase power on the wholesale market, these purchases are simply to take advantage of a peak/off-peak price differential, or to satisfy some short-term balancing need. These purchases average around 7 aMW, far less than the 220 aMW the utility typically sells.[28] The revenues earned through these sales help Tacoma Power to maintain low retail rates. Following is a more thorough description of Tacoma Power's power supply portfolio.

## The BPA Contract

The BPA currently supplies electricity to Tacoma Power under a Priority Firm Power Block Sales Agreement (Block Contract). This contract guarantees Tacoma Power 435 aMW of power each year; however the monthly amount varies relative to Tacoma Power's load. In years when BPA's generation exceeds its total load (from Tacoma Power and other utilities), BPA sell its surplus electricity and rebates the sales revenue to Block Contract customers on a proportional basis. From Tacoma Power's perspective, the principle advantage of the Block Contact is the guarantee of a set amount of power from BPA regardless of the water conditions facing BPA. The current contract will expire on September 30, 2011.

[28] Purchases and sales averages from 2006 through 2009.

***The Bonneville Power Administration***

The BPA was established by Congress in 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 Figure F1). 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.

As part of the 2008 IRP, Tacoma Power evaluated two options for a new BPA contract. The first was a renewal of the current block contract, albeit with certain modifications. The alternative was quite different. While it had elements of the "Block" contract, it also included another very different part, known as "Slice." The "Block" element again guaranteed Tacoma Power a set amount of power, again with some monthly variation, while the "Slice" element guaranteed a specific portion of the output of BPA's resources. The 2008 IRP determined that combining the flexibility of the Tacoma Power's own resources with the excess electricity typically provided by the BPA Slice/Block contract would allow the utility to maximize the value of power sales in the wholesale market. As a result, Tacoma Power selected and signed a new contract for the BPA Slice/Block option. This new BPA contract begins on October 1, 2011 and runs through September 30, 2027.

During the initial phase of the 2010 integrated resources plan, the utility anticipated that the "Block" and "Slice" elements of the BPA contract would provide 204, and 210 aMW, respectively under critical water conditions. The resulting 414 aMW was used in the base load-resource balance analysis. However, recent information regarding BPA's weather normalization procedures (a fundamental input to Tacoma Power's load calculation) and generating capacity has lowered this number. The utility now expects to receive around 400 aMW from the BPA contract.

## Own Resources

Tacoma Power's own resources are geographically diverse from BPA's. The 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 (See Figure E1). Conversely, Tacoma Power's resources and their attendant watersheds are on the west side of the Cascades. (See Figure E2). This geographic diversity provides real benefits in that weather patterns have different effects east and west of the Cascades. As recent flow patterns demonstrate, dry conditions on one side of the mountains can be balanced out by wet conditions on the other. The 2010 mid-June forecast of Columbia river flow past the Dalles (east side) from April through August, was 78 percent of normal, while flow in the Cowlitz river at Mayfield (west side) was forecasted at 102 percent of normal.

**Figure E1**
**BPA's East Side Resources**

**Figure E2**
**Tacoma Power's West Side 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. The rebuild of generating unit No. 51 is complete with a new turbine runner, generator stator, static exciter, and electronic governor along with numerous other refurbished pieces of equipment. Unit 52 has a scheduled commissioning date around the end of October 2010. At the conclusion of this overhaul, units 51 and 52 are expected to have FERC 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 at 379 MW.

***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, and 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. Overall, the hydroelectric relicensing process is complex, political and usually controversial.

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

**Figure E3 – Mossyrock Dam**

**Figure E4 – 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.

**Figure E5 – Alder Dam**

The LaGrande 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.

**Figure E6 - LaGrande Dam**

**Figure E7 - LaGrande 6 MW Turbine/Generator**

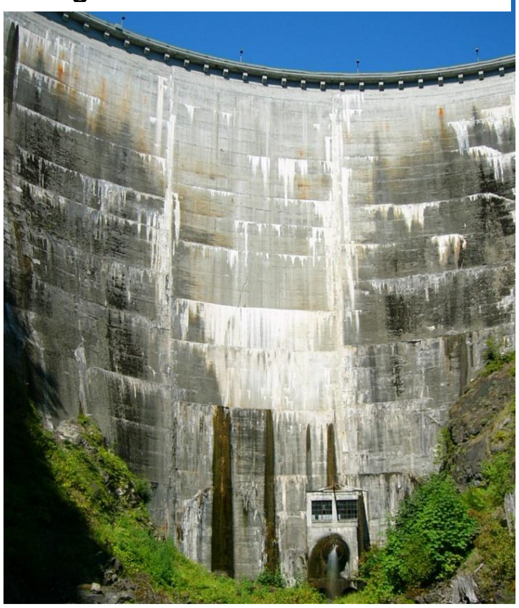
The National Hydropower Association has three times given its annual Outstanding Stewardship of America's Rivers award to the Nisqually River Project. The Nisqually River Project also received a five-year, low impact hydroelectric certification from the Low Impact Hydropower Institute which was recertified in 2008 and extended 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 No. 1, a 275-foot tall concrete arch dam, was completed in 1926 with two 25 MW Francis generating units. Its construction created the Lake Cushman reservoir.

**Figure E8 – Cushman No 1 Dam**

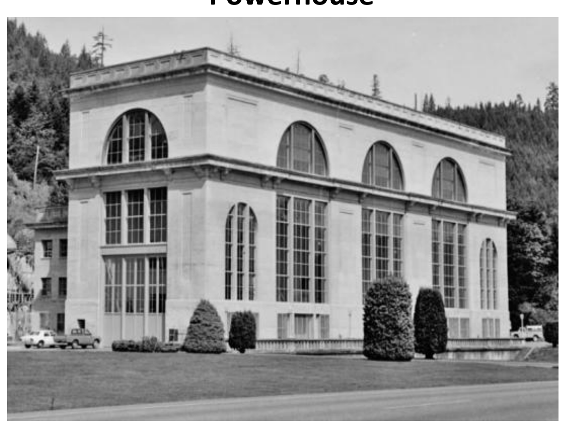


Cushman No. 2 was constructed in 1930 with two 27 MW Francis generating units. A third 27 MW Francis unit was added in 1952. The total installed nameplate rating of Cushman No. 2 is 81 MW. Cushman No. 2 is somewhat unusual in design in that the powerhouse is 2.5 miles from the dam and is fed by a 17-foot diameter power tunnel.

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.

**Figure E9 – Cushman No. 2 Dam**

**Figure E10 – Cushman No. 2 Powerhouse**



## *The Wynoochee Project*

Wynoochee 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 and over BPA's transmission grid to Tacoma Power.

**Figure E11 – Wynoochee Dam**

Currently the cities of Tacoma and Aberdeen share ownership of the facilities at the Wynoochee Project. 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.

Wynoochee 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 will decline should Grant County's load increase as forecasted.

In April 2008, FERC issued a new 44-year operating license for the Priest Rapids Project. Tacoma Power's contract with Grant County PUD runs for the term of this license.

The Grand Coulee Project Hydroelectric Authority constructed five low-head hydroelectric projects along irrigation canals in eastern Washington. The Grand Coulee Project Hydroelectric Authority (GCPHA) is owned by three Columbia Basin Irrigation Districts: South, East and Quincy. These projects produce power during the summertime irrigation season. The total installed capacity of all five projects is approximately 130 MW. Over the years 2004-2007 Tacoma Power's share of the output of these projects averaged approximately 251,000 MWhs. The cities of Tacoma and Seattle have entered into five power purchase agreements for the acquisition of the output from these projects. Tacoma Power receives 50% of the actual output of each project. These five agreements terminate between 2022 and 2026.

# Appendix G

# Operation of Tacoma Power Resources under Peak Load Conditions

The Cowlitz Project At the onset of the cold snap, generation from the Mayfield dam is increased to 164 MW. Generation at the Mossyrock dam is increased to near-maximum levels, 268 MW. Mossyrock is not run at the absolute maximum level of 310 MW in order to meet spinning reserve requirements. Riffe Lake, the Cowlitz Project's storage reservoir, drafts about 2.6 feet per day (7 feet below planned levels, during the course of the 72-hour cold snap).

The Cushman Project At the onset of the cold snap, generation at the Cushman No. 1 dam is increased to maximum, 40 MW. Cushman No. 2 dam generation is increased to near-maximum levels, 71 MW. Cushman No. 2 is not increased to the absolute maximum levels of 81 MW in order to support spinning reserve requirements and to provide a balanced water condition in the Cushman No. 2 reservoir. Lake Cushman, the Cushman Project's storage reservoir, drafts about 1.1 feet per day (2.4 feet below planned levels, during the course of the 72-hour cold snap).

The Nisqually Project Generation is not increased above the required minimum flow levels at either the Alder (13 MW) or LaGrande (22 MW) dams. This is due to constraints imposed by FERC license Article 404, which prohibits discharge from being increased above minimum levels if Alder Lake drops below 1170 feet. Since, during critical water conditions, Alder Lake is likely to be below 1170 feet, Article 404 requirements are in effect. Because generation is not increased above planned levels, Alder Lake is not drafted below planned levels.

The Block Portion of the New BPA Contract As the name implies, the BPA Block contract consists of a predefined block of power. The amount of energy does vary from month to month. However, within the month, energy will be delivered in a flat (same amount 24x7) schedule. The BPA Block contract will deliver 225 MW each hour during January 2012.

The Slice Portion of the New BPA Contract The BPA Slice contract represents a share or "slice" of the Federal System. Tacoma Power's Slice contract will be equivalent to a share of about 3% of the Federal System. It is difficult to precisely define the amount of energy and capacity that will be available from the Slice contract during a future cold snap. However, BPA provided the hourly Federal System generation for a 4-year period of 2003-2006. The highest 72-hour, winter generation was selected. This period occurred in January 2006. The 72-hour period served as a proxy for the energy and capacity that Tacoma Power would expect from BPA during a cold snap. Tacoma Power's Slice share was 451 MW during both the 1-hour and 18-hour periods and 364 MW over the entire 72-hour period.

