KING COUNTY

DRAFT GMA ELECTRICAL FACILITIES PLAN

PREPARED BY:

PUGET SOUND POWER AND LIGHT COMPANY, INC.

LAND PLANNING AND LAND USE PERMITTING

JANUARY 1993

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I. INTRODUCTION

PUGET POWER AS RESOURCE PLANNER

Puget Sound Power & Light Company ("Puget Power") is an investor-owned public utility with the responsibility for providing electrical service to more than 750,000 residential, commercial, and industrial customers in a nine-county, 4,500-square-mile service territory in western Washington.

In the past 10 years, 200,000 customers have been added in Puget's service territory. In providing and maintaining reliable service to present and future customers, Puget Power builds, operates, and maintains an extensive electrical system consisting of generating plants, transmission lines, substations and distribution systems. In planning this system, Puget Power is guided by many considerations, including the reliability of its service, the health and safety of its customers and employees, protection and preservation of the environment, and affordability of electricity.

In order to fulfill its state regulated obligation to serve, Puget Power must be ready with plans to extend or add to its facilities when conditions require expanded service. Because of the high cost of facilities, and because electric service is viewed as a basic necessity, it is important that Puget Power make those additions and expansions in a cost-effective and timely fashion.

This electrical facilities plan reflects Puget Power's conservation, system planning, and growth management planning efforts.

In May 1992, Puget Power filed its most recent biennial update of the Company's Integrated Resource Plan with the Washington Utilities and Transportation Commission (WUTC). The biennial resource plans are developed under guidelines established by the WUTC and are based on a resource acquisition strategy to achieve the Company's least-cost planning objectives and provide flexibility to address future uncertainties. As with other versions, the 1992 resource plan continues reliance on conservation programs; resources acquired through competitive bidding and negotiated purchases; and small hydroelectric projects, depending on the outcome of licensing efforts. Expanded transmission continues to be an integral part of the Company's ability to carry out this plan and make the most of existing resources. The resource acquisition strategy provides for meeting customer loads in the least-cost manner over a range of potential future scenarios. The resource plan is developed by Puget Power in consultation with interested parties, including WUTC.

This electric facilities plan also reflects the Company's efforts to comply with and to assist local governments in their compliance with Washington's Growth Management Act (GMA) of 1990-1991. The GMA requires that local comprehensive plans prepared under the Act include a "utilities element" that addresses the location and capacity of electric, as well as natural gas and telecommunication, facilities.

PURPOSE

The electrical system serving the King County Area is reviewed and summarized in this document in determining whether and how the current system should be strengthened to respond to expected customer growth in the area, taking into account future regional power needs over the next 30 years.

The Electric Facilities Plan for the King County Area is not submitted, nor is any element of this plan submitted, by Puget Power as a "proposal" for the purposes of Washington Administrative Code 197-11-784; nor is Puget Power requesting that any of the cities in the King County Area take any "action" for the purposes of WAC 197-11-704. Rather, Puget Power submits this plan to the cities in the King County Area for informational and discussion purposes only. It is a workable alternative for serving King County with electricity for the foreseeable future.

STUDY AREA

For the purposes of this plan, the King County area is divided into eight subareas, which include Eastside, Northshore, Bear Creek/East Sammamish, Snoqualmie/North Bend, Skykomish, Highline/Green River, Benson/Tahoma/Raven Heights and Newcastle. These Electrical Subareas have names similar to those community planning areas used by King County Planning but do not strictly correspond to them. Puget Power's subareas reflect electrical planning. The study areas include a wide range of electrical use intensities, from wetlands with no electrical demand to high demand commercial customers such as Bellevue Square.

SCOPE

Only the transmission system and distribution substations are reviewed in this plan. The future distribution feeder system is not discussed, because its location is largely development driven. However, the existing distribution feeder system has been, and must be, carefully considered in the siting of distribution substations. Siting of future generation facilities to support the load may be required. However, it is assumed that Puget Power will continue to rely on electrical energy imported into the King County Area on transmission lines. This is consistent with Puget Power's least-cost resource strategy to bring in low-cost power from Canada, the Columbia River, and other generation sites both inside and outside of Puget Power's service territory.

II. METHODOLOGY

Long-range plans are developed by Puget Power's System Planning Group, of the Transmission & Distribution Engineering Department. The plans are based on electrical growth projections anticipated for the years 2010/2020 and beyond. The company uses population and employment forecasts supplied by the Puget Sound Regional Council (PSRC), county and city planning departments, the state Office of Financial Management (OFM), and other agencies as well as other commercial and industrial forecasts.

County population projections produced by OFM are used to determine new load growth for the next 20 years. For load growth beyond 20 years, PSRC population and employment forecasts are used for King, Kitsap and Pierce counties. Projected load is calculated as the existing load, minus conservation reductions, minus demand side management, plus the forecast of new load.

The population and employment forecasts and their distribution produced by the PSRC are used as data reflecting land use activities, which are in turn used to develop a model for forecasting new load. The location of the population and employment increases is determined by the cities and counties. In those counties included in PSRC, the population and employment is broken down into Forecast Analysis Zones (FAZ's).

For those counties and subareas not covered by the Puget Sound Regional Council, information for load conversion is based on forecasts produced by county and city planning departments and industry.

To supplement the PSRC and other forecasts in predicting future load growth, Puget Power studied the energy usage of customers and the ensuing load placed on the system by each new resident and each new employee. The studies included an analysis of: various types of structural dwellings such as single family residences, multi-family residences, and mobile homes; types of fuel used, that is, gas vs. electricity; load factors for each group; and diversity factors for all of the groups combined.

OTHER LOAD FORECASTING METHODS

Other methods of forecasting the new load are zoning analysis, construction forecasts by a jurisdiction, and trending. These forecasting methods can be used to validate the above procedures.

Load Saturation Method by Zoning Analysis

This method uses the existing zoning as enacted by a jurisdiction. An area within the utility service area with similar zoning that has no more land available for development is selected. The electrical demand load in Mega Volt Amperes (MVA) per square mile is determined from load records. This amount of demand load per square mile is multiplied by the number of square miles in that type of zoning in the area. Adding the load for each type of zoning in an area will give the total load for the area.

The new forecasted load is total load minus the existing load. Since this method uses historical load data, conservation is not completely incorporated into the total load. Estimates of conservation must be made for the total load. This will decrease the forecast of the total load for the area. In addition, this zoning analysis does not allow for changes in zoning that increase load density and total load.

Typical values of MVA load per square mile for Puget Power are:

- Single-family = 8
- Multifamily = 17
- Commercial = 29
- Central Business District (CBD) = 250
- Parks/Open Space = 0

Construction Forecasts

A city may provide a forecast of new commercial and office space. From Puget Power's data base, a load of 4 watts per square foot of new energy efficient structures was obtained. Using these numbers, a load for the new construction may be developed. Since this load per square foot is based on energy efficient structures, the forecasted new load also includes conservation. (Note: Construction forecasts do not include hospital, school, hotel, institutional, government, or recreational loads. Estimates of these loads must be specifically made.)

Trending

The load growth for an area is retrieved from the data base. A 10-year period is usually selected and a calculated trend line will give the total load for an area. The trending analysis assumes a constant growth rate but, as an area develops, the growth rate slows down. Using this method, the forecasting error increases as the area being forecasted gets smaller. The forecasting error also increases if the density of development in the area is low.

PLANNING PHILOSOPHY AND GUIDELINES

The objective in Puget's planning methodology is to achieve a balance between system reliability and the cost of service to the customer. To achieve this goal, flexibility must be built into the planning process to allow for changing conditions in:

- Urban growth and development
- Zoning and land use
- Population density
- Energy resource strategies
- National environmental standards
- Energy policies
- Major economic events
- Technological development
- Government policies

These conditions guide the development of Puget's system planning. Puget uses planning guidelines to evaluate the performance of the existing and planned expansion of Puget Power's electrical system. The planning criteria are guidelines to aid in making prudent decisions, not policy statements that must be implemented.

General Planning Guidelines

- Acceptable compromises between reliability and cost, while achieving the corporate objective of providing quality service, should be made when designing the electrical system.
- The careful selection of sizes and types of equipment is required so that the equipment removed from service may be re-used at other locations. The electrical design process should include provisions for using electrical components for their full service life.

- Installation of all electrical equipment should be planned and constructed to minimize environmental impact.
- Flexibility should be incorporated in the system expansion plans as insurance against unpredicted growth patterns and unexpected loads.
- Continual contact with state, county, and city planning departments is needed to obtain information regarding possible areas of development and any large new loads.
- Quality of service should not be degraded below minimum standards. These minimum standards are defined by Washington state law and by Puget Power's tariffs filed with the Washington State Utilities and Transportation Commission.
- Studies involving power flow, transient stability, and short-circuit analysis should be carried out on a continual basis as an aid in monitoring present system performance as well as to assist in determining projected facilities necessary to serve future load growth.

Planning Criteria

The development of Puget Power's long-range plans are based on so-called "**n-1**" planning criteria. These criteria provide that one system element (generally, a line, circuit breaker, or transformer) can be out of service at any one time and still provide power to all customers without exceeding loss-of-life loading limits or the load capacity of the remaining equipment. These criteria allow for equipment maintenance or failures without causing extended outages to the customers. Having two system elements out simultaneously (double contingency) is only considered in certain circumstances. Although double contingency failures are rare, they do occur, and the consequences cannot be ignored. The most likely double failure scenarios are: 1) the failure of a piece of equipment when another is out of service for maintenance, and 2) multiple line failures during storms.

Contingencies

Contingencies (especially typical ones) are considered and investigated. They include the following:

- Outage of any power plant, including the largest, on any one of the interconnected electrical systems.
- Outage of the most critical transmission line on any one of the interconnected systems, as a result of a fault (short circuit), during the outage of another critical line on the same or on an adjacent system.
- The outage of all transmission circuits on any one common right-of-way as the result of simultaneous faults.

- The outage of an entire transmission substation on any one of the interconnected systems.
- The sudden dropping of a large load or a major load center.
- The effect of electrical disturbances outside of the individual utility system or coordination area.

Transmission Lines

- Loss of a bulk power transmission line should not cause loss of service to customers.
- Outage of a transmission line with two or more sources should interrupt service to customers only until switching to the alternate source is accomplished.
- Loss of a radial transmission line may cause interruption of service to customers until the load is switched to other distribution stations.
- Existing transmission lines should be used to fullest capacity, and at the same time substantially improve reliability. To accomplish this, transmission switching stations are often built. They connect transmission lines together with circuit breakers. The result is that the existing lines can then provide mutual support for each other, the number and the duration of customer outages is substantially reduced, and the operating flexibility of the system is enhanced.

Substations

- Substation switching arrangements should avoid excessive concentration of critical circuits.
- Switching arrangements should also permit the effective maintenance of equipment, such as circuit breakers, without subjecting the system to increased outages.
- Relay schemes should be employed that minimize complexity and provide the required system protection in the event of faulty operating or testing errors.

ASSUMPTIONS

Puget Power's long-range plans are developed based on the fact that our urbanized and industrialized society is dependent upon receiving continuous electric power. It is important to ensure that every effort is made to reduce the likelihood of potentially hazardous power failures. In addition, it is assumed that Puget Power will rely on electrical energy through its least-cost resource strategy of bringing in low-cost power from Canada and the Columbia River and from generation sources available through the competitive bidding process.

Although the sequence may change slightly, Puget's long-range plans are not expected to change unless there are significant and unexpected changes in the economy, energy consumption, supply, demand for increased reliability, current policies regarding land use and the environment, government policies, or technology. The plans are not dependent on the hopes of future technological developments.

Finally, Puget's plans assume that the transmission system will be overhead. The cost of underground transmission is significantly higher than overhead, the community and environmental impacts are different, and the capacity of underground cables is more limited. In addition, the repair time for underground cables is measured in weeks as opposed to hours for overhead lines. If underground transmission is required, the proposed system will have to be re-evaluated.

SUMMARY OF PLANNING PROCESS

The following is the general sequence of work in the development of Puget Power's long-range plans:

- A projection of load growth.
- Development of alternative programs for system expansion over a long term of 20-30 years.
- Selection of a preferred plan and its continual updating and revision.
- Close liaison between planning, design, construction, and operation.
- Improvements in planning based upon operating experience.

The uncertainty in successfully completing electrical utility projects increases with the size of the project and thus the length of the construction schedule. Factors that have significant, cumulative effect on the planning process are the economy, electric rates, the capital financing market, government, conservation, technology, and the environment.

The King area transmission system must be designed around and complement the regional transmission system. The projects involved are the most expensive, difficult to permit, and environmentally sensitive. These projects generally involve improvements that carry power from the generating plants to the load centers. Similarly, the distribution substations and lines must be integrated into the area transmission system. This top-level down design creates the most reliable and economic electrical system.

The electrical system is expanded as the area load develops. If additional loads do not develop, or develop more slowly than anticipated, the construction timing of the individual projects is simply extended so that the overall plan completion date is deferred. If the electrical load stops growing all together or decreases, no further construction would be necessary, except for facility maintenance and replacement needs, and unless reliability enhancements are desired. Likewise, if the load develops faster than anticipated, the timing of the construction of the projects can be accelerated.

Section III
MAIN GRID TRANSMISSION SYSTEM PLAN

INTRODUCTION

This section discusses the planning efforts of Puget Power and other utilities for the Puget Sound Region main grid transmission system and its relationship to the larger western interconnected power network that extends from Alberta and British Columbia to northern Mexico. The main grid transmission system includes the facilities that move bulk power over long distances within the region or between regions to connect generators to major load areas. These facilities would typically operate at 500 and 230 kV, whereas 115 kV and lower voltage transmission facilities move smaller quantities of power over smaller distances to meet more localized needs. The network also includes low voltage, low capacity distribution facilities that carry power to a single neighborhood or smaller industry. Transmission facilities that primarily serve local needs, and distribution facilities, are not discussed in this section. This section includes:

- a general overview of the main grid transmission system
- a summary of projected loads based on population forecasts produced by the state and other governmental agencies
- alternative power sources and generation
- Pacific Northwest transmission requirements
- a discussion of projects and future plans for the transmission system described as Transmission Projects in Process, Mid Term Transmission Plans and Long Term Transmission Plans

The Puget Sound electric utilities share an "integrated electric system." All elements of the system (e.g. transmission lines, substations and generation facilities), regardless of individual ownership, are designed and operated to work in a complementary, coordinated manner. As a result the plans of other utilities often affect Puget Power. For this reason, this section frequently discusses plans being considered by other electric utilities in the Puget Sound Region. However, it should be noted that Puget Power does not represent the other utilities or their plans. The approximate geographic locations of transmission facilities are shown in maps 2.1 to 2.3 (immediately following this section).

Maps:

2.1) Existing Transmission System, 500 kV and 230 kV system of lines and substations
2.2) Generation and 230 kV & 115 kV Supply Transformers, Detailed description of generators and two 230 kV & 115 kV supply transformers in the Puget Sound region
2.3) Future Transmission System, Description of additional facilities planned for the region

THE PUGET SOUND REGION ELECTRIC SYSTEM

The Puget Sound Region electric system extends from the Canadian border south through Thurston County and from the Cascade Mountains west to the Olympic Peninsula, (see *Existing Transmission System,* Map 2.1). Transmission and distribution facilities in this system are owned and operated by public utility districts, municipalities, investor owned, cooperatives, Rural Electrification Associations (REA'S), and federally controlled utilities such as the Bonneville Power Administration (BPA). The following utilities are included in the Puget Sound Region electric system:

Puget Sound Region Electric Utilities

1. City of Blaine
2. City of Port Angeles
3. City of Centralia
4. Eatonville
5. Fircrest
6. Seattle City Light
7. Steilacoom
8. City of Sumas
9. Tacoma City Light
10. Clallam County PUD #1
11. Grays Harbor County PUD #1
12. Mason County PUD #1
13. Mason County PUD #3
14. Snohomish County PUD #1
15. Whatcom County PUD #1
16. Alder Mutual
17. Elmhurst Mutual
18. Lakeview Light & Power Company
19. Ohop Mutual
20. Peninsula Light Company
21. Parkland Power & Light
22. Orcas Power & Light Company
23. Tanner Electric Cooperative
24. Puget Sound Power & Light, PSP&L
25. Bonneville Power Administration, BPA

Through interconnections, these utilities can improve reliability, access power generated beyond their own system, and provide cost effective service to users. For example, Tacoma City Light can access power generated outside of its system from the Centralia Coal Plant through its interconnection with the Puget Power and BPA electrical systems. Otherwise, Tacoma City Light would have to construct its own power lines between Tacoma and the Centralia plant. Another example of accessing power efficiently and cost-effectively is Puget's ability to receive power from eastern Montana via the high voltage transmission lines owned by BPA and the partners in the Colstrip Project.

BPA, a major supplier of power to the Puget Sound electric system, owns and operates most of the 500 kV and 230 kV lines and substations in the Pacific Northwest Region. BPA utilizes these facilities to market power generated at federally operated hydro dams and Washington Public Power Supply System (WPPSS) generators. Puget Power and other utilities purchase power and/or transmission services from BPA and use their facilities when it is economical or necessary. BPA can also sell these services to utilities outside its service boundary by using its interconnections with other utilities. For example, BPA can transfer Canadian power to California utilizing facilities in Washington and Oregon and interties with Canada and California.

At any given time the transmission system supports a significant variety of electric power transfers that are superimposed on the network. Each utility has a generation schedule to meet its loads or to sell power to others. Power is scheduled by adjusting generation so that generation equals the load plus the power lost on the system. However, the flow of power over individual lines is almost never directly controlled by the utilities. The power flows over the transmission system according to the laws of physics, so that each load draws the power that it needs. The power flowing on a particular line may be the consequence of the net effects of numerous transactions on the power system.

General Requirements

The Puget Sound electrical system is required to:

- transfer power from outside of the region into the region
- transfer power scheduled to other regions
- integrate and collect power generated within the region
- distribute power to consumers within the region
- operate reliably under a full range of loads (for all seasons) with varying temperatures and with a wide variety of generating patterns, without detrimentally impacting other regions or utilities.