Other Resources Tacoma Power's Wynoochee resource was assumed to operate normally. Grand Coulee Project Hydroelectric Authority is offline during the winter season. All other resources were assumed to operate at their average level for the month of January.

# Appendix H

# Review of Potential Resources

*Tacoma Power has evaluated multiple potential portfolio resource technologies. This appendix discusses the salient features of these technologies. The information is arranged according to conventional technologies, conventional renewable technologies and un-conventional alternative resources. Conventional technologies include Hydro generation as well as usual thermal resources like Natural Gas and Coal. Conventional renewable resources include wind, solar, and geothermal technologies. Un-conventional alternative resources fuel cells and other emerging generation technologies. Each technology is identified as being a baseload, intermediate or peaking resource.*[29] *In addition, basic technology characteristics of resources are discussed as well as cost, availability, and environmental attributes.*

## Conventional Generation Technologies

### *Natural Gas Combustion Turbines*

<u>Technology</u>*:* 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.

<u>Resource Characteristics</u>*:* SCCTs typically range in size from 10 to 150 MW. CCCTs are usually larger up to 500 MW. Combined-cycle combustion turbines have the lowest levelized energy cost for NG resources at $95 to $120/MWh and a levelized capacity cost of $92 per kilowatt-year.

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 $SO_2$. These

[29] Baseload power resources (hydro plants) run continuously except during repair or maintenance. They typically have low variable operation and maintenance costs compared to other resources. Intermediate resources (combined cycle gas fired turbines) are used in conjunction with baseload resources but cost more and are less-efficient than baseload plants. Peaking plants are fast response resources used to provide power during peak load periods, e.g., simple gas turbine generator.

facilities have an industrial look and need to be sited near a major natural gas transmission line and the operator must secure natural gas supply contracts and transmission rights.

Availability and Outlook: Both CCCTs and SCCTs are readily available. They can be permitted and constructed relatively quickly.

### *Hydroelectric*

Hydroelectric power generation is by far the largest source of renewable energy in the Pacific Northwest. However, it is not an "eligible" renewable under the Energy Independence Act.

There are four principle types of hydroelectric projects: impoundment, run-of-river, irrigation and efficiency upgrade. 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. Opportunities to construct new impoundment or run-of-river facilities are virtually non-existent due to environmental regulations and an absence of good sites. New hydroelectric facilities are more likely on irrigation canals. Electricity from these types of facilities is usually seasonal (mostly summer) and is considered of secondary importance relative to the delivery of irrigation water.

A fourth type of hydroelectric resource is efficiency upgrades. This resource adds to, refurbishes, or alters an existing hydroelectric facility to increase generation 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 such as replacing turbines or adding a new powerhouse.

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 when the value of the electricity produced is high. Pump storage can also be used to store energy that would otherwise be lost. Such as when electrical supply exceeds load so that available hydro or wind energy is allowed to bi-pass the generating units. The energy returned from pump storage is typically about 75 percent of the energy input.

Technology: The conventional hydroelectric facility uses a dam to restrict the flow of water through a river or stream in order to store the kinetic energy of that water. Kinetic energy is then converted to electric energy through a controlled release of the water through a turbine generator.

The 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.

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. However, there may be opportunities for new relatively small scale projects of less than 10 MW. Some of these may be extensions of or additions to, existing hydroelectric facilities while others could be new generation added to existing irrigation and flood control dams.

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

In addition to building new hydroelectric facilities, improvements to hydroelectric facilities (characterized as incremental hydroelectric) 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 source. Capability also exists for its use as an intermediate source or peaking plant. Capacity can become an issue during dry years when water conditions limit river flow. When sufficient water exists, hydro facilities are normally available for generation except during 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 temperature levels and construction of fish ladders to allow safe passage for fish.

Pumped storage has the ability to provide firm capacity and peak energy. Additionally, it can provide balancing reserves using its variable generation ability and its ability to create 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 additional hydro power is likely to become available from improvements to existing facilities (Incremental Hydro). Generally, upgrades to hydroelectric plants will not require upgrades to existing transmission facilities. The added power generated from these types of improvements should qualify 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 to meet power peaks by using turbine capacity on existing hydro projects. However, the growing prevalence of wind power and the need to integrate it could create opportunities for pump storage projects. There are estimated to be many potential development sites in the region, representing thousands of megawatts of potential availability. Pumped storage costs vary significantly from project-to-project and this resource has a long development lead time of up to ten years.

## *Fuel Cells*

Technology: 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 a relatively new commercial technology with relative high cost and uncertain reliability. Fuel cells use is presently limited to off-grid and back-up power applications.

Resource Characteristics: 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 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. Fuel cells produce no harmful emissions.

Availability and Outlook: The environmental impacts from fuel cells are largely dependent upon the process used to obtain the fuel source, typically hydrogen. The use of a fossil fuel-driven process will contribute to the release of air emissions, typically NOx, $SO_2$, $CO_2$, particulates, mercury, and $CH_4$. The use of nuclear reactors to extract hydrogen will produce radioactive waste that poses environmental threats if not properly handled and stored.

Unless the fuel source is processed using a “clean” method, fuel cells are not considered a renewable resource and do **not** qualify as such under the Energy Independence Act definitions.

## *Coal Generation*

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 large facilities that require significant amounts of land. 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 available. As a result, there is little likelihood that this resource technology will be available to Tacoma Power during the planning period of this IRP.

## Conventional Renewable Technologies

### *Wind*

Wind power is the conversion of wind energy into electricity by wind turbines. It is also a fast growing source of “eligible” renewable energy. The Pacific Northwest currently has more than 3,000 MWs of installed nameplate wind capacity operating or under construction, over 2,600 of which is in the BPA balancing authority area. In addition, some Northwest utilities, including BPA, purchase wind power from Wyoming, which has almost 1,000 MWs of installed 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; that is, on average they to produce 30 percent of the energy as they would if they operated at their peak output 100 percent of the time. For capacity planning purposes, the NWPCC’s Sixth Power Plan assigns a 5 percent capacity value to wind. However, recent studies correlating wind speed and load patterns show that the wind in the Columbia Basin tends to die down and remain calm during sustained peak-load periods such as hot spells and cold snaps. BPA is working with the NWPCC to determine if regional wind power can be assigned a peak capacity value with the certainty necessary for resource planning.

According to NWPCC estimates, wind power costs range from $88 to $108/MWh including transmission to the nearest wholesale delivery point. 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.

<u>Technology</u>: The typical wind generation facility, or wind farm, consists of an array of wind turbines that can range in size between one and three megawatts each. As the technology has advanced, wind turbines have become taller and larger which improves there capacity and efficiency.

In addition to land based wind generation, developers are considering offshore wind generation. Offshore wind generation would be more efficient because offshore turbines are expected to be 3-5 MW compared to the 1-3 MW size for land-based wind turbines.

Resource Characteristics: Wind power uses no fuel and releases no greenhouse gasses. The big drawback to wind generation is that it is expensive relative to conventional resources; it is highly variable and provides little capacity value. Utilities using wind generation must have other sources of electricity available ramp up and down in response to changes in wind speed – wind turbines have been known to cycle from no generation to full generation back to no generation within a single hour. In some cases, this variability can be met with hydroelectric reserves. In other cases, the reserve energy requirement must be met using a fossil fuel source such as a SCCT. This variability also limits the amount that wind resources can be relied upon to help meet system peak loads.

Availability and Outlook: The majority of wind generation currently available in the Pacific Northwest is being provided to regional utilities through long-term power purchase agreements. Because wind generation continues to be an attractive renewable resource for the area's utilities, significant construction is underway and/or planned.

The biggest obstacle to building wind is integrating this variable resource in the transmission grid for reliability and load balancing purposes. For this reason, many planned wind farms will be scaled back over the next three-to-five years.

Another barrier to wind generation is the fact that the best wind generation sites lie primarily in Central Washington and Oregon, far from the urban areas that need the power. Making this situation more difficult is the fact that serious constraints either exist or are forecast in the near future for transmitting wind power over the Cascades into Western Washington. The result is that new and/or upgraded transmission lines will need to be built. The cost of this new transmission is estimated to be in the billions of dollars.

One final obstacle comes from nearby residents opposing the construction of wind farms in proximity to their homes. A strong "Not in My Back Yard" reaction is common when wind turbines obstruct coveted views, are perceived as a threat to flying animals (e.g., birds and bats), or are seen to blight sensitive wilderness.

Even with these obstacles, wind generation remains the most viable renewable source for meeting I-937 requirements in the foreseeable future. The NWPCC predicts an additional 2,400 MW of wind generation will come on-line in the Pacific Northwest over the next three years. They also predict that up to a total of 6,000 MW of cost-effective wind generation is possible.

On April 28, 2010 the US Department of Interior granted the first Federal permit to build an off-shore wind farm in the US. The project, located in Cape Cod, Massachusetts, will eventually produce 468 megawatts of electricity, an amount that could power about

150,000 homes. Off-shore wind generation development is gaining interest in other states as well like Delaware, Massachusetts, New Jersey, North Carolina, Ohio, Rhode Island and Texas. Offshore wind generation, however, remains too expensive as a generation source in the Pacific Northwest for the foreseeable future. Preliminary estimates by the Ocean Renewable Energy Group in Canada put offshore wind generated electricity at over $250/MWh.

### *Solar*

Solar power is a viable but expensive renewable energy source. 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.

While large scale solar generation facilities have been built, solar power is more commonly thought of as a distributed generation source. This is because it can easily and unobtrusively be installed on the roofs of commercial buildings and personal residences. To a lesser extent, solar power is also used to replace or augment an electric or gas fired hot water heater.

<u>Technology</u>: The best known type of solar power 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 other 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 building roofs and the power generated can be used on-site, reducing load from the electrical distribution system. Designs now allow solar panels to blend into the existing roofing, making them more attractive. The ability to be installed anywhere makes photovoltaic generation a good distributed generation choice.

With thermal generation, solar radiation is 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 first large scale design for a commercial thermal power plant was Solar One in California. It used an array of mirrors that focused solar radiation on a specific area of a central tower. The focal point was a black receiver that contained liquid sodium. This liquid sodium was used to create steam that could run a turbine. The design proved to be efficient and the Solar One model was upgraded in the 1990s.

Another thermal technology uses an array of parabolic troughs whose focal points are tubes containing a thermal oil. This design has proven to be more cost effective than the tower used in Solar One. Like the liquid sodium, the thermal oil is used to create steam that can be used to run a turbine generator.

Both thermal generation and photovoltaic generation have advantages and disadvantages. Thermal generation is more cost effective, but it requires large areas of land in locations that receive significant amounts of sunlight year round. Photovoltaic generation is around 50 percent more expensive per kW of power generated than thermal solar, but it can more easily be incorporated into a distributed generation strategy by installing the equipment on rooftops.

Resource Characteristics: Solar power's primary benefit is that it is a 100% renewable source. However, it is highly dependent on the weather and, in the case of photovoltaic generation, is limited to daylight hours for power production. Thermal solar generation stores solar thermal 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 sources.

Availability and Outlook: Solar power is best used as a distributed resource. While areas of central Washington, Oregon and Southern Idaho have climates appropriate 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.

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 cost for a 20 MW plant would be approximately $300 per MWh. Costs are expected to decline over time. Financial incentives are not included in the levelized cost estimate. Public support for this technology could potentially make development feasible, though the Northwest is not optimal locale for the highest power production from solar plants. While the development potential for this technology is abundant, its cost disadvantage limits its attractiveness as a power source.

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 require a major transmission investment to bring Southwest power to serve Northwest loads. 600 aMW 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 cost of energy from this resource is estimated at more than $200/MWh, about a third of which would be transmission costs.

## *Biomass*

Biomass generation qualifies as a renewable energy source under the Energy Independence Act for that portion of the 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 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 also from the residue 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.

Also, biomass can 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.

Still another use of biomass uses is creating ethanol via a fermentation process. The ethanol can then be used as a fuel additive or in rare cases directly combusted to generate electricity.

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. Recent additions include a 55 MW pulp liquor and biomass generating plant at the Simpson paper mill in Tacoma, WA, and a 1.5 MW plant at a waste water treatment plant in Portland, OR. 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.

Most of the Northwest potential lies in woody residue biomass, with about 290 MWs of installed capacity today and a development potential of about 665 aMW (requiring about 830 MW of installed capacity). This potential includes emerging sources of additional woody residue biofuel from forest thinning and more aggressive management of commercial timber lands.

Other biofuels are expected to be available in smaller quantities and at varied costs depending on location and whether each project also fills a dual purpose, such as cogeneration or other use of waste heat or by-products. For example, biogas from wastewater treatment in the Northwest currently provides 22 MW of power capacity in 19 projects.

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 one anaerobic digester facility in operation. It supplies the 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.

Resource Characteristics: Biomass plants have 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 be economical only in areas where there is no cost involved in transporting fuel. Anaerobic digesters are ideal facilities to locate at the site 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 distributed generation benefits, improving electric distribution system security.

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. There is also a plan to further expand the generation capabilities at the City of Tacoma central municipal waste treatment plant.

### *Geothermal*

Geothermal resources qualify as a renewable resource under the Energy Independence Act. Geothermal power plants produce electricity by converting the energy of below-ground thermal reservoirs, such as those that create hot springs and geysers, into steam to drive a steam turbine generator. Geothermal generation is notable among non-hydro renewable resources in that it produces a steady output that does not require balancing reserves. The 15.8 MW Raft River project in Idaho is the first commercial geothermal power plant in the Northwest. It came on line in 2008. Several geothermal projects are under development in Oregon, including Neal Hot Springs, Newberry Crater, Linskey Farms and Crump Geysers. Most integrated resource plans of major Northwest utilities include the development of geothermal resources. 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 nearly $100 per MWh.

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 give dry steam turbines a very short useful life.

The third method, binary-cycle, is the newest technology and can use water temperatures less than 300° F. This method takes hot water from the geothermal source 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.

Resource Characteristics: Geothermal energy has the potential to become one of the largest renewable resources in the Pacific Northwest. According to United States Geological Service estimates, identified resource sites may contain 22,000 MW of potential power and unidentified sites may contain an additional 100,000 MW of potential power. The Western Governors' Association Geothermal Task Force projected that 13,000 MW of geothermal energy could be developed on specific sites within a reasonable timeframe. Of this 13,000 MW, 5,600 MW is considered to be viable for development by 2015 and 1,300 MW is in the Pacific Northwest. This represents only the known potential resources. Unknown resources could greatly increase this number.

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

Drawbacks of geothermal power include high upfront capital costs and site location. Most Pacific Northwest identified sites are in rural locations far from existing transmission lines. Therefore significant amounts of capital would be needed to build the transmission lines necessary to connect the plant to the grid. These costs are comparable to those expected to connect future wind resources.

Availability and Outlook: The most likely locations for new geothermal development are in southern Idaho and eastern Oregon. Few sites have been proposed for development, but this will likely change with both Oregon and Washington having aggressive, mandated renewable portfolio standards. Geothermal plants are currently located in five states (California, Alaska, Hawaii, Nevada and Utah) and have a total of 2,830 MW of installed capacity. The Geothermal Energy Association estimates that nationwide, energy from geothermal sources could provide 20,000 MW of electricity by 2025.

## Un-Conventional Renewable and Non-Renewable Technologies

***Ocean Energy***

There are several technologies in development which will convert energy from the oceans into electricity. 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. Both 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 would provide only a limited contribution to system capacity. In addition, ocean energy is not yet commercially available, and many questions persist regarding its cost and technological reliability.

Technology: 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.

Resource Characteristics: Of the emerging renewable technologies, in-stream tidal power offers a benefit that few other renewable sources can: It is a 100% predictable renewable energy source. Once the tidal currents have been measured, the amount of electricity available can be predicted hundreds of 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 likely 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, since the size of the waves is totally weather dependent, predicting the amount of available electricity may be difficult.

Availability and Outlook: There are no ocean energy resources currently available in the Pacific Northwest. However, there are numerous local feasibility studies in progress. First and foremost is Tacoma Power's own effort to research tidal stream generation opportunities in the Tacoma Narrows.[30] This recent study concluded that the cost of tidal power is currently not competitive with other resource opportunities. Snohomish County PUD and Clean Current of British Columbia are also conducting tidal studies.

There are several major wave energy projects underway. Finevera LTD's Makah Bay Project on the Olympic peninsula of Washington state is currently being developed using the new limited FERC licensing process. There are also several projects being studied off the coast of Oregon. Additional wave energy projects will likely begin in the next few years.

### *Bloom Energy*

Since 2008 several intriguing electric supply options have emerged which promise to challenge the basic orthodoxy about efficient generation. One of these technologies, "Bloom Energy" was introduced with much media fanfare.

Technology: The Bloom Energy technology is a variant of fuel cell 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 could changes direction and uses the stored gases to make electricity.

Resource Characteristics: 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 intermittency characteristic of wind or solar. The current levelized cost is about 12.8 cents per kWh. Bloom Energy is not currently an eligible renewable resource under the Energy Independence Act.

Availability and Outlook: 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. It is unclear what the payback would be without such subsidies.

[30] Tacoma Narrows Tidal Power Feasibility Study, available on the Tacoma Power web site: http://www.tacomapower.com.

## *Portable Nuclear Reactors*

In early 2010, Microsoft Founder Bill Gates initiated a discussion about the potential to use repackage used uranium. The joint venture, Gates' TerraPower and Japan's Toshiba could help spur the development of a traveling-wave reactor that runs on depleted uranium, a waste byproduct of the enrichment process. TerraPower asserts that such a reactor could supply the world's energy needs for thousands of years.

Technology: The basic idea is to create a reactor that needs only a small amount of enriched uranium to get started, and then uses depleted uranium (spent fuel) or natural, unenriched uranium to produce the nuclear-fission reactions necessary to generate power for 60 years or more without refueling. The design is called a traveling wave reactor, and the idea dates back to the early 1990s. If proven to work, this technology could produce cheap, plentiful power, more efficient nuclear waste disposal, and reduce the risk of nuclear proliferation.

Resource Characteristics: Unlike conventional reactors that take in new fuel and expel high-level waste about every 18 months, a traveling-wave reactor can, in principle, be fueled once, sealed and run without refueling for 60 years or more. It would also generate much less waste than traditional reactor designs.

Availability and Outlook: The nuclear reactor envisioned by TerraPower hasn't been built. There is no precedent for TerraPower's particular design, and the project faces some major challenges—technical, business, and regulatory. So far the physics has only been tested in computer simulations.

## *How Much do Alternative Generation Technologies Cost?*

Tables 1 & 2 are from the NWPCC. They provide the Council's most recent (April 2010) levelized cost estimates for hydro power and a wide range of alternative generation technologies. The costs are projected over the next ten years. Table F1 looks at levelized costs for the first five years (2010 -2014) and Table F2 projects what these resources will cost from 2015- 2019. Over the next five years conventional renewables like wind, biomass (woody residue) and solar will cost $100 or more on an MWh level. These costs reflect bus bar, integration, transmission and $CO_2$ components. PV Solar is projected to cost nearly $300 per MWh. During the last five years of the projection, renewable costs decline but are still cost prohibitive compared with new hydro.