Inter-regional Transmission Lines

Power is imported to, exported from, and transferred across the Puget Sound electric system by high voltage inter-regional transmission lines that connect the Pacific Northwest to other regions. For example, there are two 500 kV transmission lines that cross the US-Canadian border near Blaine, Washington. Frequently, during the spring season, these lines transfer large amounts of power that flow from the Columbia River across the Cascades and north into Canada. This power is exported to Canada for storage using B.C.

Hydro's hydroelectric storage capabilities. At other times, the same lines transfer power from Canada into the United States serving loads in the Pacific Northwest and farther south, (see Map 2.1, Existing Transmission System). The following are transmission lines that connect the Pacific Northwest to other regions.

Interconnecting Transmission Lines

- Pacific Northwest with Canada-Ingledow-Custer #1 & #2 500 kV lines (Vancouver B.C.-Bellingham)

- Pacific Northwest to the Portland area-Paul-Allston #1 & #2 500 kV lines and the Chehalis-Longview #1 & #2 230 kV lines (Chehalis-Portland)

- Cascade Mountain transmission lines-Connect the Columbia River generators and the Eastern Washington transmission network: (See Map 2.1)

  1) Chief Joseph-Monroe 500 kV
  2) Chief Joseph-Snohomish 1&2 345 kV
  3) McKenzie-Beverly (IP Line) 115 kV
  4) Taunton-Snoqualmie 115 kV
  5) Rocky Reach-Maple Valley 345 kV
  6) Columbia-Covington 230 kV
  7) Coulee-Raver 1 & 2 500 kV
  8) Sickler-Raver 500 kV
  9) Vantage-Raver 500 kV
  10) Rocky Reach-White River 230 kV
  11) Coulee-Olympia 287 kV

Integrating Local Generation

Electric power generation in the Pacific Northwest serves local loads and helps to regulate voltages in the region. The power from generators at the Seattle Skagit Project, and Tacoma's Mayfield and Mossyrock generating plants is electrically connected to the system at a 230 kV voltage level. Power from the Centralia coal plant is integrated at 500 kV. Power supplied from all other local generators is integrated at 115 kV or lower voltages, (see Map 2.2, *Generation and 230 & 115 kV Supply Transformers*).

Although most of the local generators provide power at 115 kV, they still influence and support the entire region, which is connected through transformers to the 230 and 500 kV grid. This method of integrating local generation into the 115, 230 and 500 kV grid allows generators in areas such as Whatcom, Skagit, and Lewis counties to be connected electrically to the King, Pierce and Thurston counties system.

Supplying Local Loads

Power is supplied to local loads through high voltage transmission lines that are connected in substations to transformers. These 500-230 kV transformers reduce or step-down the voltage levels for power distribution to local loads. 500-230 kV transformers are located at the Custer, Monroe, Maple Valley, Covington, Tacoma, Olympia and Satsop substations. Lines energized at 230 kV exit from these substations. The 230 kV lines feed smaller substations that transform power down to 115 kV, (see Map 2.2, *Generation and 230 & 115 kV Supply Transformers).* Many 115 kV and lower voltage lines serve neighborhood distribution substations that typically have 115 to 13 kV transformers. The 115 kV lines and distribution substations are discussed in detail in each of the area plans.

High voltage transmission lines are used because the transmission capabilities of these lines are greater than lower voltage lines and they have lower losses at high power levels. A 500 kV line can transmit several times more power than a 230 or 115 kV line over much longer distances. However, lower voltage lines are preferred for local distribution purposes since they are cost efficient and have adequate thermal capacity for the neighborhood loads they serve.

Planning Guidelines and Reliability Criteria

Each utility serving the Puget Sound region typically follows system planning guidelines to aid in planning system improvements and operational changes. These guidelines usually include reliability criteria to facilitate evaluation of the performance of the utility's electric system. Reliability criteria addresses the effects of contingencies--planned and unplanned losses of system components--on the electric system. On transmission issues that affect more than one utility, reliability criteria that are developed through the Western Systems Coordination Council (WSCC) usually apply. The WSCC is an organization of electric utilities in the western third of the United States, Western Canada, and northwestern Mexico.

Each utility's reliability criteria can vary according to that utility's requirements within the region. In addition to the WSCC reliability criteria, Puget Power has planning guidelines that are adapted to its transmission and distribution requirements. Other utilities (such as BPA) have reliability criteria that are especially suited to serving its customers. For example, BPA criteria are used primarily for its transmission system. When more than one utility is involved, the various standards are similar (but not identical) and require some interpretation and coordination.

Puget Power's electrical facilities plans are developed within the criteria established by the WSCC, BPA, and Puget Power. Although the use of reliability criteria by each regional utility varies, it seldom conflicts with other interconnected utilities. Periodically, two or more utilities will conduct joint studies using criteria observed by the individual utilities.

EXPECTED GROWTH IN DEMAND

The expected growth in demand is guided by population and employment projections for local areas. These projections are supplied by the Washington State Office of Financial Management (OFM), the Puget Sound Regional Council (PSRC), county and city planning departments, and other commercial and industrial sources. The PSRC produces population and employment forecasts for 30 years. Forecasts produced by the counties are typically for 20 years.

To compute Puget Power loads, the forecasted changes in population and employment were multiplied by the average electrical consumption for new residential and commercial additions. The average electrical consumption for each new person in Puget Power's service territory is 1.63 kVA and the consumption for each new employee is 2.21 kVA. The new loads were added to the existing loads. The amount of power saved through conservation and the power shifted off peak through demand side reductions, (time of use rates, interruptible rates, heat and cold storage, and direct control of appliances and heating/air conditioning), was then subtracted. The following formula illustrates the process for computing future winter peak loads with an ambient temperature of 13 degrees Fahrenheit (°F).

Computing Winter Peak Loads with an Ambient Temperature of 13°F

Existing Load (extreme winter peak, 1 in 20 Years, 13°F)	=	X
Plus 2010 / 2020 Load Increase (Includes conservation at 11 aMW/year; 1.17 multiplier for extreme peak)		
Population increase *times* 1.63 kVA *times* 1.17	=	Y1
Employment increase *times* 2.21 kVA *times* 1.17	=	Y2
Plus High voltage industrial addition	=	Y3
Less Demand-side Reductions (10% *times* X)	=	Z1
Less additional conservation (11 to 16 aMW/year or 6.94% *times* X	=	Z2

TOTAL (kVA) = X + Y1 + Y2 + Y3 - Z1 - Z2

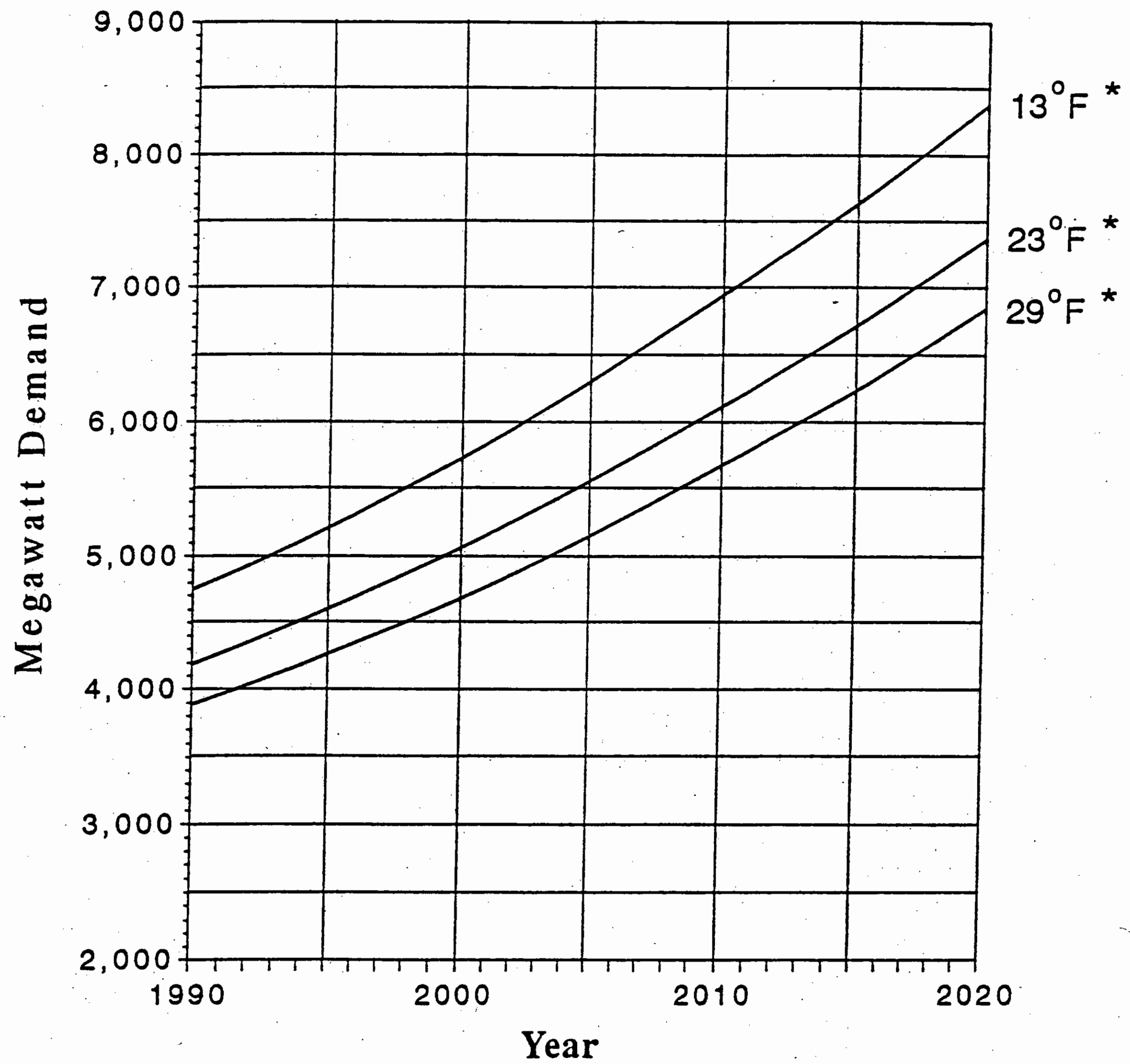
The forecasts for population and employment are often arranged according to Facility Analysis Zones (FAZ) or by zip code areas. For the purpose of transmission planning, county subareas, FAZ and zip code areas were grouped into larger areas. The expected Puget Power loads by area are given in Table 1 according to the 20 or 30-year forecasts. Puget delivers power to other utilities such as Blaine, Sumas and Tanner Electric whose systems are integrated with Puget's. These loads are included in Table 1 by geographic area and total approximately 30 MW in 1990 and 44 MW in 2010.

Table 1 - Load by Area, Puget Power (MVA)

Region	Existing 1990	Projected 2010	Projected 2020
Whatcom County	500	662	
Skagit County	280	431	
Island County	142	226	
Kittitas County	42	48	
King County (North)			
Skykomish/Scenic	2		3
Eastside	407		584
Northshore	276		613
Bear Creek/E. Sammamish	119		364
Snoqualmie/North Bend	45		70
King County (South)			
Newcastle	209		341
Highline/Green River Valley	621		1026
Benson/Tahoma/Raven Heights	165		393
South King-Pierce			
Christopher/Frederickson	578		1005
Berrydale/Electron	314		625
Thurston County	496	753	
Kitsap County			
South of Sinclair	108		163
North of Sinclair	379		555
Jefferson County	77	90	
Sub-totals 20-year loads	[1537]	[2210]	
30-year loads	[3223]		[5742]
MVA Totals (w/ interpolation)*	**4760**	**6947**	**8392**

*By assuming a constant increase in demand, the 30-year loads can be interpolated to 20 years and summed with the 20-year totals. Similarly, the 20-year loads (which are much smaller than the 30-year loads) can be extrapolated and added to the 30-year loads. This results in reasonable totals for 20 and 30-year loads. By doing this, a company wide 20-year load estimate

Figure 2.1 Load Demand Projections, Peak Load



* Load Demand at Degrees Fahrenheit Ambient Temperature

is 6947 MVA, or an increase of 2187 MVA. This includes the benefits of conservation and demand side reductions and corresponds to a demand increase of 1.9% per year. These are illustrated in Figure 2.1 which shows three curves of peak load for future years. Each curve corresponds to the demand at an ambient winter temperature of 13°F, 23°F, and 29° F.

Integrated Resource Plan - Projected Loads

Puget Power has published an Integrated Resource Plan to assist in long term resource planning, (see *Puget Power Integrated Resource Plan,* Puget Sound Power & Light Company, page 32). This is Puget's third published resource plan, which includes perspectives obtained through public involvement, and qualitative and quantitative analyses.

In the Integrated Resource Plan, multiple scenarios are used to project plans for resource needs to meet growing load and to test the flexibility of the different resource plans. Projected loads are shown in terms of average MW before conservation benefits are subtracted from them. Conservation is counted separately as one of the resources.

The Medium Scenario in the Integrated Resource Plan most nearly matches the demands calculated from the PSRC and county population and employment forecasts (1.9%). After subtracting the benefits of conservation from load, the Medium Scenario growth rate for average energy load is 1.87%.

Other Northwest Utilities - Expected Growth in Demand

Regional transmission facilities serve both Puget Power and other utilities in the region. Each utility serving the Puget Sound region has developed a 20-year load forecast for the area it serves. Table 2 shows the existing 1991 loads, which are based on actual 1991 electric energy use, including the benefits of conservation. The projected 2010 peak loads represent energy demands during extreme cold weather (a "20-year" winter) and also reflect the projected benefits of all forms of energy conservation. Table 2 shows these loads.

Table 2 - Load By Area, Other Utilities (MW)

Non-Puget Power Utilities	Existing 1991	Projected 2010
Snohomish County PUD	1612	2406
Seattle City Light	2040	2582
Tacoma City Light	1228	1443
BPA Loads		
Whatcom Co PUD & GP	55	62
Orcas Power & Light	38	52
Teanaway	2	2.5
Pierce County Mutuals, REA's	232	351
Peninsula Light Company	130	210
City of Centralia	62	80
Lewis Co PUD	179	227
Clallam PUD+Pt Townsend Paper	167	219
US Navy	74	79
Intalco & Kaiser Tacoma	620	625
Grays Harbor County PUD	292	302
Mason County PUD	154	160
City of Port Angeles	153	151
MW Totals	**7038**	**8952**

The demand increase for these non-Puget Power utilities during this period is expected to be 1914 MW. If the Direct Service Industry loads (Intalco and Kaiser) are subtracted from these loads, the average annual growth in demand is 1.38 %. This average annual growth in demand is lower than the expected growth demand in Puget Power's service territory. Since the service territories of SCL, TCL, and most smaller electric utilities of the Puget Sound region are expected to experience a lower rate of population growth, they will also experience a lower rate of growth in the demand for electric energy.

ALTERNATIVE POWER SOURCES

Puget Power owns and operates generating facilities both inside and outside the Puget Sound region. It shares joint ownership of other generating plants such as the Centralia and Colstrip coal plants. Also, it purchases power generated by other utilities and non-utility generators. Generators outside the region are as far away as Colstrip in Montana, Peace River Hydro in northern British Columbia, and thermal plants in southern California.

Since the Columbia and Snake River hydro power plants are becoming more restricted in their ability to generate power, their ability to satisfy growing regional loads is diminished. Puget Power must look to a variety of resource options, including Non-Utility Generators (NUGs), Independent Power Producers (IPPs), and projects developed and operated jointly among utilities. NUGs and IPPs are generation facilities which are developed and operated by an entity other than an electric utility. Typically, they are cogeneration plants added to an existing or proposed industrial facility. Most of the energy produced by these facilities is acquired through a competitive bidding process. Puget Power typically does not know the locations and size of future IPPs and NUGs. (As a consequence, the locations of transmission facilities needed to integrate these resources into the electric system also generally are not known.). However, many of these facilities may be located in existing heavy industrial areas such as around the refineries near Anacortes in Skagit County or adjacent to existing natural gas corridors.

When planning generation additions Puget Power also has to take into account the anticipated loss of existing generation. Existing thermal generation plants have finite life expectancies and will be retired at some date in the future. The Trojan Nuclear Plant in Oregon has recently been closed. Absent any further agreements, the Canadian Entitlement energy produced on U.S. Columbia River dams that have been sold to Puget Sound region utilities, will have to be delivered to Canada as the sale contracts expire.

Existing and planned generating plants, conservation and long term resource plans will be discussed in the following order:

- Existing Generators
- Planned Generating Projects
- Conservation
- Long-Range Resource Additions

Existing Generators

The existing generators in the Puget Sound region are listed in Table 3, which shows the power output in megawatts expected during an average January load peak period. (For some hydro generating plants, this may be lower than the output during the spring). Energy in average MW (aMW), shows the average power output in megawatts over the course of the whole year. The combustion turbines shown in Table 3 are used primarily as backup generation and to meet the system peak, so the average energy produced is low. The locations of generators are given in Map 2.2, *Generation and 230 kV & 115 kV Supply Transformers*. Table 3 and Map 2.2 do not include generators outside the Puget Sound basin that are owned or contracted by the regional utilities.