The information in Figures G1 and G2 strongly suggests that an aggressive deployment of renewable generation in the Northwest is highly unlikely, given the cost structure for the respective resource. Combined with the intermittent feature of 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 to a rate increase for electric power. The findings for renewable levelized cost warrant

Tacoma Power to refrain from adopting such resources and continue the current strategy of hydro electric generation.

**Figures G1**

**Projected Levelized Energy Costs, Resource Available 2010 - 2014**

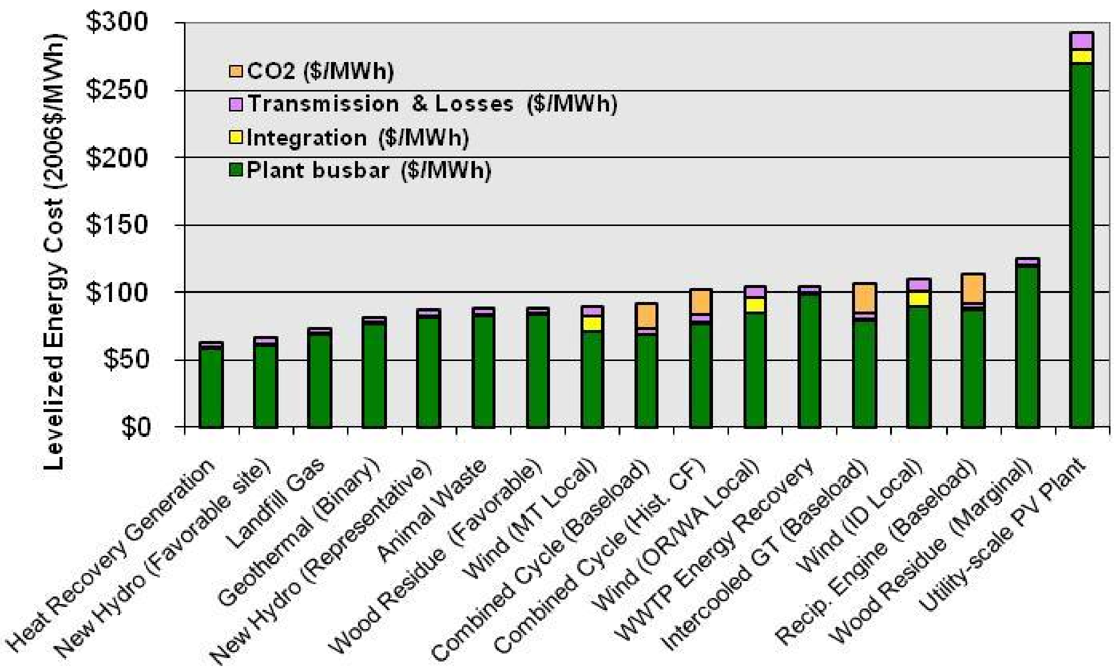
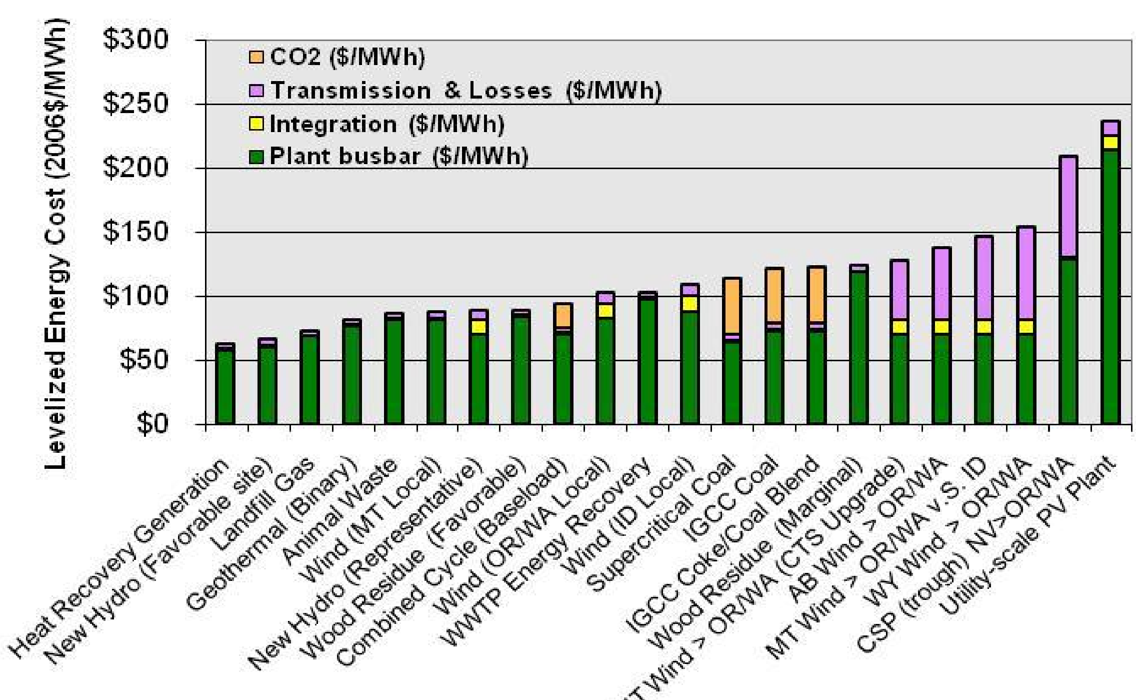



**Figure G2**

**Projected Levelized Energy Costs, Resource Available 2015 - 2019**



# Appendix I

# Energy Independence Act: Sources of Renewable Energy

The renewable resource portion of the Energy Independence Act (a.k.a., I-937) becomes effective in 2012. The first compliance period runs from 2012 through 2015. Tacoma Power expects to need about 155,000 renewable MWhs or RECs during this compliance period. The utility presently has acquired about 130,000 MWhs/RECs for 2012 and nearly 159,000 MWHs/RECs for 2013 through 2015. The utility's renewable energy/RECs come from three source categories:

1. Incremental hydro;
2. RECs from BPA; and,
3. RECs from a contract with Iberdrola

## Incremental Hydro

Department of Commerce[31] (DOC) regulations implementing the Energy Independence Act define incremental hydro as:

> [The] Incremental electricity produced as a result of efficiency improvements completed after March 31, 1999, to a hydroelectric generation project owned by one or more qualifying utilities… and located in the Pacific Northwest … where the additional electricity generated in either case is not a result of new water diversions or impoundments WAC 194-37-040 (13)(b)

Improvements made to three Tacoma Power hydroelectric projects qualify as renewable under this definition.

### *The LaGrande dam*

The bulk of the power from LaGrande dam is produced by four 6 MW and one 40 MW Francis turbine/generator units for a total nameplate rating of 64 MW. In addition, Tacoma Power has a 437-kilowatt (kW) turbine/generator unit installed at the base of LaGrande dam known as LaGrande Unit 6. This unit came about as a result of a new operating license issued by FERC in 1997. Article 403 of that license requires Tacoma Power to maintain a minimum in-stream flow of 30 cubic-foot-per second (cfs) in the 1.7-mile-long LaGrande bypassed reach. In 2001, Tacoma Power applied for and received permission from FERC for a license amendment to install a turbine/generator unit to produce electricity from this flow

[31] Formerly the Department of Community, Trade and Economic Development.

release. Since it came into service in 2003, electrical output from LaGrande Unit 6 has annually averaged about 3,280 MWhs. (see Table I1)

**Table I1**
**Annual Output of LaGrande Unit #6**

| 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | **Average** |
|---|---|---|---|---|---|---|---|
| 2,181 | 3,666 | 3,531 | 2,742 | 3,004 | 3,305 | 3,432 | **3,280** |

This project meets all the requirements to qualify as incremental hydro under DOC regulations. It was completed after March 31, 1999. It is located in the Pacific Northwest. And, it did not result in a new water diversion or impoundment.

### *The Cushman No. 2 hydro-electric plant*

Tacoma Power was recently was granted a new multi-year operating license for the Cushman project. The previous license expired in 1974, and since that time Tacoma Power operated the project under repeating annual licenses. The new license resolved longstanding issues between Tacoma Power and the Skokomish Tribe and had near unanimous support. To create a fish-friendly environment, the license required Tacoma Power to annually release 160,000 acre-feet of water from the base of the dam. (See Figure I1) This water release began in March, 2008. The actual amount of water released at any given time is determined by a fish committee but must fall within a range of 100 to 300 cubic feet per second (cfs).

**Figure I1**
**Water released from Cushman No.2 Hydroelectric plant**

Tacoma Power has developed a plan to construct a new powerhouse to calm the outflow and capture the energy in this minimum flow requirement. [32] The new powerhouse will be co-constructed with a new fish collection and by-pass system. The powerhouse project will include twin 1.8 MW capacity Francis turbine/generator units. Engineering studies place the overall annual output of this project at 23,500 MWh (2.7 aMW). However, similar to the LaGrande project, Tacoma Power will directly measure the amount of power actually produced by the new powerhouse at Cushman No. 2. The new powerhouse is projected to come online at the end of 2012.

The new powerhouse at Cushman No.2 meets all DOC regulatory requirements to qualify as an eligible incremental hydro resource. It will be completed after March 31, 1999. It is located in the Pacific Northwest, and it will not create a new water diversion or impoundment. Finally, Tacoma Power intends to use sufficient apprenticeship labor on this project to qualify for the multiplier credit.[33]

### *The Mossyrock dam*

In 2005, the utility determined that a complete overhaul of the generating units at the Mossyrock dam was in order including: including replacing turbines, wicket gates, generator frame core and coils, generator step up transformers, exciters, governors refurbishing the rotor poles along with station service upgrades and a new plant control system. Andritz Hydro was contracted to perform the overhaul. Refurbishment work on units 51and 52 began in 2008 and 2010, respectively and the entire upgrade is expected to be completed by January 2012.

According to DOC regulations, utilities can document through engineering studies "The increase in annual megawatt-hours of generation attributable to the qualified incremental hydropower efficiency improvements." (WAC 194-37-130 (3)) Tacoma Power has assessed the increase in power generation and efficiency that has and will result from overhaul of Mossyrock turbine/generator units 51 and 52. The performance improvements fall into three categories: reduced wicket gate leakage; more efficient turbine power conversion; and, more efficient project transformer. All together these improvements are expected to provide Tacoma Power with 41,530 MWhs (4.74 aMW) of eligible renewable electricity.

<u>Wicket Gate Leakage</u>. Historical 1-minute data from 2001 through 2003 was used to build leakage curves for the existing unit 51 & 52 turbines with head variation. This data was selected because the previous work had shown it to have relatively consistent flow meter

[32] On August 12, 2010, the Public Utility Board approved resolution U-10409 to award a contract to Andritz Hydro Corp. to purchase two turbine-generators and accessory equipment for the North Fork Skokomish Powerhouse to be construction at Cushman No. 2 Dam.

[33] Through the use of apprenticeship labor, the incremental hydro output of the new Cushman powerhouse will be counted at 120 percent of its actual value.

performance. Additional data from 2008 was also included as a data cross check. The data was sorted by increments of the lake level or net head and graphically resolved.

The GE contract guarantee is for leakage less than 5 CFS each for the two turbines. Comparison of the historical leakage and operating hours to a rate of 5 CFS at the rated head of 310 FT gave a total annual energy improvement of 15,260 MWh.

Turbine Generator Improvement. The analysis of Mossyrock power plant started with the documentation of existing plant performance. These performance values form the base for comparison of the projected upgrades. Many years of operational data were used to develop Mossyrock performance curves and tables. In addition to the turbine generator performance, operation profiles were also extracted.

A "Mossyrock Unit Upgrade Study" was conducted by Acres International. Acres consultants considered and analyzed a number of upgrade options using their "Auto Vista" and "HydroVantage" computerized modeling programs. Acres developed the Auto Vista computer model to optimize the operations of hydro-electric projects. The HydroVantage computer model is an engineering decision and risk analysis program for optimizing interventions such as replacement and rehabilitation of aging equipment.

The Acres analysis focuses on the operational improvements and maximizing the potential of the selected turbine generators. Optimizing the use of the plant equipment to maximize the value of the plant's stream flow was performed with the HydroVantage program. The Acres report calculated the total average annual improvement of upgrading the Mossyrock turbine/generation units with their AutoVista program. The projected increase was 26,000 MWh per year. The rebuild contract with General Electric was tailored to the findings and recommendations of the Acres study.

The GE contract and guarantees are based in the results of the turbine model testing performed in Toronto, Ontario, CA. The GE model testing has been completed and accepted by Tacoma Power. To check to the validity of the Acres results, Tacoma Power compared those results to the performance curves of the GE Turbine-Generator. This comparison required scaling of the GE model prototype to match the full size turbine performance. GE provided this scaling for unit No. 51 but not for unit No. 52 – Tacoma Power scaled-up the unit No. 52 turbine model curve in-house. The utility found a good correlation between the scaled-up GE performance curves and the Acres recommendation. Generally, the scaled up GE turbine provides better performance than the Acres recommendation. The one exception is the low end of the new unit No. 52; an area is outside the range of the GE guarantee.

Transformer Efficiency Improvement. As part of the Mossyrock rebuild, a new power transformer was installed that is more efficient than the transformer previously used. As a result of this efficiency improvement the Mossyrock plant is expected to annually deliver an additional 270 MWh of electricity to the busbar.

# Renewable Energy Credits

## *RECs from BPA*

The BPA owns several wind generation projects which produce about 65 aMW of renewable energy. According to Tacoma Power's new BPA contract, the utility is entitled to a portion of the environmental attributes associated with that wind power. More specifically, from October 2011, through September 2016, BPA's REC inventory will be offered at market prices to entities with existing contract rights to BPA's RECs. (About 80 percent of BPA's REC inventory is contractually committed.) After Sept 2016, BPA's entire REC's inventory will be provided to BPA's slice contract customers.

Tacoma Power's projection of the yearly number of RECs it will receive from BPA:

2012-2016: 6,605 MWhs (=65 aMW * 8760 hours * 20% uncommitted RECs * 5.8% TP's share of BPA's load)

2017-2019: 33.025 MWhs (=65 aMW * 8760 hours * 5.8% TP's share of BPA's load)

<u>BPA contract language that deals with renewable energy.</u>

**RENEWABLE ENERGY CERTIFICATES AND CARBON ATTRIBUTES**

**1. DEFINITIONS**

1.1 "Carbon Credit" means an Environmental Attribute consisting of GHG emission credits, certificates, or similar instruments.

1.2 "Environmental Attributes" means the current or future credits, benefits, emission reductions, offsets and allowances attributable to the generation of energy from a resource. Environmental Attributes do not include the tax credits associated with such resource. One megawatt-hour of energy generation from a resource is associated with one megawatt-hour of Environmental Attributes.

1.3 "Environmentally Preferred Power RECS" or "EPP RECs" means the portion of BPAs Tier 1 RECs that is equal to an amount of up to 130 percent of the annual average of equivalent environmentally preferred power (EPP) contracted for as of October 1, 2009, for FYs 2010 and 2011 under Subscription power sales contracts containing rights to Environmental Attributes through FY 2016, as determined by BPA to be necessary to administer such rights.

1.4 "Renewable Energy Certificates" or "RECs" means the certificates, documentation, or other evidence that demonstrates, in the tracking system selected under section 5 of this exhibit, the ownership of Environmental Attributes.

1.5 "Tier 1 RECs" means the RECs composed of a blend, by fuel source, based on' annual generation of the resources listed in or pursuant to section 2 of this exhibit.

1.6 "Tier 2 RECs" means the RECs associated with generation of the resources whose costs are allocated to a given Tier 2 Cost Pool in accordance with the TRM.

**2. BPA'S TIER 1 REC INVENTORY**

BPA's Tier 1 REC inventory shall include all RECs that BPA has determined are associated with resources whose output is used to establish Tier 1 System Capability, as Tier 1 System Capability is defined in the TRM. The disposition of any Carbon Credits that BPA determines are associated with resources listed in, or in accordance with, this section 2 shall be as described in section 3 of this exhibit. The disposition of any Carbon Credits that BPA determines are associated with resources not listed in, or in accordance with, this section 2 shall be consistent with section 7 of this exhibit. As of the Effective Date, BPA has determined that the following resources have RECs associated with them that will be included in the Tier 1 REC inventory: Foote Creek I, Foote Creek II, Stateline, Condon, Klondike I, Klondike III, and Ashland Solar. BPA shall maintain this list on a publicly accessible BPA website and shall periodically update this list to include any then current resources that BPA has determined have* Tier 1 RECs associated with them. BPA shall calculate its inventory of Tier 1 RECs annually and after the fact based on energy generated by listed resources during the previous calendar year.

3. **TACOMA POWER'S SHARE OF TIER 1 RECS**

Beginning April 15, 2012, and by April 15 every year thereafter over the term of this Agreement, BPA shall:

(1) transfer to Tacoma Power, or manage in accordance with section 5 of this exhibit, at no additional charge or premium beyond Tacoma Power's payment of the otherwise applicable Tier 1 Rate, a pro rata share of Tier 1 RECs based on Tacoma Power's RHWM divided by the total RHWMs of all holders of CHWM Contracts; and

(2) for transferred RECs, provide Tacoma Power with a letter assigning title of such Tier 1 RECs to Tacoma Power.

The amount of Tier 1 RECs available to BPA to transfer or manage shall be subject to available Tier 1 REC inventory, excluding amounts of Tier 1 REC inventory used to provide EPP RECs.

**4. TIER 2 RECS**

If Tacoma Power chooses to purchase Firm Requirements Power at a Tier 2 Rate, and there are RECs which BPA has determined are associated with the resources whose costs are allocated to the Tier 2 Cost Pool for such rate, then beginning April 15 of the year immediately following the first Fiscal Year in which Tacoma Power's Tier 2 purchase obligation commences, and by April 15 every year thereafter for the duration of Tacoma Power's Tier 2 purchase obligation, BPA shall, based on Tacoma Power's election pursuant to section 5 of this exhibit, transfer to or manage for Tacoma Power a pro rata share of applicable Tier 2 RECs generated during the previous calendar year. The pro rata share of Tier 2 RECs BPA transfers to. Tacoma Power shall be the ratio of Tacoma Power's amount of power purchased at the applicable Tier 2 Rate to the total amount of purchases under that Tier 2 Rate.

**5. TRANSFER, TRACING, AND MANAGEMENT OF RECS**

Subject to BPA's determination that the commercial renewable energy tracking system WREGIS is adequate as a tracking system, BPA shall transfer Tacoma Power's share of Tier 1 RECs, and Tier 2 RECs if applicable, to Tacoma Power via WREGIS or its successor. If, during the term of this Agreement, BPA determines in consultation with customers that WREGIS is not adequate as a tracking system, then BPA may change commercial tracking systems with one year advance notice to Tacoma Power. In such case, the Parties shall establish a comparable process for BPA to provide Tacoma Power its RECs.