Table 3 - Existing Local Generators

Utility Company	Average Energy aMW	Peak MW
PUGET SOUND POWER & LIGHT		
Lower Baker Hydro	38	63
Upper Baker Hydro	35	92
Snoqualmie Falls, Electron, Nooksack	49	72
White River Hydro	27	62
Whitehorn Combustion Turbine 1	36	67
Whitehorn Combustion Turbines 2 & 3	4	178
Fredonia Combustion Turbines	6	247
South Whidbey Combustion Turbines	1	29
Frederickson Combustion Turbines	4	178
Shuffleton	2	86
Crystal Mountain	0	3
March Point Cogeneration, Phase I	75	80
Miscellaneous small generators		
Nooksack Hydro	2	2
Sumas Mountain	.7	.7
Sygitowicz Creek	.2	.2
Bellingham Municipal Solid Waste	1	2
Weeks Falls	1.8	1.8
Twin Falls	8.3	8.3
Skagit County Municipal Solid Waste	2	2
Komo Kulshan	6.4	3.9
SNOHOMISH COUNTY		
Jackson Hydro	41	103
SEATTLE CITY LIGHT		
Skagit Project Generators		
Ross Hydro	70	357
Diablo Hydro	83	159
Gorge Hydro	95	177
Cedar Falls, Newhalem Hydro	9	31
Metro Westpoint	1.2	1.2

Table 3 - Existing Local Generators (continued)

Utility Company	Average Energy aMW	Peak MW
TACOMA CITY LIGHT		
Alder Hydro	20	39
La Grande Hydro	33	65
Mossyrock Hydro	93	309
Mayfield Hydro	64	172
Cushman 1 Hydro	11	29
Cushman 2 Hydro	24	88
Steam Plant #2	17	38
MISCELLANEOUS		
Yelm, City of Centralia	9	10
Morse Creek, Port Angeles	0	1
JOINT OWNERSHIP		
Centralia #1 & #2	1086	1280
Totals	**1954**	**4035**

Currently Identified Generating Projects

Most currently identified generation projects proposed by Puget Sound area electric utilities are relatively small in scale compare to existing generation plants (less than 250 MW as compared to facilities such as Trojan, which produced approximately 1200 MW). In addition to utility-proposed projects, 120 MW of non-utility co-generation has recently been placed in service in the Puget Sound region under contract to Puget Power. An additional 820 MW of non-utility generation is being planned (most of this is currently under construction).

Table 4 lists currently identified (published) generation projects. Transmission projects required to integrate these generation facilities into the regional electric system are discussed later in this report. Identified generation projects are shown on Map 2.2 (Generation & Supply Transformers).

Table 4 - Planned Generators

Utility Company	Average Energy aMW	Peak MW
PUGET SOUND POWER & LIGHT		
Nooksack Falls	5.1	8
Thunder Creek	5.8	9.4
White River Addition	9.5	14
Enserch Cogen	130	160
March Point Cogen, Phase II	48	60
Sumas Cogen	90	110
Tenaska Cogen	220	245
Black Creek		3.8
Misc. Small Hydro	Not Identified	Not Identified
SEATTLE CITY LIGHT		
South Fork Tolt	8.4	15
SNOHOMISH PUD		
Scott Paper Cogen	33	43
TACOMA CITY LIGHT		
Barrier Dam (2 units)	6.3	9
Elkhorn (Units 1&2)	5.6	13.3
Glacier Creek	3.4	7
Ruth Creek	1.4	2.8
Swamp Creek	1.6	4.3
Wells Creek	7.5	14.4
Wynoochee Dam	4.3	10.8
BPA		
Tenaska Washington II		248
MISCELLANEOUS		
Mason County PUD #3 - Hamma Hamma	8	17
Mason PUD #3 - Simpson Cogen	14	14
Lewis Co PUD - Cowlitz Falls	44	44
Total Projected MWs (Rounded)	**646**	**1053**

Conservation

Conservation is a resource that reduces existing or projected load on the electric system, thereby delaying the need for construction of new or expanded facilities to serve this load. Also, conservation can delay the need to expand existing or develop new generation resources. In addition, it may help delay the need for some transmission system improvements.

Conservation is expected to yield an additional 296 MW and 592 MW on system peak in 2010. The 296 MW is listed in Puget Power's Integrated Resource Plan, 1992-1993, which describes the Medium Scenario target for all resource additions. Load demand for the Medium Scenario meets the load demand computed by using population and employment forecasts from PSRC and county governments.

Demand management is one program that utilities use to persuade or require customers to change their energy use patterns. Typically, demand management programs result in the shifting of peak energy use to normally off-peak times. Examples of demand management include: 1) information programs, e.g., encouraging residential or commercial customers to reduce electric use during peak load periods; 2) and differential rate structures, i.e., based on time of day or amount of energy use; and occasionally 3) direct control by the utility of energy use by certain industrial or residential customers.

Puget Power is undertaking a pilot program to develop demand management as an effective tool to reduce peak load demand. The 2010 demand growth included in this report reflect a peak load reduction of 300 MW through shifting of demand to off-peak periods. Demand management targets are expected to change as the technology of demand management evolves. Puget Power is keeping abreast of changes and improvements to use this resource to its fullest potential.

Long Range Resource Additions

Puget Power's Integrated Resource Plan discusses scenarios of new resources to meet different growth rates (see *Integrated Resource Plan, 1992-1993,* page 64). The new resources listed in the Medium Scenario for the year 2010 include conservation, hydro, geothermal, wind generators, high efficiency cogenerators and clean coal plants. Table 5 of this report, gives the outputs from these resources for the Medium Scenario in average megawatts (aMW) and peak megawatts (MW). (Note: while Table 5 includes conservation, the loads indicated in Table 1 also include conservation. To compare loads with resources, conservation should be deducted from resource totals or added to loads to avoid double counting.)

Table 5 - Resource Additions for Medium Scenario in 2010.

Resource Type In Year 2010	Average Energy aMW	Peak MW
Conservation	296	592
Hydro, geothermal, and wind	90	200
Cogenerators	1000	1251
Clean coal plants	210	300
Peaking Resource	--	1788

In the *Puget Power Integrated Resource Plan,* the coal generation additions shown for the Medium Scenario begin near the end of the 20-year plan. If the plan were extended to 30 years, generation from coal could become an increasingly dominant resource.

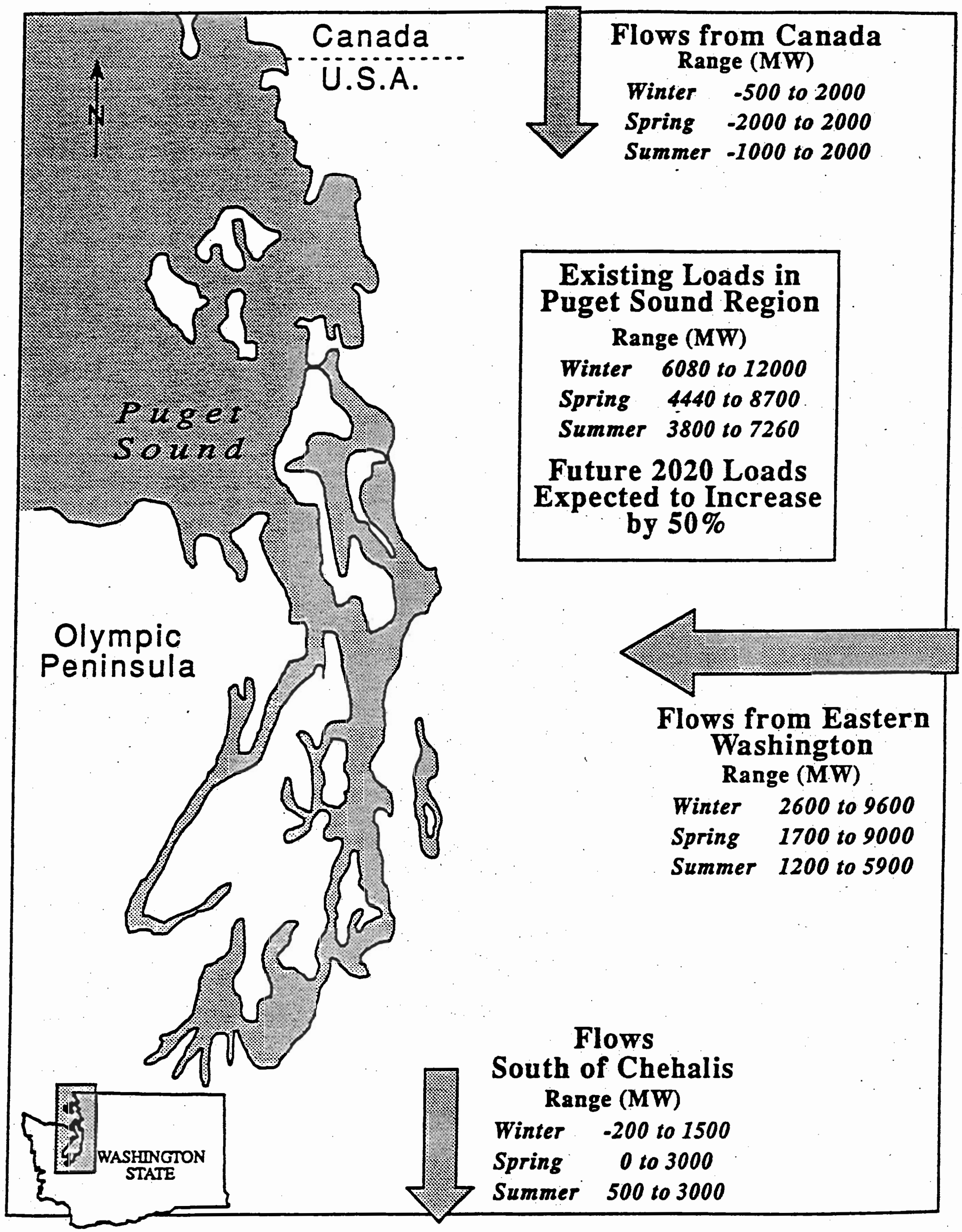
The transmission facilities to integrate these resources cannot be discussed in these plans. Although they will be needed, specific transmission plans cannot be developed until the locations, sizes and types of future generators have been determined.

PACIFIC NORTHWEST TRANSMISSION REQUIREMENTS

As discussed in general requirements for the Puget Sound electric system, all transmission systems are required to receive power from outside their boundaries, support transfers to other regions, integrate internal generation into the system, and reliably supply loads. These requirements must satisfy a wide variety of load conditions such as forced outages, planned outages, and generating patterns, (see Figure 2.2, *Loads, Imports, & Through Flows*). The power that flows in and out of, and across the Puget Sound region transmission system is subject to extreme changes within hours. Consequently, the longer high voltage lines and substations require devices to regulate and maintain stable operating voltages. In some cases these devices will require the construction of new or expanded substations.

The demands placed upon the existing Puget Sound regional system and plans for future improvements may be grouped into several broad geographic and functional categories, which follow. Map 2-1 (Electrical Transmission System, Proposed Facilities) illustrates possible additions and changes to the existing transmission system. Transmission facilities which primarily serve local needs, and distribution facilities, are not discussed here. The proposed improvements to the main transmission grid are discussed in greater detail in the next section entitled "Projects and Plans".

Figure 2.2 Loads, Imports & Through Flows



The plans discussed below are conceptual from the standpoint of a long-range horizon. Since any number of contingencies may cause these conceptual plans to be re-evaluated, they are presented only for informational and discussion purposes. Each category covers a variety of independent needs. In turn, one or more of these needs may require additions or improvements to the electrical system.

The Existing Transmission System

- REGIONAL TIES TO CANADA
- REGIONAL TIES TO PORTLAND METROPOLITAN AREA
- LINES ACROSS CASCADE MOUNTAINS
- CORRIDORS WITH SINGLE 500 KV LINES
- 230 kV SUPPLY
- LOCAL GENERATION INTEGRATION
- SUPPLY OF LOCAL LOAD
- OLYMPIC PENINSULA REQUIREMENTS

REGIONAL TIES TO CANADA

Need

Canada currently supplies power to many consumers both inside and outside the Pacific Northwest. Storage capabilities of Canadian systems, such as the Columbia and Peace River hydro systems in British Columbia, allow the effective generation and transfer of power from the United States to Canada during high spring run-off periods (energy can be stored as water behind the Canadian dams). Power transferred north for Canadian storage in the spring can be returned during other seasons such as winter.

There are two 500 kV lines between Ingledow Substation in Canada and BPA Custer Substation in Whatcom County, Washington. Lines that cross the border and lines south of the Canadian border into the Puget Sound region must be capable of importing and exporting power under a range of conditions. These conditions include heavy and light load periods, adverse weather conditions, and equipment outages. A critical condition could be the loss of both of the Ingledow-Custer 500 kV lines or both of the Custer-Monroe 500 kV lines. Although, generation from Canada could be cut should a severe outage occur, maintaining stable voltage in the Vancouver, B.C. area would then become a difficult problem.

Potential Improvements

Strengthening the 230 and 115 kV system in Whatcom and Skagit counties can raise the transfer capability in western Washington. Additional transmission lines crossing the border will both reduce the amount of generation that has to be dropped during a double line outage, and reduce the severity of voltage swings in the Canadian system. The line(s) may need to extend from Canada to substations in south Snohomish or north King counties, passing through Whatcom and Skagit counties. They could be tapped to the BPA Custer Substation or the Sedro-Woolley Substation in Skagit County. Preferably new transmission lines would be placed in a separate corridor from the existing lines to reduce the probability that one event could take out existing and new lines.

REGIONAL TIES TO PORTLAND METROPOLITAN AREA

Need

The Portland area has transmission ties to the Puget Sound area. Some of the power flowing through the Puget Sound area uses these transmission lines to supply loads in southwest Washington, Oregon and California. The amount of power flowing between the Puget Sound region and Portland depends on load levels and where power is being generated. Generation and load levels may vary daily and seasonally. As seen in Figure 2.2, the power flows south out of the Puget Sound region are highest during spring and summer, when loads in the region are lower and hydro-generated power is more available for transfer south.

To supply increasing loads in the Puget Sound region, new generation and transmission facilities must be built to bring power into the area. One effect of these additions will be to increase power flows from the Puget Sound region to loads in the Portland area and beyond. Since the Trojan Nuclear Plant outside of Portland has been removed from service, the power it had generated will need to be made up in part by increased power flows from the north.

Potential Improvements

Additional transmission lines could be built to better support heavy transfers between South Puget Sound and Portland. As described above, it is preferred that new transmission lines be located in separate corridors from the existing lines to reduce the probability that one event could take out both existing and new lines.

LINES ACROSS CASCADE MOUNTAINS

Need

Existing hydroelectric plants on the Columbia River system and coal-fired, and nuclear generation plants east of the Cascades can generate large amounts of electric energy. This energy has to be efficiently transferred from east of the Cascades to the major load center in and around the Puget Sound area. Cross Cascade transmission lines are necessary to carry this energy from the generation source to the demand. Currently there are five major cross-Cascade transmission lines. The loss of one or more of these lines during heavy load conditions might result in adverse voltage conditions which could cause widespread brownouts or blackouts in the Puget Sound area.

Proposed Improvements

Among the measures that can be taken to improve adverse voltage conditions during severe outages is the construction of new cross-Cascades transmission lines to import additional Columbia River hydro-electric power into the Puget Sound area system. Additional transmission capacity can also be obtained by rebuilding and converting lower voltage lines (having lower capacity) to higher voltage lines. Examples would be converting 345 kV lines to 500 kV, or converting 115 kV lines to 230 kV. Substation equipment such as capacitors, could be installed to help improve voltage conditions.

CORRIDORS WITH SINGLE 500 KV LINES

Need

Transmission paths require multiple parallel lines that carry power in the event that one or more lines are out-of-service due to an unplanned or forced outage. When one line is lost from service, the parallel lines can carry additional power up to the amount that was carried by the out-of-service line. Through some corridors in the Puget Sound region a single 500 kV line has been constructed that is paralleled by local 230 and 115 kV lines and remote 500 kV lines. In normal peak load operation, or when most of this power is being transferred across the system, the 500 kV line will carry most of this power. However, when that 500 kV line is out-of-service, the remaining 230 kV & 115 kV lines suddenly experience a large increase in power. The increase in power corresponds in part to the power that flowed on the single 500 kV line before it was lost from service. These projects include building parallel 500 kV lines so that one 500 kV path will remain under single line outages. Parallel 500 kV lines are needed so that high transfers can be sustained when a single 500 kV line is lost from service.

Currently, a single 500 kV line connects the Monroe Substation in Snohomish County to the Raver Substation in King County. Another single 500 kV line connects Raver--through Pierce and Thurston counties--to the Paul Substation in Lewis County. An outage of either of these 500 kV lines would overload the lower-voltage system. Therefore, new north-south 500 kV lines are needed.

Potential Improvements

The new Echo Lake Substation which is currently under construction about 12 miles north of Raver, will divide the Monroe-Maple Valley-Raver 500 kV Line into segments. This will minimize the risk that a single event could remove all of the line segments from service. An additional 500 kV line could then be constructed between Monroe and the new Echo Lake Substation. In addition, a second 500 kV line is being considered between the Raver and Paul substations.

230 KV SUPPLY

Need

The electric system needs adequate supply to the 230 kV system to keep the underlying lower voltage (115 kV) system functioning properly. This supply can come from 500-230 kV transformers or from generation at 230 kV (the latter also requires transmission to integrate 230 kV generation into the system). The size of the existing 500-230 kV transformers ranges from 900 to 1800 MVA. These transformers are located at the following BPA substations; Custer (two), Monroe, Maple Valley, Covington (two), Tacoma, Olympia and Satsop. Map 2.2 gives the locations of the 500-230 kV transformers, the 230-115 kV transformers and the local generation.

Potential Improvements

New transformers will be needed in areas where loads are increasing. With load growth, the existing transformers become overloaded when some other system element is lost from service, e.g., the loss of another transformer. A new transformer would be placed as close to the growing loads as possible, where it could provide the most benefit to the 230 and 115 kV transmission system. If transformers were located away from the loads they serve, then many lower voltage lines must be constructed to transfer power at the lower voltage to the load centers.

LOCAL GENERATION INTEGRATION

Need

Local generating equipment reduces the need for an equivalent amount of transmission into the Puget Sound region electric system. However, this equipment also increases the level of transfers that exit or flow through the region. Local generation helps maintain stable system voltages within acceptable levels during outages by its inherent ability to quickly supply reactive deficiencies resulting from outages.

When a new generating plant is added, new lines are usually required to reliably bring power from the plant site to existing substation facilities. Line and substation upgrades may also be required. Each project usually requires a combination of new lines, new equipment, and upgrades to the existing system.