Starting on July 15, 2011, and by July 15 prior to each Rate Period through the term of this Agreement, Tacoma Power shall notify BPA which one of the following three options it chooses for the transfer and management of Tacoma Power's share of Tier 1 RECs, and Tier 2 RECs if applicable, for each upcoming Rate Period:

## *Iberdrola REC Contract*

Tacoma Power's 2008 IRP concluded that "under all futures, the preferred REC strategy for 2012-2015 is to acquire RECs sooner rather than later." As a result of this conclusion, on February 14, 2008, Tacoma Power issued a request for proposals to acquire RECs. Tacoma Power subsequently entered into negotiations with respondent Iberdrola Renewables. The negotiations concluded with a draft contract for the environmental attributes associated with all the energy produced by two small wind farms located in Idaho. The contract was approved by the Board of Public Utilities on August 13, 2008, and signed on August 25, 2008. At the time of the contract signing, the wind farms were under development and therefore, historical production figures were unavailable. However, based on nanometer data, engineering calculations and an expected capacity factor of 21.6%, these plants were projected to annually produce 79,000 MWhs of electricity.

# Appendix J

# Estimating the Potential Impacts of Climate Change on Tacoma Power's Power Supplies

**– NOTE –**

**The following assessment is Tacoma Power's first attempt to consider the potential effects of climate change on utility operations. This assessment requires consideration of the potential changes to both Tacoma Power and BPA resources.**

**For Tacoma Power, this assessment requires disaggregating regional estimates of climate impacts to a local scale. While rapidly evolving, computer models to project regional and local scale impacts are in the initial stages of development. For BPA, it requires an understanding of how that agency might alter the amount and timing of power generation given the potential changes in river flows. Obviously, Tacoma Power has limited ability to predict future BPA behavior. Therefore, the following analysis should be taken as indicative of the direction of changes that Tacoma Power could face, but not as a projection of future circumstances.**

**Finally, most of this integrated resource plan focused on Tacoma Power's projected status in 2017-18. This section considers the affects of climate change in 2020-25. The slow nature of potential affects from climate change necessitated this model shift.**

This integrated resource plan's assessment of Tacoma Power's load-resource balance was based on modeling the performance of the utility's hydro-generation resources over 75 years of historic stream flows. This analytic approach assumes that operating year weather patterns vary around a stationary climate. In other words, it assumes no trends in weather patterns that change the volume or timing of stream flows.

This assumption runs counter to a general consensus among many scientists and governments that climate change is occurring. For example, in February of 2007, the Intergovernmental Panel on Climate Change (IPCC)[34] released their Fourth Assessment Report which stated, "[the] warming of the climate system is *unequivocal*… The observed climate trends of the 20th century *will continue*, with an expected warming of 0.2ºC per decade for the next two decades."[35] According to a June 2005 statement ("Global response

[34] The IPCC was established by the United Nations Environment Programme and the World Meteorological Organization.

[35] Alley R., and collaborators, 2007: Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva, Switzerland.

to climate change") released by the national science academies of the G8 nations, along with Brazil, China and India, "[t]he projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources…"

On a regional level, the U.S, Climate Change Science Program, Unified Synthesis Product's "Global Climate Change Impact in the United States," January 2009, 2nd Public Review Draft asserts that for the Northwest a warmer climate means changes in streamflows, increases in winter and early spring, and decreases in late spring, summer, and fall. More specifically:

> "Extreme high and low streamflows also are expected to change with warming. Increasing winter rainfall (as opposed to snowfall) is expected to lead to more winter flooding in relatively warm watersheds on the west side of the Cascades. The already low flows of late summer are projected to decrease further due to both earlier snowmelt and increased evaporation and water loss from vegetation. Projected decreases in summer precipitation would exacerbate these effects. Some sensitive watersheds are projected to experience both increased flood risk in winter and increased drought risk in summer due to warming."

As a hydro-based utility, such potential changes are of interest to Tacoma Power. From an integrated resource planning perspective, the principle issue is to assess how climate change might affect the timing and magnitude of electricity from Tacoma Power's owned and contracted resources. To begin to understand the possible implications of climate change, Tacoma Power undertook two preliminary analyses. For the first, the utility retained the consulting firm 3TIER to conduct a preliminary study of potential changes to Tacoma Power's resources on the west side of the Cascade mountains. More specifically, 3TIER assessed changes to the timing and volume of streamflow within the Cowlitz and North Fork Skokomish River basins (Cushman Project). The second analysis dealt with contracted resources east of the Cascades.

### *West-Side Analysis*

The hydrologic regimes of the Cowlitz and the North Fork Skokomish Rivers are closely linked with temperature and precipitation patterns in each basin. The temperature during winter storm events affects the elevation of each basin's snow line, which in turn determines the proportion of the winter precipitation that is stored as snow. Melting snow is the source of most of the streamflow during the summer whereas rainfall has a more immediate effect on streamflow. The North Fork of the Skokomish River is a rainfall dominated basin. While its hydrologic regime does have a small snow component, the snow is typically depleted by late July. The Cowlitz is a transitional basin with considerable amounts of rainfall and snowmelt. Given the relationship between temperature and the timing of streamflow runoff, there exists a potential for changes in each basin's hydrology caused by the increasing temperatures associated with climate change.

To perform a system assessment under altered climate conditions, one must distinguish the effects caused by an underlying climate trend versus the natural inter-annual variability that arises even in the absence of climate change. To distinguish these effects, 3TEIR used the regional scaled, spatially based Distributed Hydrology Soil Vegetation Model (DHSVM). The DHSVM model is physically based and was originally developed at the University of Washington for use in mountain watersheds.

The model accounts for the spatial distribution of soil moisture, snow cover, evapotranspiration,[36] surface flow and subsurface flow. Monthly historic meteorological records were adjusted to predict changes in average temperature and precipitation in 2025. The monthly adjustments were derived on a regional basis from the average of 10 General Circulation Models from the latest IPCC report based on an "A1B" emissions scenario. The 10 models were deemed to be the 'best' by the University of Washington's Climate Impacts Group.

In 1996 the IPCC approved a set of 40 climate change scenarios that cover a wide range of the main driving forces of future greenhouse gas and sulfur emissions. Each of these scenarios represents a specific quantification of one of four storylines each containing varying degrees of demographic change and social and economic development, technological change, resource use and pollution management. Of these 40 scenarios, three are commonly chosen for forcing General Circulation Models (GCMs): A2 (high emissions), A1B (medium emissions) and B1 (low emissions).

The DHSVM model predicts the extent and magnitude of the changes to each basin's hydrology that can be expected to occur under the A1B emissions scenario in 2025. 3TEIR projected the impacts of climate change in terms of changes to each basin's snowpack, flood frequency probabilities, seasonal reservoir refill volumes, and naturalized average monthly flows.

Temperature projections predict a warmer future, while changes in precipitation are less certain. Monthly average temperature changes ranged from +0.88ºC in November to +1.84ºC in August for the future period of 2010-2039 when compared to the baseline period of 1970-1999. Projected changes in precipitation ranged from 83% of the historical average in August and 108% of the historical average in November. (See Table J1) The average annual change in precipitation was 97% of the historical average, making it reasonable to plan for future precipitation to remain similar to the present.

The consistent changes projected for temperature and the changes projected for precipitation combine to result in a pattern of declining basin-wide average annual snowpack. Average annual snowpack in the Cowlitz River basin is projected to decrease 25%, where as in the North Fork Skokomish basin that number is a reduction of 39%.

[36] Evapotranspiration is the process by which water evaporates from surface soil and water transpires from plants and trees.

Changes in the snowpack will shift the timing of streamflows. While overall annual total flows are likely to remain similar to present values, the distribution of monthly flows are projected for both basins with increased flows November through February and decreased flows May through September.

**Table J1**
**2025 Projected Changes in Average Watershed Temperature and Precipitation**

| Month | Temperature Change (deg C) | Precipitation % change |
|---|---|---|
| January | 1.21 | 0 |
| February | 0.95 | 3 |
| March | 0.98 | 0 |
| April | 1.17 | 1 |
| May | 1.18 | -5 |
| June | 1.50 | -10 |
| July | 1.70 | -11 |
| August | 1.84 | -17 |
| September | 1.57 | -12 |
| October | 1.01 | 4 |
| November | 0.88 | 8 |
| December | 1.12 | 1 |

- For the Cowlitz River flow rates increase for November, December, January and February of 14%, 19%, 20% and 15% respectively when compared to the historical average. May, June, July and August projected flow rates decrease 16%, 24%, 29% and 27%, respectively, compared to the historical average.
- In the North Fork of the Skokomish, increases from November through February of 11%, 14%, 12% and 10% are respectively projected compared to the historic average. Conversely, flow rates in May, June, July and August decrease 18%, 27%, 32% and 30% as compared to their respective historic average.

This pattern is best characterized as a shift in the hydrograph of both basins, toward a more rain-fall dominated, single peaked hydrograph which could affect the volume of water available for reservoir refill in the spring and summer months.

Cowlitz River flows were predicted to shift from a double peak to being more rainfall dominated under the A1B 2025 climate change scenario. However, average annual flow was essentially unchanged. Increases in streamflow during the usual snow accumulation months of November through February effectively offset the decreased streamflow during the April through July snowmelt period (see Table J2). Average winter monthly flow rates increase by 13% (989 cfs) in November, 19% (1480 cfs) in December, 20% (1781 cfs) in January, 15% (1191 cfs) in February and 9% (656 cfs) in March. April flows remain essentially unchanged, however, spring and summer flow rates decline with May showing 16% (1466 cfs), June 24% (1975 cfs), July 29% (1397 cfs), August 27% (705 cfs) and September showing a decrease of 25% (509 cfs).