To provide increases in generation capacity and to provide local voltage support, many small, local generating plants are being considered or are under construction west of the Cascades. While most of the local generators provide power at 115 kV, they still support the entire region, as they are connected through transformers to the 230 and 500 kV grid. This method of integrating local generation into the main transmission grid allows generators in outlying areas to be connected electrically to the major load centers.

Potential Improvements

Various transmission facilities are needed to integrate identified generation projects into the existing transmission network. (These new transmission facilities are described in greater detail in the following section on Projects and Plans.) Additional transmission facilities will be needed to connect future generation resources whose locations are not yet known. These transmission needs cannot be determined until actual generator locations, sizes, and types are selected.

SUPPLY OF LOCAL LOAD

Need

Local load supply addresses the function of lines typically operating at 230 kV that transfer and distribute power to smaller area substations. As load demand in a local area increases, additional 230 kV lines are connected to the smaller area substations and new substations are constructed. Smaller area substations have transformers to reduce transmission voltage to subtransmission voltages (between 115 kV and 55 kV) or sometimes to distribution voltages (less than 55 kV).

Potential Improvements

The improvements here address needs that are currently anticipated. It is expected that additional needs will be determined further out in the planning horizon. Additional transmission lines will be required in Skagit County and on Whidbey Island to maintain stable voltages as loads increase. New lines will also be needed in Skagit, Snohomish and King counties to transfer power and to relieve loading on existing lines. A line from Kirkland west under Lake Washington could supply additional power to north Seattle. New lines in King County are needed to serve rapidly expanding loads through areas near Duvall, Snoqualmie, Issaquah, Maple Valley, east Kent and Lake Morton. Additional transmission capacity is needed from east Kent into south Seattle. Other lines are being considered throughout the Kent Valley south to White River (near Sumner), and in the Fredrickson area east and south into Thurston County.

OLYMPIC PENINSULA REQUIREMENTS

Need

Since the Peninsula system is radially fed from the BPA Olympia Substation, the power flow on the peninsula is not affected by high transfers across the regional system. However, this part of the system can be adversely affected by problems on the main grid, such as regional voltage collapse. The peninsula has large loads in such remote areas such as Bremerton and Port Angeles. These loads are connected to the main system at BPA Olympia by long transmission lines. In turn, the BPA Olympia Substation is connected to large 500 kV substations, like Raver, by long transmission lines. Loads at the end of this extended system are more affected by voltage changes than loads close to the large 500 kV substations. Due to its great distance from large 500 kV substations like Raver, and because it contains large loads, the Peninsula system is most adversely affected by problems such as regional voltage collapse.

Potential Improvements

In addition to 230 kV lines there are existing 115 kV transmission facilities that bring power to the Olympic Peninsula and Kitsap County. Transmission capacity to these areas can be increased by upgrading these lines and converting some of the lines to 230 kV. High voltage underwater cables could also be installed to connect areas separated by water. These lines would improve reliability and supply new loads in Kitsap, Jefferson, and Clallum counties. A 500 kV line could be built from Olympia, and terminated at a 500 to 230 kV transformer at Shelton. A line from Shelton to the Fairmount Substation and the Shelton transformer will support voltage on the entire Peninsula and supply additional power to these areas.

PROJECTS AND PLANS

Current projects and future plans for transmission facilities are organized into three categories: 1) transmission projects in progress, 2) mid term transmission plans, and 3) long term transmission plans. Map 2.3, *Future Transmission System*, shows the transmission lines and substations that are discussed. Each term is organized geographically, beginning in the north and then progressing south and around to the Olympic Peninsula.

This report is not submitted, nor any part of it is submitted, as a "proposal" for purposes of the State Environmental Policy Act ("SEPA"). Jurisdictions receiving this report are not requested to take any "action" for purposes of the SEPA with respect to any part of this report. Also, please note that discussion in this report of individual projects, and the relationship of individual projects to other projects, are presented in a regional context. However, any one or more of these projects (or a portion of a project) may solve independent local or subregional needs.

EXISTING LINES IN WASHINGTON STATE

Safety requirements specify the height that conductors must be located above streets, highways, railroads, open space and other types of land uses. Land use under transmission lines can change and/or the electrical loading on existing lines can change from the original design conditions, causing the need to raise conductors. Utilities will continue to modify existing lines as necessary to accommodate changing conditions. Often these changes only involve increasing the mechanical tension of the conductors, with little or no change needed in the support structures.

TRANSMISSION PROJECTS IN PROGRESS

These are near-term projects, which are often well defined with most of the system design features already resolved (see table 6).

Table 6 - Transmission Projects in Progress

AREA	PROJECT NAME
Whatcom & Skagit Counties	BPA/Puget NW Washington Transmission Project
Snohomish County	Sedro-SCL Bothell 230 kV Line Reconnect
Island County	March Point-Whidbey #3 115/230 kV Line
King & Kittitas Counties	Echo Lake Substation Schultz Substation Static VAR System at Maple Valley Substation
230 kV Facilities in King County	Lakeside 230 kV Substation Project IP Line Rebuild Berrydale 230 kV Development Christopher-O'Brien 230 kV Line Talbot-O'Brien 230 kV Line Upgrade Christopher 230 kV Development
Pierce & Thurston Counties	South Puget Sound Reinforcement White River-Cowlitz 230 kV Line Southwest-St. Clair 230 kV Line Southwest-Henderson 115 kV Line Southwest-Henderson 230 kV Line Conversion Alderton Transmission Station
Kitsap & Jefferson Counties	Henderson-South Bremerton 115 kV Line Salsbury Point-Fairmount 115/230 kV Conversion

WHATCOM AND SKAGIT COUNTIES

BPA/Puget NW Washington Transmission Project

This project includes rebuilding a 230 kV line to double circuit: one segment of the line would be from the BPA Custer Substation to BPA Bellingham; the other segment would be from BPA Bellingham to Sedro-Woolley. The project will improve reliability to the Whatcom and Skagit County areas, and increase the transfer capability between Canada and Western Washington to approximately 2850 MW.

The project includes rebuilding 37 miles of line to double circuit 500/230 kV, installing a second 230-115 kV transformer at the BPA Bellingham Substation, rebuilding one 115 kV line, constructing two short 115 kV line segments and upgrading other lines.

Sedro - Seattle City Light (SCL) Bothell 230 kV Line Reconnect Project

Two existing 230 kV lines run from Sedro-Woolley to the south. One line is a long tap of the Monroe-Snohomish 230 kV Line. By building a new substation in the tap, the Monroe-Snohomish Line can be protected from exposure to most faults on the long tap. This improves reliability for the

Monroe-Snohomish line. The Sedro-Woolley tap must be upgraded to increase its capacity in order to transfer load. By extending the Sedro tap from the new breaker to the Bothell Substation, loading on the Snohomish-Bothell 1&2 230 kV lines will be reduced.

ISLAND COUNTY

The Puget Sound area is unique in that the water boundaries dictate constrained transportation and growth patterns that are not typically found in other areas such as southern California. These water boundaries also affect the placement and development of transmission lines to serve customers. Since Whidbey Island is long and narrow, transmission facilities must be constructed the whole length of the island. Because of the difficulties of water crossings, the two existing 115 kV lines to the island were constructed from the north where they could cross Deception Pass with long aerial spans instead of using undersea cables.

March Point-Whidbey #3, 115/230 kV Line

A third line, the March Point-Whidbey #3, 115/230 kV Line, is planned for Whidbey Island from the mainland. This line will serve several purposes: 1) improve reliability against blackouts to the Island; 2) provide additional power capacity, and 3) improve voltage. The March Point-Whidbey #3 Line will operate at 115 kV, but it can be installed with 230 kV insulation so that it and other lines to Whidbey Island can later be converted to 230 kV.

KING AND KITTITAS COUNTIES

In the near future, most of the 500 kV improvements will maintain voltage stability under winter outage conditions.

Echo Lake Substation

BPA is constructing the Echo Lake Substation south of Snoqualmie at a location where the Rocky Reach-Maple Valley 345 kV Line intersects the Monroe to Raver 500 kV right-of-way. The resulting station would loop the Monroe-Maple Valley and Raver-Maple Valley 500 kV lines onto a new 500 kV bus. The 500 kV circuit breakers will sectionalize the existing Monroe-Maple Valley-Raver Line, improving reliability during outages. Shunt capacitors will be installed to provide added voltage support.

Schultz Substation

BPA is constructing a substation east of the Cascades to improve voltage stability in the Puget Sound region. Schultz Substation will be constructed near Ellensburg (Kittitas County) at about the midpoint of four of the cross-Cascades 500 kV lines. Each of these lines will be looped into the new substation with breakers on each line. Therefore, under an outage, only half of the former line will be lost from service, leaving the unfaulted half in service and continuing to support the voltage west of the Cascades. Series capacitors will be installed to provide added voltage support.

Static VAR System at Maple Valley Substation

Another near-term substation improvement currently under construction by BPA is to install a Static VAR System at Maple Valley Substation. This system is an arrangement of reactors, capacitors and solid state (static) thyristors that allows extremely fast changes in reactive supply. The system is planned to have a capacity of -300 to +300 MVAR and will support voltage if major cross-mountain lines or other nearby capacitor banks or reactors are switched in and out of service. The Maple Valley Substation is located on the east side of Renton.

230 KV FACILITIES IN KING COUNTY

500 kV facilities transfer power across the system and supply power through 500-230 kV transformers to the 230 kV network. The 230 and 115 kV systems then receive power from the 500 kV system, but they also receive power from many local generators and through 230 and 115 kV lines that extend outside the region. There are four of these lower voltage lines that cross the Cascades to the Columbia River system.

Discussion of the 115 kV system is contained in the local area electrical facilities plans. The 230 kV system needs and development will be discussed here. Because the 230 kV and lower voltage lines underlay the 500 kV grid they may transfer large quantities of power during outages of 500 kV lines and 500-230 kV transformers. This is a critical consideration in designing the 230 kV system.

Lakeside 230 kV Substation Project

The 230 kV sources for the 115 kV system in northeast King County are primarily the Sammamish and Talbot Hill substations. The loads on 230-115 kV transformers in these substations will be high enough to require new sources of transformation. The Lakeside Substation is near the major load center in this area and has been designed to accommodate 230-115 kV transformers. The Lakeside 230 kV Substation (Southeast Bellevue) project will rebuild two existing 115 kV lines to 230 kV between Sammamish and Lakeside, and between Lakeside and Talbot Hill. One of these lines will be energized at 230 kV to serve--initially one and later two--230-115 kV transformers at the Lakeside Substation.

Intermountain Power (IP) Line Rebuild Project

Puget Power owns the 115 kV line that crosses the Cascades and extends from Snoqualmie to east of the Columbia River. The structures for this line are wood poles that have deteriorated badly. The IP Line Rebuild project will rebuild the components of the line to 230 kV capability over many years, beginning with the worst condition equipment. The line will connect between the Grant County PUD Wanapum Substation near Wanapum Dam and the Puget Power Lake Tradition Substation in King County.

As part of the project, the IP line will terminate on a 230-115 kV transformer at Lake Tradition and provide 115 kV power to the East King County area. Substations that the IP line now serves will be converted to 230 kV. In the future, 230 kV lines will be energized from Lake Tradition to the proposed Novelty Substation and Berrydale as described later. By converting the IP Line to 230 kV, it will become a stronger link in transferring power from Columbia River dams to eastern King County and strengthen the 230 kV system.

Berrydale 230 kV Development

In southeast King County the 230 kV sources for the 115 kV system are the Talbot Hill, O'Brien and White River substations. During a single transformer outage at Talbot Hill or White River, the remaining transformer overloads. To the east, the existing Berrydale Substation is planned to have one 230-115 kV transformer installed initially, with room for a second transformer to be installed later. The Berrydale 230 kV Development is to rebuild an existing 115 kV line between Talbot Hill and Berrydale to double circuit 230 kV and use one circuit at 230 kV to feed a new transformer at Berrydale.

The Christopher-O'Brien 230 kV Line & Talbot-O'Brien 230 kV Line Upgrade

In southwestern King County, O'Brien and White River are the major substations supplying the 115 kV subtransmission network. Through the Renton/Kent/Auburn Valley, the Talbot Hill-O'Brien-Christopher 230 kV Line has only one circuit strung on a line which has double circuit structures. When other transmission facilities are out of service, this line can overload. The Christopher-O'Brien 230 kV Line upgrade and Talbot-O'Brien 230 kV Line Upgrade are projects to increase the rating of the lines.

Christopher 230 kV Development

Currently, the Christopher Substation has a 115 kV switchyard. It is planned to add first a 230 kV switchyard with 230-115 kV transformers and then later a

500 kV bus with a 500-230 kV transformer. The Christopher 230 kV Development is the first step to construct a 230 kV bus, line breakers and a 230-115 kV transformer. This transformer will provide 115 kV power to serve growing loads in the Sea-Tac, Federal Way and the Green River Valley areas. Studies have confirmed that this location is effective in sharing and relieving load on the transformers at O'Brien and White River.

PIERCE AND THURSTON COUNTIES

Puget Power and TCL developed a joint plan to address several needs in Pierce, Thurston and Kitsap counties. TCL receives most of its power through a 230 kV bus at BPA Tacoma Substation; failure of a bus section-breaker could result in loss of most of their system. TCL wheels power for BPA to Peninsula Power and Light situated north of the Tacoma Narrows. The Peninsula load is growing beyond the capacity of the existing transmission lines which also require rebuilding. In Kitsap County, Puget Power and BPA loads are projected to be higher than the capacity of the one supply transformer at the BPA Kitsap Substation if the other transformer is out of service. There is one 230 kV line to Thurston County from Pierce and King counties. (That line is paralleled by a 287 kV line from Grand Coulee to Olympia). A 500 kV line outage can cause the 230 kV line to overload. A 230-115 kV transformer is needed at St. Clair Substation which would add more load to this line.

The South Puget Sound Reinforcement Plan was developed by TCL and Puget Power to address these needs and to provide for additional growth. It has three 230 kV elements that are called: (1) TCL/Puget White River-Cowlitz Interconnection, (2) TCL/Puget Southwest-St. Clair Interconnection, and (3) TCL/Puget Southwest-Henderson Interconnection.

A 115 kV BPA element called Gig Harbor Area Reinforcements will be perfected with additional studies that addresses the integration of the TCL Cushman generation.

White River-Cowlitz 230 kV Line and Southwest-St.Clair 230 kV Line

The White River-Cowlitz 230 kV Line will give TCL an additional strong source of power to their system at 230 kV. A Southwest-St. Clair 230 kV Line will parallel and reduce loading on the existing 230 kV line to Olympia, and a transformer at St. Clair will provide load relief for the Olympia 230-115 kV transformers.

Southwest-Henderson 115/230 kV Line

The Southwest-Henderson 230 kV Line and an associated 230-115 kV transformer at Henderson will provide a new, strong source of 115 kV supply to Peninsula Power and Light, and to Kitsap County loads. This project is planned to be constructed in phases. Existing 115 kV lines between Southwest and the future Henderson Substation will be rebuilt for 230 kV and with higher capacity conductors. These lines will be initially operated at 110 kV.

Two years after the line from Southwest to Henderson is rebuilt, it will be converted to 230 kV and terminate at a 230-115 kV transformer at Henderson. These stages will provide more capacity to serve increases in load demand and to reduce flows on transmission lines from Pierce to Thurston County.

Proposed Alderton Transmission Station

The proposed Alderton Substation is located between Puyallup and Orting, on the east side of the South Hill area. Initially it will interconnect four 115 kV lines, improving reliability in this area. Later in the mid term, a 230/115 kV transformer may be added as a source for the 115 kV system.

KITSAP & JEFFERSON COUNTIES

Kitsap County electrical loads are supplied by two 230 kV lines connected to two 230-115 kV transformers at Kitsap Substation. The East Port Orchard area in the south is also served by a 115 kV line from the O'Brien Substation in King County that uses undersea cables to cross Puget Sound. The load in Kitsap County is reaching the capacity of these facilities under conditions when one of the lines or transformers is out of service. Additionally, Peninsula Power and Light loads in north Pierce County will soon exceed the capacity of the existing Tacoma City Light Potlatch 110 kV lines.

Henderson-South Bremerton 115 kV Line

In conjunction with the Southwest-Henderson 115/230 kV Line, a new line will be constructed between Henderson and Puget Power's Fernwood Substation. The circuit will be connected to South Bremerton using an existing 115 kV line.

Salsbury - Fairmount 115/230 kV Conversion

A 115 kV (future 230 kV) transmission tie is planned between the Salsbury Point Cable Station in Kitsap County and the Fairmount Substation in Jefferson County. This line will be constructed by rebuilding the existing Shine-Irondale 69 kV Line, laying a new submarine cable across Hood Canal, and constructing a new line segment from Irondale to Fairmount on an existing powerline right-of-way. The line is being rebuilt with 230 kV insulators and the new Hood Canal cable will be insulated for 230 kV, but they will be initially energized at 115 kV. These lines will serve existing needs and will be important elements of a future 230 kV grid as loads grow and they are needed.

MID TERM TRANSMISSION PLANS

The previous section on Projects in Process discussed projects that are often well defined with most of the system design features already resolved. The Mid Term Transmission plans are more conceptual in nature. In the case of the Mid Term and Long Term Transmission Plans, the needs must be anticipated from the expected load growth and probable generation sources. These plans will sometimes change as loads, generation, and technology opportunities change.

MID TERM TRANSMISSION PLANS	
COUNTY/AREA	PLAN NAME
Skagit & Island Counties	Sedro-Woolley-March Point #2 230 kV Line March Point-Whidbey 230 kV Line Conversion Sedro-Woolley-Novelty 230 kV Line
King and Kittitas Counties	King County System Reinforcement Project
Snohomish County	Central County Reinforcement Puget/Snohomish PUD 115 kV Interconnections
Monroe 500 kV Integration	Puget Sound Reinforcement North Seattle Transformer Reinforcement
King County (North)	Novelty Substation McKenzie-Novelty 115 kV Line Sammamish-Novelty 230 kV Line Novelty-Lake Tradition 230 kV Line Lake Tradition-Berrydale 230 kV Line
King County (South)	White River-Christopher 230 kV Line Christopher 500-230 kV Transformer Newaukum Substations Berrydale-Lake Morton 115/230 kV Line
Pierce & Thurston Counties	Alderton 230-115 kV Transformer Alderton-Frederickson #1 230 kV Line South Seattle-Olympia System Reinforcement Frederickson-St. Clair 230 kV Line Frederickson-Tono 230 kV Line St. Clair-BPA Olympia 230 kV Line Frederickson-Cowlitz 230 kV Line Frederickson to Southwest 230 kV Line
Kitsap County	Henderson-South Bremerton 230 kV Line BPA Kitsap-South Bremerton 230 kV Line Kitsap-Foss Corner 230kV Line Foss Corner-Fairmount 230 kV Line

SKAGIT AND ISLAND COUNTIES

Sedro-Woolley-March Point #2 230 kV Line

Power to the Anacortes area and Whidbey Island passes through the Sedro-Woolley and March Point substations. A single 230 kV line from Sedro-Woolley serves a 230-115 kV transformer at March Point Substation. The 230 kV bus and transformer at March Point stabilize voltage for Anacortes and Whidbey Island loads. However, loss of the 230 kV line or transformer can result in large power and voltage swings, or low voltage.

A second Sedro-Woolley to March Point 230 kV line will maintain stable voltage at March Point when the existing line is out of service. With a second line, the greatest remaining risk is loss of the single 230-115 kV transformer at March Point.

March Point-Whidbey 230 kV Line Conversion

The next step could be converting the new March Point-Whidbey #3 115 kV Line to 230 kV and installing a 230-115 kV transformer at the Whidbey Substation. The resulting system will have two 230 kV lines from Sedro-Woolley to March Point, one 230-115 kV transformer at March Point, one transformer at Whidbey on a radial 230 kV line from March Point, and two 115 kV lines between the two transformers.

Sedro-Woolley-Novelty 230 kV Line

Much of the currently planned generation for the region is in Whatcom and Skagit counties. This is due in part to proximity to Canadian natural gas supplies and existing industrial processes that can readily use the large quantities of low pressure steam available from cogeneration processes. In addition to generation planned south of the border, it is expected that Canada will also construct generating facilities and offer energy for sale to the U.S. A network of 500 and 230 kV lines is necessary to transfer the generating resources from Canada, and from Whatcom and Skagit counties. Additional 230 kV lines from Skagit to King County are needed to transfer power from the north.

A 230 kV line is planned to be extended further south to the new Novelty Substation in east King County. The line be named the Sedro-Woolley-Novelty 230 kV line. To accomplish this, the 115 kV line from Sedro to the Beverly Park Substation in Snohomish County would be rebuilt as a double-circuit 115/230 kV line. A portion of the McKenzie (in Chelan County), to Beverly Line (going east from Beverly) would be rebuilt for 230 kV. A new line would be further extended south from the McKenzie-Beverly Line at a point east of Monroe to Novelty. (This is described further in a discussion on the Novelty Substation.)

KING AND KITTITAS COUNTIES

King County System Reinforcement Project

The transmission paths from the north, east and south all have two or more 500 kV lines. However, in the center of the system, between the Monroe, Raver and Paul substations, there is only a single 500 kV line. When this line is lost from service, most of the power previously flowing on that line will then flow on the underlying 230 and 115 kV system. Since the underlying system already carries power to supply the loads it normally serves, this additional load has a high impact on the lower voltage system and can cause system overloads.

The purpose of the King County System Reinforcement is to reinforce the transmission system between the Monroe and Echo Lake substations. One alternative to this project is to build a second 500 kV line between Monroe and Echo Lake parallel to the existing line. During outages, the new line would serve as a back up for the existing 500 kV line. Then the underlying 230 and 115 kV systems would not overload due to an outage of either Monroe-Echo Lake 500 kV Line.

An alternative to the Monroe-Echo Lake 500 kV Line is to rebuild the Monroe-Novelty portion of the Monroe-Sammamish Line and to rebuild part of the Sammamish-Maple Valley Line. A second Monroe to Echo Lake 500 kV line can be obtained by rebuilding parts of these lines to single or double circuit 500 kV construction. These sections of line are located on a separate corridor from the Monroe-Raver 500 kV Line.

SNOHOMISH COUNTY

Central County Reinforcement

The Snohomish County PUD will need additional sources of 115 kV power in the Everett area. The Beverly Park Substation was rebuilt to allow a 230 kV bus and 230-115 kV transformers. To bring 230 kV to Beverly Park Substation, one of the 230 kV lines from Sedro-Woolley can be looped into the substation, or a BPA 115 kV line from BPA Snohomish Substation can be converted to 230 kV.

Puget/Snohomish PUD 115 kV Interconnections

A new line from Skagit County to Snohomish County is under review. Initially, the line would be built for 115 kV, but could be later converted to 230 kV. It would transmit power generated in Skagit County into Snohomish County, providing an additional source of power to the northern area of Snohomish County and Camano Island.

Interconnecting lines between Snohomish County PUD and Puget Power's proposed Moorland Substation are being studied. Other ties are being reviewed. These ties will strengthen the 115 kV subtransmission system for South Snohomish and North King counties.

MONROE 500 KV INTEGRATION

Puget Sound Reinforcement Project

BPA is developing a plan to construct a double-circuit 500 kV line between the Columbia River system and King County called the Puget Sound Area Reinforcement. There are several variations of this plan under review. Potential corridor locations have been identified in the draft BPA study "North Cascades Corridor Availability Study" (May 1990). The plan that BPA currently has in their budget is to rebuild its double-circuit Chief Joseph-Snohomish 345 kV Line that passes through Stevens Pass to a double-circuit 500 kV line. Both circuits would be connected between the Chief Joseph and Monroe substations. A double 500 kV circuit would extend from Monroe to the Snohomish Substation with one side operated at 500 kV, terminating in a 500/230 kV transformer, and the other side operated at 230 kV.

An alternative to converting the Chief Joseph to Snohomish lines is to rebuild and convert the Rocky Reach-Maple Valley 345 kV Line to double circuit 500 kV. It would be extended to terminate at Chief Joseph and Echo Lake substations.

Another version of Stephen's Pass 500 kV Line plan is to bring one circuit from Chief Joseph into Monroe and the second circuit into Echo Lake to the south. By connecting the lines together with a switching station near Index they would effectively provide a second 500 kV line between Monroe and Echo Lake, and thus provide the second Monroe to Echo Lake line that is needed for the King County Reinforcement Project.

North Seattle Transformer Reinforcement, (BPA)

BPA plans to install a 500-230 kV transformer at the Sno-King Substation, South Snohomish County. The BPA project is called the North Seattle Transformer Reinforcement. The Sno-King tap of the Monroe-Sammamish

230 kV Line would be converted to 500 kV and a 500-230 kV transformer added at Sno-King Substation. An existing SCL 230 kV line would be looped into the Sno-King 230 kV bus to distribute additional power from Sno-King Substation.

KING COUNTY (NORTH)

Northeast King County 230 kV Source

The sites for 500-230 kV transformers nearest North King County are Monroe and Sno-King to the north and Maple Valley to the southwest. A substation site in North King County will need to be developed as a source of 500-230 kV transformation in that area. It will need to be situated to serve growing loads around it and connect 230 kV lines that will strengthen ties and give support to the north, south, east and west.

Proposed Novelty Substation

The Novelty Substation will be developed first as a 115 kV substation interconnecting local 115 kV lines. Later, a 230-115 kV transformer will be installed as loads on the 115 kV system require it. The McKenzie-Beverly 115 kV Line will be looped into Novelty by constructing a 15 mile double circuit 115/230 kV line from a point on that line near Monroe, south to Novelty, paralleling the Monroe to Sammamish 230 kV right of way.

A new 230 kV circuit between Sedro and Novelty will be obtained by rebuilding the Sedro-Beverly 115 kV Line and the McKenzie-Beverly 115 kV Line between Beverly and Monroe. Many other 230 kV lines will also be constructed and connected to a 230 kV bus at Novelty.

East Sammamish

The existing 230 kV ties with Monroe and Maple Valley will be maintained. The proposed East Sammamish 230 kV Line to Lake Tradition would parallel other north-south 230 kV lines electrically and reduce their loading under outage conditions, such as the loss of the Maple Valley 500-230 kV transformer.

Lake Tradition-Berrydale 230kV Line

Initially, the Lake Tradition 230 kV bus and transformer will be supplied by the IP Line after it is converted to 230 kV. This will improve reliability and provide stable voltage regulation will be improved for the substations that are served along the line. In the winter, 500 kV outages will cause the Lake Tradition 230-115 kV transformer to load heavily. However, connecting the Lake Tradition 230 kV bus to other 230 kV buses will greatly improve voltage regulation, and unload the 230-115 kV transformer. The portion of the East Sammamish 230 kV Line described above and the Lake Tradition-Berrydale 230 kV Line will do this and also provide a strong north-south parallel path to unload existing 230 kV lines.

KING COUNTY (SOUTH)

Large increases in population and employment are expected in south King and Pierce counties. Additional 500-230 kV transformation is projected to serve new loads and integrate co-generation that is expected in Tacoma and Frederickson. Substations that can utilize 500-230 kV transformers need to have a 230 kV bus and a network of 230 kV lines. The year by year development of the lower voltage network comprises the majority of improvements discussed here for south King and Pierce counties.

White River-Christopher 230 kV Line

The 230 kV bus at Christopher Substation has already been discussed as a transmission project in progress. The nest 230 kV connection will be a White River-Christopher 230 kV Line. At that time, Christopher will have a 230 kV line north to O'Brien, east to Covington, west to BPA Tacoma, and now south to White River.

Christopher 500-230 kV Transformer

A 500-230 kV transformer will be installed at Christopher, making it a strong source for the O'Brien and White River substations, and providing backup to the Covington and Tacoma 500-230 kV transformers. The transformer could be fed at 500 kV by using an existing 500 kV circuit from Raver to Covington that is currently jumpered in parallel with the Raver-Tacoma 500 kV Line, and converting a Covington to Christopher 230 kV Line segment that is already insulated for 500 kV.

Two other 500-230 kV sites are similar to Christopher but require much more work and are expected to be fully developed farther in the future. They are Newaukum, which is eight miles east of White River Substation, and Graham, which is near and to the south of Frederickson Substation in Pierce County. These transformer projects may extend into the Long Term period, and are discussed further in the Long Term section.

Newaukum Substation

Newaukum is a Puget Power site that is located at the intersection of the Rocky Reach-Berrydale 230 kV Line and the White River-Krain Corner 55 kV Line. As a 500-230 kV transformer site, the Rocky Reach-White River right of way would be used to bring a 500 kV line to the location. The site is centrally located in southeast King County as a collector for 230 kV lines from all directions. During the Mid Term, Newaukum will be a 115 kV switching station. Later, the lines constructed to Newaukum will be converted to 230 kV after a 500-230 kV transformer has been installed there.

Berrydale-Lake Morton 230 kV Line

The Berrydale-Lake Morton 230 kV Line will be built in the near term as a double circuit line. One line will serve distribution load. The second line is planned as one of several lines to terminate at Newaukum. The Berrydale-Krain Corner Line could become a second Newaukum to White River 115/230 kV tie. The White River-Krain Corner 55 kV Line would be rebuilt and looped into Newaukum. It will be used as a 115 kV tie and later as a 230 kV line. The Osceola 115 kV Line will be rebuilt and may be used as a Newaukum to Alderton 115/230 kV line. These lines will be constructed for 230 kV but operate at 115 kV until they are needed to transfer power out of Newaukum.

PIERCE AND THURSTON COUNTIES

Alderton 230-115 kV Transformer

To improve reliability and to relieve loading on 115 kV lines, the Alderton Substation (southeast of Puyallup) will be constructed in the Near Term period as a 115 kV switching station. It could be used with a 230-115 kV transformer to supply power to the 115 kV subtransmission system. Also, the White River-Cowlitz 230 kV Line could be looped into a 230 kV bus at Alderton to energize the transformer.

Alderton-Frederickson #1 230 kV Line

A new 115/230 kV line is proposed to be built between Alderton Switching Station and Frederickson Generating Station. This line would be built and energized at 115 kV in the short term, with a conversion to 230 kV during the Mid Term period. Energized at 230 kV, this line will provide a connection between Alderton and White River stations as additional generation is added to the Frederickson area. This line would also provide an additional source of power to the proposed 230-115 kV transformer addition at Alderton Substation when a 230 kV station is developed at Frederickson. The development of a 230 kV station at Frederickson depends upon BPA's plans for their South Tacoma Substation rebuild and additional generation proposed in the area.

South Seattle-Olympia System Reinforcement

During heavy import and export periods, there are heavy flows across King, Pierce and Thurston counties and on south into southwestern Washington and Oregon. In addition, power flows through these counties to serve Peninsula loads. The result is that generation and imports added into the Puget Sound Basin will increase the flows south. An outage of the Raver-Paul 500 kV Line causes stress on the underlying system. The Raver-Paul Line is the only 500 kV line that is built across Pierce and Thurston counties to link Raver with Paul. Raver is the terminus for many cross-Cascades 500 kV lines while Paul is the terminus for the Portland/Olympic Peninsula 500 kV lines.

A second 500 kV line is being planned to parallel the Raver-Paul 500 kV Line. BPA has a project under study entitled *South Seattle-Olympia System Reinforcement*, which will probably include this addition. The project is still under study. Another option is to rebuild some existing 230 kV lines to 500 kV to form a Raver to Olympia 500 kV line (which together with the existing Paul-Olympia Line effectively forms a second Raver to Paul 500kV line).

Frederickson-St. Clair 230 kV Line

There are large parcels of industrially zoned property in the Frederickson area south of Tacoma. Companies are interested in large-scale development that will require new sources of power. A major gas pipeline also passes through the area, and Puget Power and other utilities have received bids by potential Independent Power Producers to construct co-generation facilities. The existing 230 kV facilities do not have capacity to receive the non-utility generated power.

To add capacity, to prevent overloading on existing lines and to allow integration of independent power producers, new 230 kV lines are planned from the Frederickson Substation to St. Clair Substation in Thurston County and the Tono Substation in Lewis County. The Frederickson-St. Clair 230 kV Line is expected to parallel the existing South Tacoma-Olympia 230 kV Line and then turn north near Lake St. Clair towards the St. Clair Substation. This line reinforces the 230/115 kV transformation at the St. Clair Substation and provides an additional 230 kV tie between Pierce and Thurston counties.

Frederickson - Tono 230 kV Line

The Frederickson-Tono Line is also expected to be constructed parallel to the existing South Tacoma-Olympia 230 kV Line, then along the City of Centralia 69 kV right of way (replacing it with the new line). The Yelm Hydro Generating Plant could be integrated into Puget Power's 115 kV system near the Longmire Substation, Thurston County. A 500-230 kV transformer will be required at Tono for termination of the new 230 kV line. Additional support may then be needed in the Chehalis/Centralia 69 kV system.

St. Clair-BPA Olympia 230 kV Line

A new 230 kV line between St. Clair and BPA Olympia will be needed to relieve loading on the existing South Tacoma-Olympia 230 kV Line. This line could be obtained by rebuilding either the South Tacoma-Olympia 230 kV Line, the Coulee-Olympia 287 kV Line, or one of the St. Clair-Olympia 115 kV lines. The result would be a continuous 230 kV path from Frederickson through Cowlitz, Southwest and St. Clair on to BPA Olympia.

Frederickson-Cowlitz 230 kV Line

A Frederickson-Cowlitz 230 kV Line is planned to further use the Cowlitz-Southwest-St.Clair 230 kV path into Thurston County (Cowlitz and Southwest substations are owned by TCL).

Frederickson to Southwest 230 kV Line

To reinforce the Southwest Substation a new line will be built from Frederickson to Southwest. This line will be needed when the loss of the Cowlitz-Southwest 230 kV Line overloads the Tacoma-Southwest 230 kV Line. This line will then provide a Frederickson-Southwest-Henderson 230 kV path into Kitsap County.

KITSAP COUNTY

Henderson- Kitsap- Foss Corner 230 kV Line

As load growth occurs in East Port Orchard, Bremerton and Silverdale, the Henderson-South Bremerton 115 kV Line will be extended through South Bremerton to Kitsap. It will be converted to become a Henderson to Kitsap 230 kV line. This line will relieve loading on the 115 kV undersea cable between the O'Brien Substation in King County, the South Bremerton Substation, and the 230 kV lines from Shelton into Kitsap County. For power that serves the Peninsula system this conversion will reduce the loading on transmission lines from Pierce into Thurston County.

A 115 kV line between the Kitsap and Foss Corner substations (described in Transmission Projects in Progress) will be converted to 230 kV. It will then transfer power at 230 kV between the north and south ends of Kitsap County. Half of the right-of-way for this line is already owned. Several miles will parallel the existing Kitsap-Bangor 115 kV Line. A 230-115 kV transformer will be installed at the Foss Corner Substation to relieve loading on the existing transformers at Kitsap.

Foss Corner-Salsbury Point 230 kV Line

Either a new 230 kV line will be constructed between Foss Corner and Salsbury Point or the existing Foss Corner-Salsbury Point 115 kV Line will be rebuilt for 230 kV. Then the Salsbury Point-Fairmount 115/230 kV Line (described in Near-Term Transmission Projects) will be energized at 230 kV to provide backup reliability to the Foss Corner transformer. As a 230 kV line in parallel with the existing Shelton-Fairmount 230 kV Line, it will improve reliability and voltage to the northern Olympic Peninsula and Port Townsend. A 230 kV stepdown transformer off this line may be installed at the Irondale Substation or a 115 kV line may be constructed from Fairmount to Irondale. Both the Kitsap-Foss Corner and the Foss Corner-Fairmount lines will then be connected at a Foss Corner 230 kV to Whidbey Island and the Skagit County system. The result of this will be a strong new source to the Fairmount Substation and Kitsap County.