**Table J2**
**Cowlitz (Mayfield) Historic and Climate Change Projected Flows**

| Month | Historic Average Flow Rate (cfs) | A1B Average Flow Rate (cfs) | Change in Flow Rate (cfs) |
|---|---|---|---|
| October | 2833 | 2737 | -96 |
| November | 7202 | 8192 | 989 |
| December | 7686 | 9165 | 1480 |
| January | 8718 | 10500 | 1781 |
| February | 7734 | 8924 | 1191 |
| March | 7606 | 8262 | 656 |
| April | 7661 | 7628 | -33 |
| May | 9107 | 7640 | -1467 |
| June | 8145 | 6169 | -1975 |
| July | 4853 | 3456 | -1397 |
| August | 2595 | 1890 | -705 |
| September | 2066 | 1557 | -509 |

North Fork of the Skokomish River   Overall annual flows do not significantly change under the A1B 2025 climate scenario. However, the hydrologic regime was predicted to become more rain-dominated. The loss of some snow melt induced spring flows is projected to be offset by increased winter flows. (See Table J3) Winter month flow rates are predicted to increase: 11% (145 cfs) in November, 14% (201 cfs) in December, 12% (185 cfs) in January, 10% (110 cfs) in February and 7% (63 cfs) in March. April and October flow rates are essentially unchanged. Spring and summer flow rates decline: May -18% (152 cfs), June -27% (197 cfs), July -32% (130 cfs), August -30% (68 cfs) and September -21% (46 cfs).

**Table J3**
**North Fork Skokomish (Cushman No. 1) Historic and Climate Change Projected Flows**

| Month | Historic Average Flow Rate (cfs) | A1B Average Flow Rate (cfs) | Change in Flow Rate (cfs) |
|---|---|---|---|
| October | 618 | 619 | 1 |
| November | 1339 | 1484 | 145 |
| December | 1453 | 1654 | 201 |
| January | 1532 | 1717 | 185 |
| February | 1075 | 1185 | 110 |
| March | 937 | 1000 | 63 |
| April | 840 | 852 | 12 |
| May | 860 | 707 | -153 |
| June | 741 | 544 | -197 |
| July | 405 | 275 | -130 |
| August | 229 | 161 | -68 |
| September | 215 | 169 | -46 |

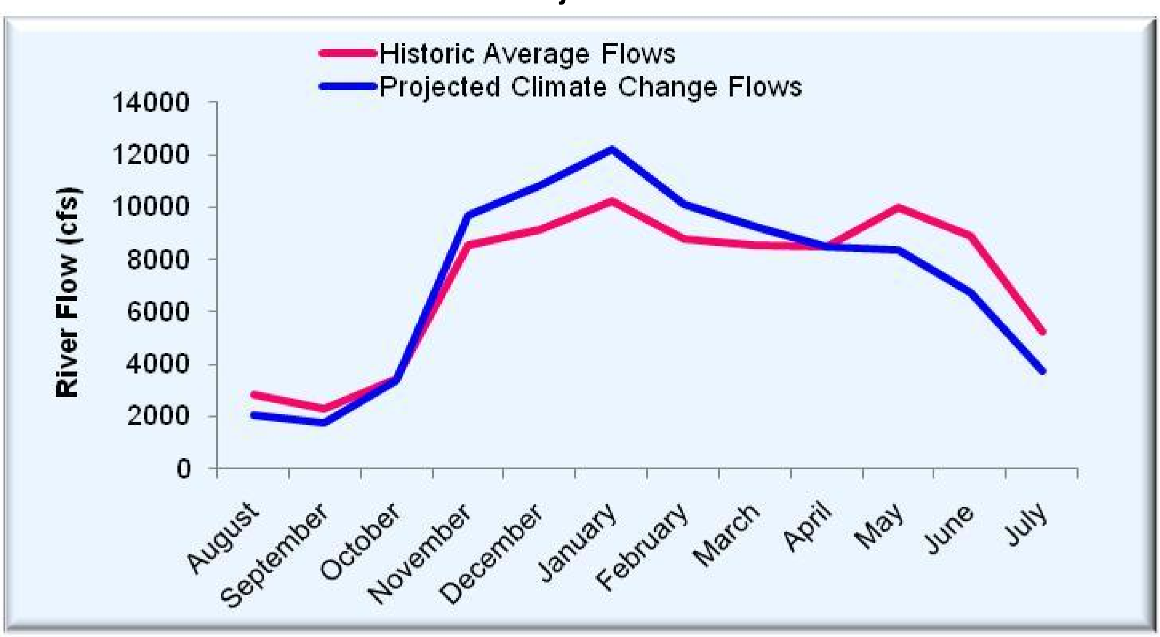
Flood frequency was not predicted to change in either basin under the A1B scenario in 2025. This is not to imply that there is no flood risk but rather that there is not a significant risk of substantial changes to the magnitude of flood events that can be attributed to climate change. Given that "event defining floods" in the historic record are typically associated with warm winter storms that bring rain to the majority of the basin, and that the majority of the impacts from climate change are associated with increased temperature, the absence of large projected changes in the magnitude of the flood events is understandable.

The Planning Implications associated with a more dominant rainfall response and a loss of spring and summer flows could require management changes. The changes indicate the need for water management planning activities for the Cowlitz and North Fork Skokomish Rivers designed to deal with increased flow volumes in the months of November thought February, and a decreased flow volumes in the months of May through July. (See Figure J1) However, given that Tacoma Power is winter peaking utility, this change in flow patterns could better align generation potential with retail load.

### *East-Side Analysis*

Given the importance of the BPA supply contract, it is important for Tacoma Power to consider the potential effects of climate change on power production in the Columbia River basin, and in turn, the electricity Tacoma Power receives through the BPA contract. Direct calculations are presently unavailable from BPA so the utility had to approach this question in a "round-about" fashion.

**Figure J1**
**Tacoma Power's Projected River Flow Rates**



One set of information the utility did have was estimated changes in Columbia River flows due to climate change from the Climate Impacts Group (CIG) at the University of Washington. Blue lines in Figure J2 represent historical average river inflows to Bonneville resources, the Red lines average inflows under A1B climate change conditions, and the pink area the distribution of potential inflows. This modeling effort indicates that inflows will peak earlier in the operating year and be lower in the summer.[37]

**BPA Use of CIG Findings**

BPA may decide to use some or all of the CIG results for its planning and the negotiations with Canada over the management of the Columbia. This information will allow BPA to analyze flows using actual head and generation data from each turbine. Such an analysis would greatly improve the accuracy and reliability of future Columbia basin climate change impact assessments. Therefore, the present analysis should be considered tentative at best.

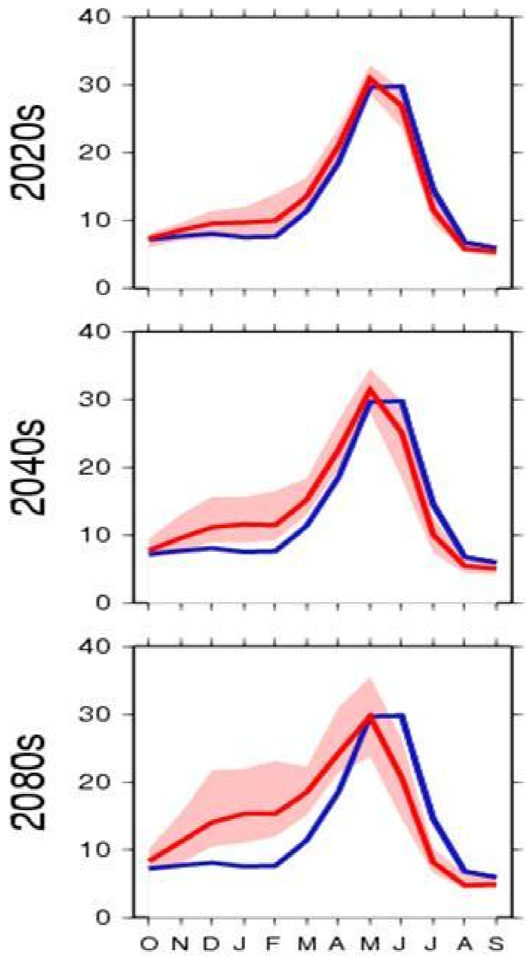
But, Tacoma purchases power not flows. And the utility lacks the engineering data on head and efficiency to directly calculate Columbia River power production. Other sets of data available to Tacoma Power were estimated historic Columbia River flows and BPA MWh generation. This information was used to develop a rough estimate of the potential revised power production associated with an A1B level of climate change.

The first step towards this rough estimate was to regress the historic flows against BPA MWh production data for past water years. Data availability limited this regression to 49 operating years, 1949-59 through 1997-98.[38] It is important to note that historical generation data was modified to conform to the current biological opinion. The regression produced BPA Generation estimates based on the estimated historic flows from each segment of the river. (See table J4).

[37] The Climate Impact Group's estimates the effect of climate change on a decade basis (e.g., 2020s or 2040s). This analysis assumed that the 2020s estimate was applicable to the 2024-25 operating year.

[38] Data gaps prevented the inclusion of all of the 75 operating years assessed in other parts of this plan.

**Figure I2**
**Projected Climate Change Inflows to Bonneville Generating Resources**




This regression, covering the new flows into and extractions from each part of the basin, had an R-squared of 0.89 which indicates a large share of past variance is explained. Nevertheless, the effect of river management on power production is important. The BPA strategically uses the storage capacity of Grand Coulee dam to manage flows for generation and flood control. Further the biological opinion can modify how much water is put through turbines and how much passes around the dams. The effect of this river management can be seen in the regression analysis error terms being positive or negative for months at a time. An analysis that fully accounted for all river management and engineering variables should produce randomly varying error terms.

A second regression (See Table J5) was used to address this issue. The regression included “Dummy” variables for months to account for the effect of flood control, of the biological opinion, and other month to month shifts in generation. The monthly dummies were regressed on the error term from the first equation. The second regression produces estimates of the mean MW shifts for each month which were not explained by the first regression. While this regression produced a relatively low R-squared value of 0.35, the fact that all monthly variables (except April) were statistically significant highlights the importance of accounting for river management activities.