LONG-TERM TRANSMISSION PLANS

These long-term conceptual plans will be influenced by load growth, generating patterns, and changes in technology. Some examples of new technology might be: 1) local loads may have new generation supplies (like solar panels) that supplement utility supplies part of the day; 2) new generating technologies (e.g., wind power) may require changes to the existing transmission system; and 3) new electric loads (such as electric-powered cars) may emerge. The long-term plans encompass the system needs that have been projected as a result of current long-range population and employment forecasts (see Table 7).

Table 7 - Long Term Transmission Plans

LONG-TERM TRANSMISSION PLANS	
AREA	PLAN NAME
Pacific Northwest-Canada Interties	Ingledow-Custer #3 500 kV Line Custer-Monroe #3 500 kV Line Rebuild
Skagit-King County	Sedro-Sammamish 230 kV Line
North King County	Novelty 500 to 230 kV Transformation McKenzie-Novelty 115 kV Line 230 kV Conversion Novelty-Lakeside 230 kV Line Bothell-Lakeside & Bothell- Sammamish 230 kV Line Mt. Si Substation 230 to 115 kV Transformation Mitchell Substation, Novelty-Mitchell, Lake Tradition-Mitchell, and Mt. Si-Mitchell 230 kV Lines Maple Valley-North-SnoKing 230 kV Line Loop
	Echo Lake-Raver #2 500 kV Line Covington-South 230 kV Line Cross Cascades to Newaukum 500 kV Line Berrydale-Newaukum #1 and #2 230 kV Lines Newaukum-White River #1, #2, and #3 230 kV Lines Newaukum-Alderton 230 kV Line
Pierce & Thurston Counties	Alderton-Frederickson #2 230 kV Line Graham Substation Tacoma Narrows Improvements St. Clair-Tono 230 kV Line Spurgeon Substation
Whidbey-Kitsap Transmission	Mutiny Bay-Foss Corner 115/230 kV Lines
Olympic Peninsula	Olympia-Shelton 500 kV Line & Shelton Transformer

PACIFIC NORTHWEST-CANADA INTERTIES

The transmission intertie between the west side of Washington State and Canada comprises two 500 kV lines. The most severe contingency for that intertie is loss of both Ingledow-Custer 500 kV lines. If there were high transfers of power concurrent with such a double contingency outage, there would be damaging high voltage swings on the system, especially in the Vancouver B.C. area. Therefore, these voltage swings become the limiting factor for the maximum power transfer that can be reliably sustained between British Columbia and Washington.

Ingledow-Custer #3 500 kV Line

If additional lines were constructed between Vancouver B.C. and Whatcom County, higher transfers could be achieved. Then, when a double-line outage occurred, there would be one or more additional remaining lines. An Ingledow-Custer #3 500 kV line is one alternative transmission improvement. Also, higher transfer levels could be achieved with 230 kV tie lines between Canada and the U. S. There are other possible connections including lines to the east of the Ingledow-Custer corridor.

Custer-Monroe #3 500 kV Line Rebuild

The two 500 kV lines south of the border between Custer and Monroe also limit US-Canadian transfers that can be reached, but at a higher level. Again, a third 500 kV line is one alternative to increase transfers. Under the BPA/Puget NW Washington Transmission Project that is now in progress, the existing Custer to Sedro-Woolley 230 kV Line is being rebuilt for double circuit. It may be rebuilt to 500 kV standards but operated at 230 kV. One circuit of this line could then be used as a portion of the third 500 kV circuit. However, the 230 kV circuit that was converted to 500 kV may still be needed and could be replaced by converting another 115 kV circuit to 230 kV.

SKAGIT-KING COUNTIES

Sedro-Sammamish 230 kV Line

The Sedro-Bothell and the Bothell-Sammamish 230 kV lines will be reinforced with an additional 230 kV line. The Sedro-Beverly 115 kV Line was described in the Mid Term plans as being rebuilt with double-circuit 230 kV, so a new circuit could connect to the Novelty Substation. Also, the Sedro-Beverly 115 kV Line will be converted to 230 kV and, by double-circuiting other lines, it will be extended from Beverly to Sammamish. Portions of the Beverly-Cottage Brook and the Sammamish-Moorlands 115 kV lines will be rebuilt for double-circuit 115/230 kV. The additional circuit will be reconnected at Beverly, forming a new Sedro Wooley to Sammamish 230 kV line.

KING COUNTY (NORTH)

Novelty 500 to 230 kV Transformation

The Novelty Substation will have 230 kV lines connecting it to BPA Monroe, Sedro-Woolley (in Skagit County), Sammamish, Lake Tradition and Maple Valley. If possible, the Novelty Substation is ideally suited for a future 500 to

230 kV transformer. If the 345 kV line bypassing that substation is rebuilt to double-circuit 500 kV (forming the Monroe-Echo Lake #2 500 kV Line), it could be looped into Novelty. To bring 500 kV to Novelty from the Monroe-Echo Lake #1 500 kV Line right of way, a 8.5 mile loop would constructed from the right of way to Novelty.

The McKenzie-Novelty 115 kV Line Lonversion to 230 kV

During this same time frame, the McKenzie-Novelty 115 kV Line will be converted to 230 kV. Like the IP Line, this is a cross-Cascades 115 kV wood pole line that will be rebuilt as needed with 230 kV insulators and heavier conductors. In the Long Term plans, it will finally be converted to 230 kV, which will allow it to support higher loads along the line and heavier flows across it.

Novelty-Lakeside 230 kV Line

A Novelty to Lakeside 230 kV line could be obtained by using the other circuit of the Novelty-Sammamish double-circuit 230 kV line and converting the Sammamish-Lakeside 115 kV Line to 230 kV. This line will serve as a second and backup path of 230 kV power to Lakeside and Sammamish substations from Novelty.

Lakeside and Sammamish Loop for the SCL Bothell-Maple Valley 230 kV Lines

One of the SCL Bothell-Maple Valley 230 kV lines could be looped into either the Lakeside or Sammamish substations. Then these lines could serve as another source for the 230-115 kV transformers at those substations. Approximately 1.5 miles of 230 kV transmission line would be required to loop the line through Sammamish. Also, a shorter distance of new line would be required to loop the line through Lakeside.

Maple Valley-North-SnoKing 230 kV Line Loop

Electrical supply to northern Seattle is provided primarily by 115 kV lines from the north. An additional source could be provided by looping the Maple Valley-SnoKing Line into North Substation between the University and Northgate districts. A 230 kV submarine cable would be installed across Lake Washington from the Bothell-Renton right-of-way and a 230/115 kV transformer would be added at North Substation.

Mt. Si Transmission Station

The Mt. Si Transmission Substation will ultimately allow the 230 kV IP Line to be used to strengthen the 115 kV grid in the East King County area. This substation could include a double banked 230/115kV substation with approximately eleven lines: two double circuit lines east and north toward Snoqualmie Switch; two single circuit and one double circuit lines west toward Lake Tradition; and the IP, Mario and Upper Preston lines south.

Mitchell Substation, Novelty-Mitchell, Lake Tradition-Mitchell, and Mt. Si-Mitchell 230 kV Lines

A 230 kV line and the projected Mitchell Substation will be needed to serve the total anticipated load for the East Sammamish area. The lines should connect Mitchell to Novelty, Mt. Si, and Lake Tradition. These lines would serve the substations in the eastern part of the plateau, as well as provide 230 kV support in the eastern part of King County. Future connections are possible to the large undeveloped area north of the City of Snoqualmie and east of the Snoqualmie River.

KING COUNTY (SOUTH)

Echo Lake-Raver #2 500 kV Line

By this time, only one section of the north-to-south transfer path through King County would have a single 500 kV line, i.e., between the Echo Lake and Raver substations. A second Echo Lake to Raver 500 kV line may be constructed so that the loss of the single line does not severely impact the underlying lower voltage system. There are alternatives that achieve the same benefit electrically by connecting a second line to other 500 kV substations. The new line must provide a parallel path with the existing line. In the event that either line is out of service, most of the power that previously flowed on the lost line will transfer to the second line, adding to the amount it was previously carrying. However, the underlying, lower voltage lines would not have to carry much of this power.

Covington-South 230 kV Line

An additional line is projected to relieve loading on existing 230 kV lines that bring power to Seattle from the south. The plan for this line involves three phases: 1) the single circuit 230 kV line from Covington Substation to the Cedar Falls right of way will be rebuilt to a double circuit 230 kV line; 2) the Cedar Falls 115 kV single circuit line will be rebuilt to a double-circuit construction which will add a 230 kV circuit from Covington-Maple Valley right of way to the West Valley Road; 3) a single-circuit, 20 mile long 230 kV line will be constructed on the West Valley Road and existing transmission right of way to the South Substation.

Cross-Cascades to Newaukum 500 kV Line

Puget Power is considering using its Rocky Reach-White River 230 kV Line as a right-of-way path for a cross-Cascade 500 kV double circuit line. This line's capacity would be comparable to the BPA cross-Cascade line (discussed under Mid Term plans.) It would be required if new generation was planned east of the Cascades. A terminus in eastern Washington has not been determined yet; there are several possibilities but they depend on the generation sources. On the west side of the Cascades, the two circuits could terminate at Newaukum or they could be joined at a junction station (e.g., the proposed Palmer Substation) and then go to two different substations, such as Newaukum and Echo Lake.

The Newaukum Substation was described in the Mid Term plans as a future 500-230 kV transformation site. The existing Raver-Paul 500 kV Line, a new line, or a second line could be looped into Newaukum. As discussed above, Newaukum could terminate one or both of the 500 kV lines that use the Rocky Reach-White River right of way. A 500-230 kV transformer is planned to provide 230 kV supply to a large area of Southeastern King County and Eastern Pierce County.

An alternative to using the Rocky Reach-White River Line is to convert the Rocky Reach-Maple Valley 345 kV Line to double circuit 500 kV. The existing 345 kV line goes through the Cascade Mountains at Snoqualmie Pass. This conversion is described as an alternative for the Puget Sound Reinforcement Project in the Mid Term plans.

Berrydale-Newaukum #1 and #2 230 kV Lines, Newaukum-White River #1, #2 and #3 230 kV Lines, and Newaukum-Alderton 230 kV Line

In preparation for a 500/230 kV transformer at Newaukum Substation, a 230 kV bus and lines must be established there. The Lake Morton and the Krain Corner lines would then become the Berrydale-Newaukum #1 and #2 230 kV lines. The existing Rocky Reach-White River 230 kV, the White River-Krain Corner 115 kV and the Sherwood 115 kV lines become the Newaukum-White River 230 kV lines. Finally, the 115 kV line through Osceola to Alderton would be converted and become the Newaukum-Alderton 230 kV Line.

PIERCE AND THURSTON COUNTIES

Alderton-Frederickson #2 230 kV Line

Once the White River-Electron Heights #2 Line is routed from Alderton Station to Frederickson Station, this portion would be rebuilt to 230 kV. In the long-term, this conversion would provide a second 230 kV line between Alderton and Frederickson, which would allow power to flow from the White River and Newaukum substations to Frederickson. From there, additional line projects would provide two 230 kV lines going southwest into Thurston County.

Graham Substation

In the long term, a 500-230 kV transformation site will be needed in south Pierce County. A specific site could be determined after studies are completed, but the Graham or Frederickson area would be the most likely area. For this report, the substation will be given the interim name of Graham. No other 500-230 kV transformation site exists or is planned south of Tacoma. The Graham site could receive 500 kV power by constructing a loop from the Raver-Paul 500 kV Line or a loop from the proposed Raver-Paul #2 500 kV Line.

Tacoma Narrows Improvements

The second crossing of the Tacoma Narrows will be converted to 230 kV and a second 230 kV line will be built between the Narrows Substation and South Kitsap County along the existing corridor from the Narrows to Purdy.

St. Clair-Tono 230 kV Line

Corridors for transmission lines between Pierce and Thurston counties are restricted because of the McCord and Fort Lewis military bases and because land north of them is already heavily populated. Puget Power has a 55 kV line that will be converted to 230 kV in the near term. A 230 kV line from Frederickson to Tono is described in the Mid Term Plans. These lines supply part of the power for Thurston County and the Olympic Peninsula, and support flows south of Thurston County.

In Thurston County, the St. Clair Substation will have 230 kV lines from Pierce County to the east and a 230 kV line tie to the BPA Olympia Substation. A 230 kV line will be constructed south to the Tono Substation, terminating at the 500-230 kV transformer there. This line could utilize parts of an old 55 kV line through central Thurston County and would provide a strong tie between north and south and could also serve distribution substation sites. The line would be looped through a future substation site called Spurgeon.

Spurgeon Substation

A 230 kV line is planned from BPA Olympia to the proposed Spurgeon Substation site. This site is located in the center of Thurston County in an area called East Olympia. It will be interconnected with the St. Clair-Tono 230 kV Line at Spurgeon, effectively forming a second St. Clair-Olympia 230 kV line. Spurgeon could later become a 500-230 kV transformer site. Since existing BPA 230 kV and 287 kV lines are adjacent to the site, one of these lines may be converted to 500 kV.

WHIDBEY-KITSAP TRANSMISSION

Mutiny Bay - Foss Corner 115/230 kV Lines

As previously discussed, areas near the Canadian border and sites in Canada are expected to provide a substantial portion of future generation and supply for the region. Loads on the Peninsula and Kitsap County are served through transmission that currently runs through King, Pierce, Thurston and Mason counties to serve load in Jefferson, Clallam and Kitsap counties. A long term 230 kV transmission tie, planned between Whidbey Island and Kitsap County would connect supply resources in Whatcom and Skagit counties to Kitsap and the Peninsula. The facilities would be constructed for 230 kV, but initially operated at 115 kV.

Two 115/230 kV undersea cables will be laid between Whidbey Island and Kitsap County. Two 115/230 kV lines will be built to connect the cables on the Whidbey Island end to the existing Whidbey 115 kV lines at a projected Mutiny Bay Substation. Two lines will be built in Kitsap County from the cables down to the Foss Corner Substation.

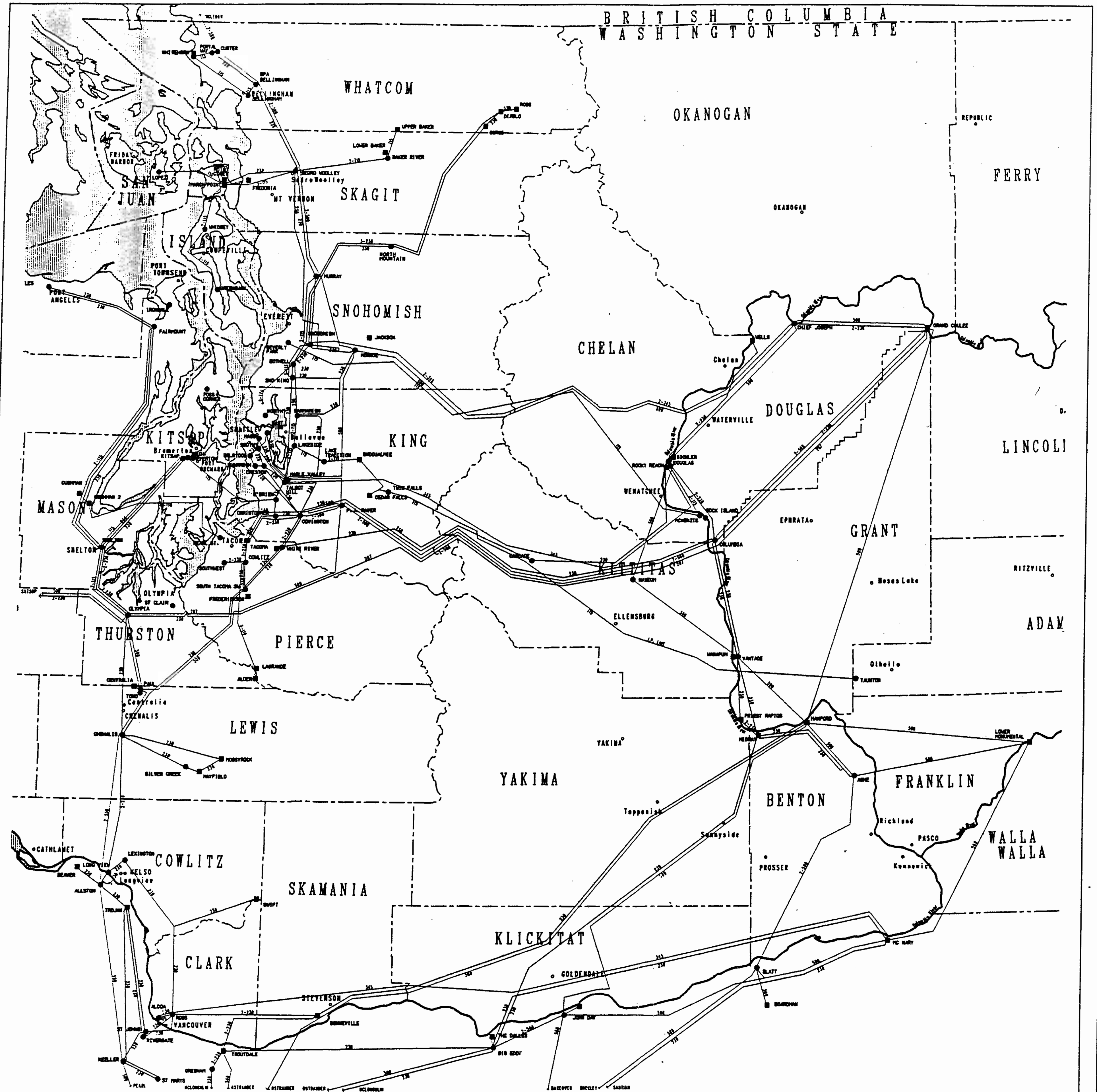
Later, as the Whidbey Island 115 kV system is converted to 230 kV, this transmission tie can also be converted to 230 kV. The new transmission network will relieve the heavy loads that occur on the lines through King and Pierce counties when 500 kV lines are out of service.

OLYMPIC PENINSULA

Proposed Olympia - Shelton 500 kV Line and Shelton Transformer

The BPA plans to extend 500 kV from Olympia to the Shelton Substation as a radial tap and install a 500-230 kV transformer there. The timing for the proposed Olympia-Shelton 500 kV Line and Shelton transformer will depend on the loading and other improvements that supply power to the Olympic Peninsula system. However, this line and transformer will eventually be needed.