**Table J4**
**SUMMARY OUTPUT- The Relationship Between Historic Flows and MWh**

| *Regression Statistics* | | |
|---|---|---|
| | Multiple R | 0.95 |
| | R Square | 0.89 |
| | Adjusted R Square | 0.89 |
| | Standard Error | 2957 |
| | Observations | 840 |

ANOVA

| | *Df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 6 | 61206720659 | 10201120110 | 1166 | 0.000 |
| Residual | 834 | 7293012532 | 8744619.343 | | |
| Total | 840 | 68499733191 | | | |

| *Independent = MW* | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Delta Grand Coulee | 0.012 | 0.002 | 5.432 | 0.000 |
| Delta Chief Joseph | 0.103 | 0.019 | 5.277 | 0.000 |
| Delta McNary | 0.043 | 0.004 | 10.898 | 0.000 |
| Delta John Day | 0.032 | 0.016 | 2.037 | 0.042 |
| Delta The Dalles | 0.285 | 0.014 | 20.896 | 0.000 |
| Delta Bonneville | 0.287 | 0.013 | 22.957 | 0.000 |

**Table J5**
**SUMMARY OUTPUT – The Relationship Between River Management and Power Production**

| *Regression Statistics* | | |
|---|---|---|
| | Multiple R | 0.59 |
| | R Square | 0.35 |
| | Adjusted R Square | 0.34 |
| | Standard Error | 2386 |
| | Observations | 840 |

ANOVA

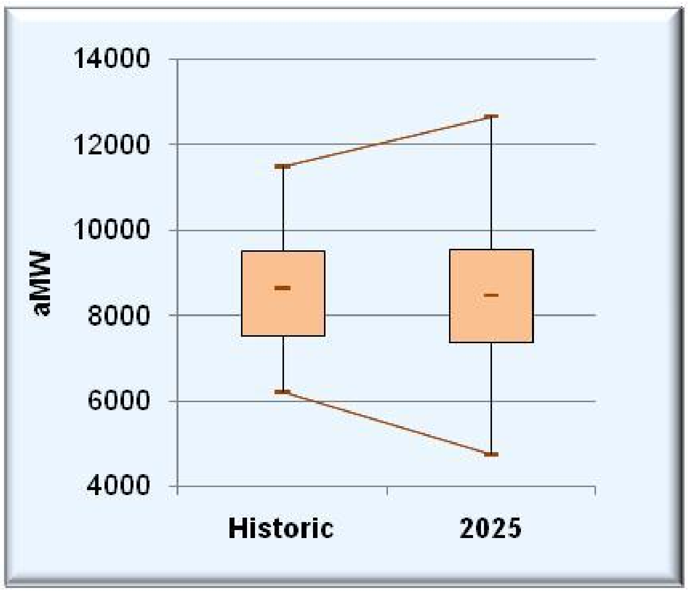
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 12 | 2580447608 | 215037301 | 37.78 | 0.0000000 |
| Residual | 828 | 4712564924 | 5691504 | | |
| Total | 840 | 7293012532 | | | |

| *Residual MW* | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 0 | #N/A | #N/A | #N/A |
| Nov | 1,380.62 | 285 | 4.84 | 0.00 |
| Dec | 1,906.11 | 285 | 6.68 | 0.00 |
| Jan | 2,813.11 | 285 | 9.87 | 0.00 |
| Feb | 2,027.71 | 285 | 7.11 | 0.00 |
| Mar | 1,561.92 | 285 | 5.48 | 0.00 |
| May | (1,012.47) | 285 | (3.55) | 0.00 |
| Jun | (1,644.37) | 285 | (5.77) | 0.00 |
| Jul | 577.74 | 285 | 2.03 | 0.04 |
| Aug | 1,870.88 | 285 | 6.56 | 0.00 |
| Sep | 2,626.12 | 285 | 9.21 | 0.00 |
| Oct | 1,537.77 | 285 | 5.39 | 0.00 |
| Apr | (187.47) | 285 | (0.66) | 0.51 |

Tacoma Power used these two regression equations to develop preliminary predictions of the effect of climate change on Columbia River power generation. Equation inputs were the estimates of revised Columbia River flows developed by the CIG for operating years 1949-59 through 1997-98 based on an A1B level of climate change.[39]

Figure J3 presents a comparison of the potential shift in generation. Overall, the maximum output may increase about 1200 aMW; the 75th percentile may increase 60 aMW, the 50th and 25th percentiles may decrease around 160 aMW; and the minimum generation may decrease nearly 1440 aMW. This suggests that while on average Tacoma Power may see a 10 aMW reduction in power from BPA in the 2020s, year-to-year electrical production could be much more variable.

**Figure J3**
**Potential Change in the Columbia River Generation due to Climate Change**



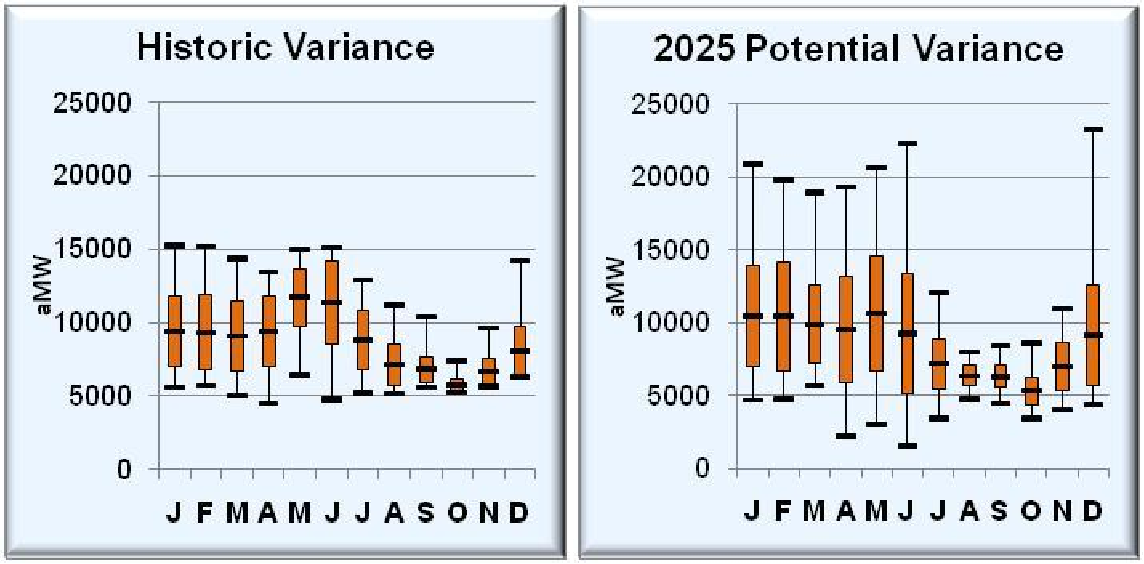

Finally, this analysis may indicate the potential for a serious impact – a higher monthly variance in the quantity of electricity generated. (See Figure J4) An increase in monthly variance would increase the probability of both spilling water during wet years and experiencing an operating year that is dryer than the current critical year. While it is likely that BPA could adjust its river management to accommodate very dry and very wet years, Tacoma Power should nevertheless, monitor ongoing research in this area and plan for such possibilities.

A final note of caution about the estimated increase in maximum generation. The model assumes that all water inflows are used to produce power. However, at the high inflow rates, there is the possibility that inflows will be spilt rather than used to produce

[39] The Climate Change analysis was limited to 49 operating years (i.e., 1949-50 through 1997-98). Data gaps prevented the including all the 75 operating years assessed in other parts of this IRP.

electricity. Moreover, given that turbines may be removed, altered, or added, it is not clear that the high end generation will take place. Therefore, the high-end production estimates may be high.

**Figure J4**
**Potential Change in Variance of Monthly Columbia River Electricity Generation due to Climate Change**




## *Load Adjustments*

The above analysis developed an initial estimate of the potential effect due to climate change on the amount of power available to the utility. Another issue is the potential change in retail load resulting from climate change. This IRP projected the load change for the 2024-25 retail load based on the difference between 3Tier's analysis and historic hourly temperature data. The adjusted load increased during summer and fell in the winter. Overall, projected annual load decreased by 2.6 aMW.

**Table J6**
**Potential Change in Retail Load Due to Climate Change**

| Month | aMW | Month | aMW |
|---|---|---|---|
| August | 2.26 | February | (5.41) |
| September | (0.64) | March | (3.88) |
| October | (2.84) | April | (3.96) |
| November | (3.50) | May | (1.39) |
| December | (6.42) | June | (0.61) |
| January | (6.18) | July | 1.21 |
| **Annual** | | | **(2.60)** |

## *Monthly modeling*

The monthly model was re-run with these climate change altered load and resource supply figures to determine what effect they might have on the utility's resource adequacy. The results indicate a single year with load-resource balance issues (1976-77) out of the 49 operating years modeled under the climate change assumptions.

The deficit in this year is serious. Ten of the months are deficit with an average monthly deficit of nearly 60 aMW. The overall year was also deficit by about 35 aMW. This result is driven by the assumed decrease in Columbia River flows during the 1976-77 dry year.

This assessment indicates the climate change could potentially pose significant issues for Tacoma Power. However, it is based on preliminary appraisals of the potential changes wrought by climate change and the resulting effects on power production. It is a near certainty that our understanding of both these issues will evolve and improve. Since this analysis was performed for the 2024-25 timeframe, the utility has time to both improve our understanding of the consequences of climate change and to develop response strategies if necessary.

**We once again remind the reader that modeling regional scale climate change is very challenging. Available computer models to project regional and local scale impacts are in the initial stages of development. Further, estimating the shift in power production resulting from the change in streamflow is difficult.**

**It is not possible to know what changes to Tacoma Power or BPA operational procures would occur under climate change or due to a new biological opinion. (This assessment assumes no change to operational procedures.) Finally our extrapolation of demand under climate change assumes no change in base technology assumptions – such as increased adoption of air conditioning. As a result, the present analysis should be taken as indicative of the possible direction of changes facing Tacoma Power, but not as a projection of future circumstances.**