The Shelton-Fairmont #3 230 kV Line will eventually be required to serve Port Angeles area loads. This could be achieved by rebuilding the existing 115 kV line or building parallel to the existing corridor.



MAP 2-1
ELECTRICAL TRANSMISSION SYSTEM
EXISTING FACILITIES
PACIFIC NORTHWEST AREA

LEGEND
EXISTING
TRANSMISSION LINES

115	115KV
230	230KV
287	287KV
345	345KV
500	500KV

STATIONS

- ■ GENERATION
- ● TRANSMISSION

BACKGROUND

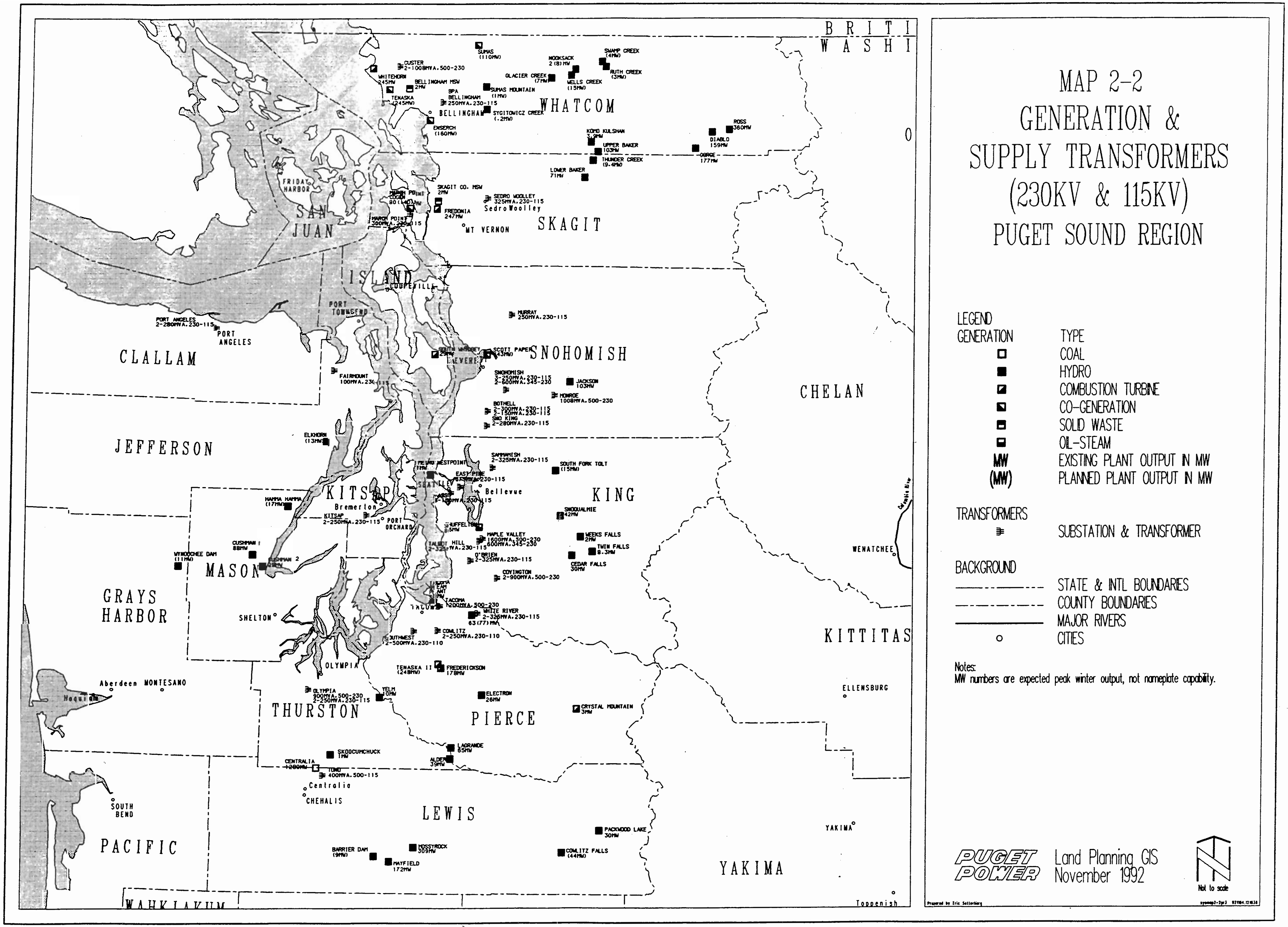
- STATE & INTL BOUNDARIES
- COUNTY BOUNDARIES
- MAJOR RIVERS
- ○ CITIES

Notes:
Most 115 kV lines are not shown.

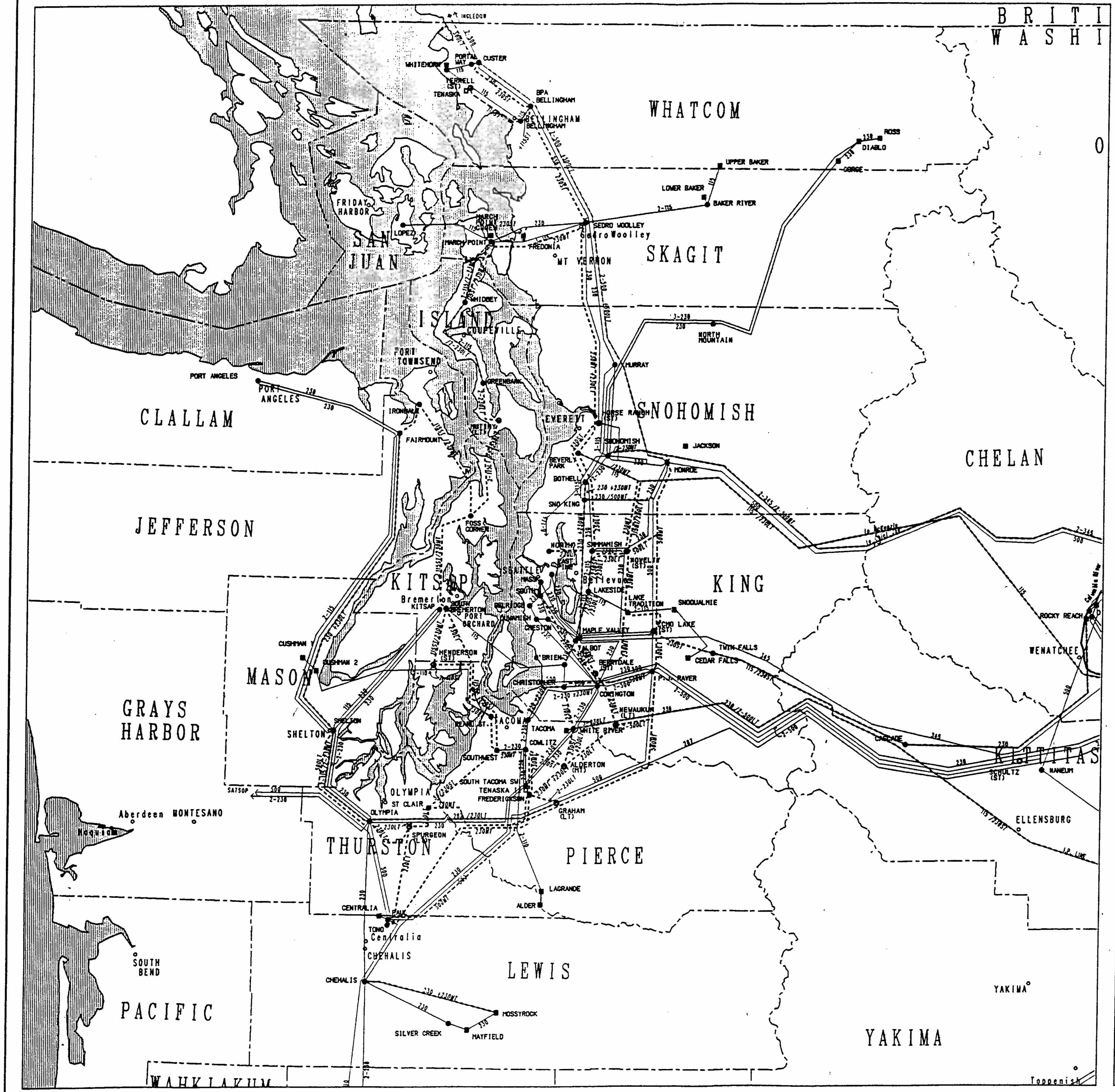
PUGET POWER Land Planning GIS
October 1992

Not to scale

Prepared by Eric Soiterberg



MAP 2-2
GENERATION & SUPPLY TRANSFORMERS (230KV & 115KV)
PUGET SOUND REGION
LEGEND
GENERATION
TYPE
COAL
HYDRO
COMBUSTION TURBINE
CO-GENERATION
SOLID WASTE
OIL-STEAM
MW EXISTING PLANT OUTPUT IN MW
(MW) PLANNED PLANT OUTPUT IN MW
TRANSFORMERS
SUBSTATION & TRANSFORMER
BACKGROUND
STATE & INTL BOUNDARIES
COUNTY BOUNDARIES
MAJOR RIVERS
CITIES
Notes:
MW numbers are expected peak winter output, not nameplate capability.
PUGET POWER
Land Planning GIS
November 1992
Not to scale
BRITI
WASHI
WHATCOM
SKAGIT
SAN JUAN
ISLAND
SNOHOMISH
CLALLAM
JEFFERSON
KITSAP
KING
MASON
GRAYS HARBOR
THURSTON
PIERCE
LEWIS
PACIFIC
CHELAN
KITTITAS
YAKIMA
WAHKIAKUM
FRIDAY HARBOR
PORT ANGELES
PORT TOWNSEND
COUPEVILLE
MT VERNON
Sedro Woolley
BELLINGHAM
EVERETT
SEATTLE
Bellevue
Bremerton
PORT ORCHARD
SHELTON
OLYMPIA
TACOMA
Aberdeen
MONTESANO
Centralia
CHEHALIS
SOUTH BEND
WENATCHEE
ELLENSBURG
YAKIMA
Toppenish
CUSTER 2-1008MVA.500-230
SUMAS (110MW)
NOOKSACK 2 (8) MW
SWAMP CREEK (4MW)
RUTH CREEK (3MW)
GLACIER CREEK (7MW)
WELLS CREEK (15MW)
SUMAS MOUNTAIN (1MW)
WHITEHORN 245MW
BELLINGHAM MSW 2MW
TENASKA (245MW)
BPA BELLINGHAM 250MVA.230-115
ENSERCH (160MW)
ROSS 360MW
DIABLO 159MW
GORGE 177MW
UPPER BAKER 103MW
THUNDER CREEK (9.4MW)
LOWER BAKER 71MW
SKAGIT CO. MSW 2MW
SEDRO WOOLLEY 325MVA.230-115
FREDONIA 247MW
MURRAY 250MVA.230-115
PORT ANGELES 2-280MVA.230-115
FAIRMOUNT 100MVA.230-115
SCOTT PAPER (43MW)
SNOHOMISH 3-250MVA.230-115 2-600MVA.345-230
JACKSON 103MW
MONROE 1008MVA.500-230
BOTHELL
SNO KING 2-280MVA.230-115
ELKHORN (13MW)
SAMMAMISH 2-325MVA.230-115
SOUTH FORK TOLT (15MW)
HAMMA HAMMA (17MW)
KITSAP 2-250MVA.230-115
CUSHMAN 1 88MW
CUSHMAN 2
WYNOOCHEE DAM (11MW)
SNOQUALMIE 42MW
MAPLE VALLEY 1600MVA.500-230 800MVA.345-230
WEEKS FALLS 2MW
TWIN FALLS 8.3MW
CEDAR FALLS 30MW
O'BRIEN 2-325MVA.230-115
COVINGTON 2-900MVA.500-230
WHITE RIVER 2-325MVA.230-115
COWLITZ 2-250MVA.230-110
SOUTHWEST 2-500MVA.230-110
TENASKA II (248MW)
FREDERICKSON 178MW
OLYMPIA 800MVA.500-230 2-250MVA.230-115
YELM 10MW
ELECTRON 26MW
CRYSTAL MOUNTAIN 3MW
LAGRANDE 65MW
ALDER 39MW
SKOOKUMCHUCK 1MW
CENTRALIA 1280MW
TONO 400MVA.500-115
PACKWOOD LAKE 30MW
BARRIER DAM (9MW)
MOSSYROCK 309MW
MAYFIELD 172MW
COWLITZ FALLS (44MW)



MAP 2-3
ELECTRICAL TRANSMISSION SYSTEM
PROPOSED FACILITIES
PUGET SOUND REGION

LEGEND

EXISTING TRANSMISSION LINES		PROPOSED
115	115KV	115
230	230KV	230
287	287KV	287
345	345KV	345
500	500KV	500

STATIONS

■	GENERATION	□
●	TRANSMISSION	○

BACKGROUND

- STATE & INTL BOUNDARIES
- COUNTY BOUNDARIES
- MAJOR RIVERS
- ○ CITIES

Notes:
Most 115 kV lines are not shown.

For proposed lines:
- \+ indicates line additions
- x indicates line removals
- / indicates line conversions
- ST indicates short-term completion estimates
- MT indicates midterm completion estimates
- LT indicates long-term completion estimates

PUGET POWER Land Planning GIS October 1992

Not to scale

INTRODUCTION

The North King County Electrical Facilities Plan includes an analysis of the existing power system, sources of power generation, growth projections, system improvements, and future considerations beyond the projected time period for the Eastside, Northshore, Bear Creek/East Sammamish, Snoqualmie/North Bend, and Skykomish subareas.

IV. EASTSIDE ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

This section includes description and analysis of the existing power system, sources of power generation, growth projections, construction projects in progress, future transmission improvements, and future considerations beyond the projected 30 year time period for this Puget Power subarea.

The Eastside area is considered to be that area of Puget Power's service territory located between the Sammamish and Lakeside Substations.[1] The Eastside subarea includes

- the Cities of Beaux Arts, Medina, Hunts Point, Yarrow Point, and Clyde Hill
- the greater part of the City of Bellevue
- major portions of the Cities of Kirkland and Redmond
- minor portions of unincorporated King County

Meetings with staff members of the Cities of Bothell, Kirkland, and Redmond, were held to consider their concerns, as well as to verify the assumptions made in regard to expected load densities, permitting issues, and timing.

Generation

Power supplied to customers in the Eastside subarea is generated from various sites outside of the area. It is delivered on 230 kV transmission lines to the Sammamish (in Redmond) and Talbot Hill (in Renton) transmission substations where the voltage is transformed to 115 kV.

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[1] This is roughly the area between Lake Washington and Lake Sammamish.

Transmission Substations

Table 1 Existing Transmission Substations

TRANSMISSION SUBSTATIONS	WINTER LOAD MVA	SUMMER LOAD MVA
Sammamish Transformer #1	250	161
Sammamish Transformer #2	246	159
Talbot Transformer #1	346	193
Talbot Transformer #2	340	191

Actual Peak Load. Table 1 lists the actual peak load on the transmission substations. The 1990-91 winter peak, occurred on December 20, 1990, at 9 a.m. The 1990 summer peak, occurred on July 20, 1990 at 4 p.m. The winter peak has historically been the system peak, within Puget Power's service area. The Eastside subarea has a peak load of 407 MVA, and is part of the peak load supplied by these transmission substations.

The manufacturer's nameplate rating of each transmission substation transformer is 325 MVA. The actual load-ability of the transformers depend on several factors, including the load factor, the temperature, and the humidity norms of the area. Normal-life and emergency ratings of the transmission substation transformers, which can be calculated, are somewhat higher than the manufacturer's nameplate rating, especially in the winter. Complex computer modeling is required, however, to determine the exact limits of each transformer. Normal-life limits are used for both normal condition and under equipment or line outage conditions; emergency limits are used for double contingency outage conditions.

As temperature decreases, the load on transformers often increases faster than the capacity increases, thus the winter failure scenarios usually determine when new transmission substation capacity is needed.

Transmission Lines

Power transformed to 115 kV at the Sammamish and the Talbot Transmission Substations, and then it flows on several 115 kV tranmission lines to distribution substations serving the area from Kent to Bothell. These distribution substations further trasform the voltage to 12.5kV (12kV, Puget Power's standard distribution voltage). The power from these distribution substations is then distributed by 12 kV feeders to the customer. In the

Bellevue Central Business District (CBD), the distribution voltage is 34 kV due to the project high load density.

The highest voltage transmission line within the Eastside subarea is a Seattle City Light double circuit 230 kV transmission line located on approximately 124 Avenue NE. Neither circuit directly serves the customers in the Eastside subarea. The east circuit connects Seattle City Light's Bothell Substation to the Maple Valley Substation owned by the Bonneville Power Administration, (BPA). The west circuit is currently de-energized in the Eastside area. However, BPA has announced plans to connect this circuit between the Maple Valley, Bothell, and Sno-King Substations, (see Regional Transmission Improvements).

The 115 kV electric system. The 115 kV electric system is mostly radial in the Eastside subarea. A radial system is one in which one or more distribution substations are fed from a single transmission line. In a radial system, a transmission line failure, (which could be caused by trees and limbs blowing into the line), a car/pole accident, or lightning striking the line, results in a service interruption to all of the substations served from that radial line and consequently, an outage of all of the customers served from those substations.

Many of the radial lines in the Eastside subarea have a normally open switch which can be closed to connect to another radial line. Without circuit breakers and switching stations, the tie switches must be kept normally open to keep line failures on one line from affecting the other. With this system, a transmission line failure will result in a service interruption to all of the customers served off of the line until the failed section is isolated (by opening switches on both sides of the failure) and the normally open switch is closed, thereby restoring power from the other direction. The use of automatic rather than manual switching is often used to reduce customer outage time from one or more hours to several seconds, (the College, Phantom Lake, and Lake Hills Substations do not have this type of backup line). This system, however, requires that the line from the other direction has the capacity to feed its own load plus the load transferred to it from the faulted line.

As development continues and reliability needs increase, the simple radial system evolves into an interconnected network (or grid) system. Table 2 lists the 115 kV transmission lines in the Eastside Subarea and their normal winter and summer peak loads.

Table 2 Existing Transmission Lines

TRANSMISSION LINES	WINTER LOAD MVA	SUMMER LOAD MVA
Eastside - Bellevue	0	0
Lakeside - Kenilworth	67	48
Lakeside - Lochleven	65	52
Lakeside - Phantom Lake	46	26
Overlake Loop	0	0
Sammamish Center	53	36
Sammamish - Kenilworth	76	44
Sammamish - Lakeside #1	38	25
Sammamish - Lakeside #2	27	25
Sammamish - Lochleven	83	61
Talbot - Lakeside #1	115	70
Talbot - Lakeside #2	115	70

All of the transmission lines except the Overlake Loop are rated at 110 MVA in the summer and 176 MVA in the winter. The Overlake loop is rated at 73 MVA in the summer, and 115 MVA in the winter.

In a transformer network, one must be cautioned against assuming that the line rating is in fact the *capacity* of the line. Power flows in the path of least resistance and not according to the line ratings. Power flow studies are necessary to determine when a line will become overloaded.

Frequently, with decreasing temperature, the load on transmission lines increases more slowly than the capacity increases, so that the summer failure scenarios often determine when new transmission line capacity is needed.

Distribution Substations

There are 21 existing distribution substations in the Eastside Subarea which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of these substations with their associated capacity and loading level is shown in Table 3. The 1990-91 winter peak occurred on December 20, 1990 at 9 AM. The 1990 summer peak occurred on July 20, 1990 at 4 PM. Table 2 lists the 115 kV transmission lines in the Eastside Subarea and their normal winter and summer peak loads.

Table 3 Distribution Substations

DISTRIBUTION SUBSTATION	WINTER LOAD (MVA)	SUMMER LOAD (MVA)
Center 34 kV	22.2	22.2
Clyde Hill	19.5	18.0
College*	13.1	8.1
Evergreen	29.4	16.9
Factoria*	10.9	6.7
Houghton	24.3	13.7
Interlaken	24.2	22.0
Kenilworth	13.1	6.3
Lake Hills	20.6	9.2
Lochleven	20.1	19.0
Medina	11.2	5.1
Midlakes	22.2	16.4
North Bellevue 34 kV	14.7	14.6
North Bellevue 12 kV	20.3	0.0**
Northup	18.4	21.1
Overlake	5.7	2.4
Phantom Lake	19.6	10.1
Rose Hill	20.3	6.6
South Bellevue	22.2	10.6
South Kirkland	22.1	22.2
Spiritbrook	33.3	21.1
Total Load	**407.4 MVA**	**272.3 MVA**

* These substations are located near the border of the Eastside Subarea. The load shown represents half of the substation's total actual load. The other half of the substations' total load is listed in the neighboring subarea's Electrical Facilities Plan.

**The 12 kV transformer at North Bellevue was added in November of 1990.

The nameplate capacity of the transformers at the Houghton and South Kirkland substations is 20 MVA. The 34 kV distribution substation transformers at the North Bellevue and Center substations have a 50 MVA nameplate rating. The remaining substations have 25 MVA nameplate rating transformers.

The 25 MVA transformers in Puget Power's service area can normally be loaded to 27 MVA in the summer and 33 MVA in the winter. The 34 kV transformers can normally be loaded to 54 MVA in the summer and 66 MVA in the winter. However, the North Bellevue and Center substations are the only sources of 34 kV for downtown Bellevue. Therefore, it is recommended that they be loaded more conservatively.

In residential areas, the winter failure scenarios usually determine when new distribution substation capacity improvements are needed. In commercial areas, the summer failure scenarios usually determine when new distribution substation capacity improvements are needed.

GROWTH PROJECTIONS

This section of the North King County Electrical Facilities Plan discusses the electrical load growth projections anticipated for the year 2020 in the Eastside Subarea.

Population & Employment Analysis:
The total anticipated load growth predicted by the population and employment methodology from 1990 to 2020 is shown in Table 4.

Table 4 Eastside Subarea. 2020 Peak Load Growth Forecast

PSCOG Zone		1990	2020	1990-2020 Growth	Load Growth
Kirkland*	Population	13351	17686	4335	8.3 MVA
	Employment	4241	8551	4309	11.1
Overlake/Redmond	Population	21425	30035	8610	16.4
	Employment	12112	21413	9301	24.0
Point Cities	Population	7806	8658	852	1.6
	Employment	686	1015	328	0.8
NW Bellevue	Population	7736	9457	1721	3.3
	Employment	5529	8838	3309	8.6
Bel-Red	Population	3906	4562	656	1.3
	Employment	15249	23385	8136	21.0
Central Bellevue	Population	15929	18083	2154	4.1
	Employment	8241	14932	6691	17.3
Bellevue CBD	Population	982	3527	2545	4.9
	Employment	25431	62134	36703	94.9
East Bellevue	Population	23922	23202	-720	-1.4
	Employment	4482	9874	5392	13.9
West Bellevue	Population	8519	9212	693	1.3
	Employment	5315	10497	5182	13.4
Eastside Subarea Subtotal					**244.8.MVA**

*Because the Kirkland FAZ is split between the Eastside Subarea and the Northshore Subarea, only half of the PSCOG forecast figures are shown here.

New residential load = 1.63 KVA/person during January average peak
New commercial load = 2.21 KVA/employee during January average peak
Extreme winter peak = 1.17 times January average peak
(Population and employment forecasts from PSCOG, 1988)

Note: PSCOG has been replaced by the Puget Sound Regional Council, PSRC.

The 244.8 MVA total is the new load predicted to be added between 1990 and 2020. To obtain the total load anticipated in 2020 that must be met by transmission and distribution facilities, the new load must be added to the existing load, then reductions factored in for company-sponsored demand-side management activities and additional conservation.

Current Peak Load (from Table 3)	407	
2020 PSCOG New Load (from Table 4)	+245	MVA
Subtotal	652	MVA
Demand-Side Reductions (10% of 407)	-41	
Subtotal	611	MVA
Additional Conservation (6.94% of 407)	-28	
Peak Load To Be Served by T&D Facilities	583	MVA

Note: This Electrical Facilities Plan, therefore, is based on a peak winter load of 583 MVA that is to be supplied by the transmission and distribution facilities. It is expected that this load will be reached in approximately the year 2020.

Other growth projection methods were used to check the validity of the PSCOG population and employment approach. Although they vary slightly in geographical area, they compare favorably with the PSCOG approach. These methodologies and forecast results are described in the following text.

1. Zoning Density Analysis

Another approach to estimating the long range ultimate system load examines the land use zoning of the area. The ultimate electrical demand per square mile of single family, multi-family and commercial zones can be determined by measuring the actual electrical load in areas of similar zoning where build-out is complete. Table 5 shows the total land area for each major zone in the Eastside Subarea and the electrical demand expected if the area is completely built-out to current zoning.

Table 5 Zoning Density Analysis

Zoning Category	Approximate Square Miles	MVA per Sq Mi If Fully Built-out	Total MVA Anticipated At Build-out
Single Family	23	8	184
Multi-family	5	17	85
Commercial	10	29	290
CBD	1	250	250
Park/Open Space	4	0	0
Subarea Totals	**43**	**304**	**809**

Thus, the above analysis predicts a total load of 809 MVA when the land is built out to existing zoning limits. This represents a load growth of 334 MVA over an indeterminate period of time.

This method ignores two facts. One is that land-use densities almost always increase with time. This would indicate that perhaps 809 MVA is too low for an ultimate load estimate. The other is that this ultimate development does not correlate with a future date. For example, this analysis assumes total saturation of the CBD to current zoning, yet the PSCOG approach does not assume the CBD is built to the current zoning limit by 2020. This would indicate that 809 MVA is probably too high for a 2020 load estimate. The two deficiencies tend to cancel one another, however.

2. City of Bellevue Construction Forecasts

The City of Bellevue provided Puget Power with various 2005 construction forecasts by TAZ (Transportation Analysis Zone) in May, 1991. The City forecasts a net increase of 17.4 million square feet of commercial/office space from 1990 to 2005. Using Puget Power's current average electrical demand of 4 watts per square foot for new energy efficient structures and a 0.95 power factor, this construction represents approximately 73 MVA of new load. (4 watts per square foot at .95 power factor = 2.21 kVA per employee at an average of 525 square feet per employee.) The City's predicted new housing construction is 15,000 new units by 2005. This represents approximately 62 MVA of new load, using Puget Power's current average of 3.9 kW demand per housing unit and a 0.95 power factor. (3.9 kW at .95 power factor = 1.63 kVA per resident at 2.5 residents per housing unit.)

The City's forecasts do not include hospitals, schools, hotels, or institutional, governmental, or recreational development, or the expansion at the Bellevue Community College. These exclusions total approximately 10 MVA. The total 2005 load growth then is estimated to be 73 + 62 +10 = 145 MVA. See Table 6.

Table 6 City of Bellevue Construction Forecasts

Category	1990	2005	Increase	Load Growth
Commercial/Office million sq. ft.	38.2	56.6	17.4	73 MVA
Housing, units	55,440	70,423	14,983	62 MVA
Other				10 MVA
Total Load Growth				**145 MVA**

3. <u>Trending</u>

The load growth over the last 10 years was reviewed to compare the past increases to the future projected increases. The past 10 years grew at 3.5% annually in the Eastside Subarea. This would predict a total load of 1143 MVA in 2020, or a load growth of 736 MVA. It is anticipated, however, that the electrical load growth will not continue at the same rate as in the past.

LOAD FORECAST METHODOLOGIES COMPARISON

The load growth estimates using the various methodologies are summarized below. All figures shown are prior to additional conservation or Company-sponsored demanded-side management reductions.

Table 7 Methodology Comparisons

Method	Period	Load Growth
Employment/Population	30 years	245 MVA
Zoning	indeterminate	334 MVA
Construction	15 years	145 MVA
Trending	30 years	736 MVA

SYSTEM IMPROVEMENTS

System improvements required to serve the forecasted load for the next 30 years are listed in this section as construction projects that are in progress, or as plans for the future. A project is considered in progress if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

CONSTRUCTION PROJECTS IN PROGRESS

- LAKESIDE-CENTER 115/230 kV LINE
- BRIDLE TRAILS SUBSTATION
- WESTMINSTER SWITCHING STATION
- BOEING COMPUTER SERVICES AND THE PHANTOM LAKE TO LAKE HILLS 115 kVTRANSMISSION LINE CONNECTION
- LOCHLEVEN SUBSTATION AND THE SAMMAMISH - LOCHLEVEN #2 115 kV LINE
- LAKESIDE 230 kV DEVELOPMENT

LAKESIDE-CENTER 115/230 kV LINE

Purpose. The construction of the Lakeside - Center 115/230 kV Line is proposed to increase the system capacity and reliability to the west Bellevue/Kirkland area, including the Bellevue Central Business District. The load growth planned for this area over the next several years indicates that capacity improvements may be needed as early as 1993. The most direct means of providing the additional capacity is to build a new Lakeside - Center line. This new line would be approximately two to three miles long and provide a substantial increase in capacity and reliability.

There are three radial 115 kV transmission lines that currently feed the areas of western Bellevue area and south Kirkland.

- the Sammamish - Lochleven line
- the Sammamish - Center line
- the Lakeside - Lochleven line.

With one line out of service during the summer, only two lines, each rated at 110 MVA, remain to serve the load. Since it is impossible to exactly balance the load between these two remaining lines, for planning purposes, a capacity limit of 200 MVA is appropriate for the three radial lines system.

The 1990 summer loads on these lines, as previously listed in Table 2, are as follows: Sammamish - Lochleven 61 MVA, Sammamish - Center 36 MVA, and Lakeside - Lochleven 52 MVA, or 149 MVA total.

The load on these three lines is expected to grow; however, the City of Bellevue is currently processing the permits for various customer projects proposed to be constructed within their CBD. If these projects are built, an additional 21 MVA would be placed on the three line system. (Details of these customer projects are included in the description of the Lochleven project. See Construction Projects In Progress, *Lochleven Substation and Sammamish Lochleven #2 Line*). There are also proposed projects in the City of Bellevue, but outside of the CBD, that would add an additional 8 MVA of load on the three transmission lines. In the City of Kirkland, the Carillon Point development will add approximately 6 MVA of load, and several apartments and condominiums, all either under construction or in permitting, will add 4 MVA of load.

In addition, the Bridle Trails area is fed predominantly from the Evergreen and Spiritbrook substations on the Sammamish - Kenilworth - Lakeside 115 kV line. Assuming Bridle Trails Substation is added, as recommend later in this Electrical Facilities Plan, approximately 15 MVA will be transferred from the Sammamish - Kenilworth - Lakeside line to the Sammamish - Center line.

Consequently, by 1993, the load on the three lines could total:

Today's load	
Sammamish - Lochleven	61 MVA
Sammamish - Center	36
Lakeside - Lochleven	52
Bellevue CBD in permitting	21
Bellevue non-CBD in permitting	8
Carillon Point new load	6
Remainder of Kirkland's new load	4
Bridle Trails area load	15
Total	203 MVA

Although it is quite possible that not all of the customer projects in permitting will actually be constructed, no doubt there will be other projects submitted and built by 1993.

The 203 MVA of load projected for 1993 will exceed the 200 MVA capacity limit of the existing three lines. Construction of the Lakeside - Center line is the best way to provide the additional capacity to meet this anticipated demand.

Reliability in the CBD would also be improved with construction of the Lakeside - Center line. Currently, the CBD is fed from the North Bellevue, Center, South Bellevue, and Lochleven substations. The Center, South Bellevue, and Lochleven substations are all served from the Lakeside - Lochleven line. A single failure anywhere on this line will cause a loss of service simultaneously to three of the four substations serving downtown. This would result in a power outage to most of downtown Bellevue. The proposed Lakeside - Center line would transfer the Center Substation from the Lakeside - Lochleven line to the new line.

Reliability to the Center Substation is improved by eliminating its exposure to failures on the Lakeside - Lochleven line. Any failure of the Lakeside - Lochleven line would then result in a loss of service to two (instead of three) of the substations serving the downtown. In the future, circuit breakers are planned to be added to the system at the North Bellevue and Center substations to increase reliability further.

If loads continue to grow, the Lakeside - Center Line will become an integral part of the proposed system serving the entire Eastside area. Assuming the 230-115 kV transformer at the Lakeside Substation is installed, discussed later in this Electrical Facilities Plan, the Lakeside - Center line will become an important line providing backup capacity to the Sammamish Transmission Substation. Without the Lakeside - Center line and with a transformer failure at Sammamish, in the future the existing Lakeside - Lochleven line will, become overloaded, potentially blacking out large portions of Bellevue, Kirkland, Clyde Hill, and the Point Cities.

BRIDLE TRAILS SUBSTATION

Purpose. The purpose of the Bridle Trails Substation is to provide additional distribution capacity to the Overlake/Southwest Redmond area. Currently, a failure or an emergency maintenance outage of either the Evergreen Substation or the Spiritbrook Substation would result in a long term outage for several thousand customers due to insufficient capacity. If Puget Power tried to restore power to these customers, the feeders and the remaining substations in service could overload. Loading the remaining facilities to above their ratings would either cause these facilities to *trip* off line due to the overload (widening the area of the power outage), or result in equipment loss of life, risking the customers served by those facilities to the outage also.

A review of recent substation loads reveals that the winter loads are more severe than summer loads. During the past three winters, the loads on the Spiritbrook and Evergreen substations were as follows:

SUBSTATION	1988-89 WINTER LOAD	1989-90 WINTER LOAD	1990-91 WINTER LOAD
Spiritbrook	28.2 MVA	29.2 MVA	33.3 MVA
Evergreen	25.0 MVA	25.5 MVA	29.3 MVA

The Spiritbrook Substation reached its normal-life load limit (33 MVA) during the winter of 1990-91. If a neighboring substation of feeder had been out of service during these loads, outages or overloads would have occurred. The loads will soon reach the emergency limit even without a neighboring substation or feeder being out of service.

Feeder additions are anticipated in 1992 and 1993 to provide some relief for the Spiritbrook and Evergreen substations. These improvements will transfer some load to the Kenilworth, Interlaken, Rose Hill, and Redmond substations. This should provide capacity for maybe two more years. The transfer to Interlaken is limited, however, because it is already heavily loaded, and the other transfers are limited because they are all too distant to provide much help.

Scope. The Bridle Trails Substation should be a standard double banked 25 MVA 115 kV to 12 kV distribution substation. Insulation for 230 kV is recommended.

Future Considerations. The load in the area is expected to increase by 30 MVA by the year 2020 (40 MVA growth based on PSCOG data, minus 6 MVA demand-side reductions, minus 4 MVA additional conservation). Even with the Bridle Trails substation, a second new substation called Ardmore, will be required in the future for the Overlake/Southwest Redmond area. The existing load justifies capacity improvements now; the future projections only indicate that without timely capacity additions, service cannot be maintained.

WESTMINSTER SWITCHING STATION

Purpose. The Westminster Switching Station is a proposed transmission switching station that will address some of the transmission line capacity deficiencies noted in the Bridle Trails discussion. Again, the deficiencies are: a failure of the Sammamish - Spiritbrook section or the Lakeside - Midlakes section of the Sammamish - Kenilworth - Lakeside line will soon cause an outage that cannot be picked up without overloading the other section.

As previously stated, the Sammamish - Kenilworth - Lakeside 115 kV line is now loaded to 98 MVA during the summer peak; its capacity is 110 MVA. The remaining 18 MVA of capacity will allow for an additional 16% growth before the overloads begin to occur. The area served by this line includes Microsoft, Eddie Bauer, Nintendo, and Space Labs. Growth in this area has increased at the rate of approximately 4% per year. Building permit applications currently submitted at the cities of Redmond and Bellevue indicate that this growth rate will continue. At this rate of growth, the existing line will be fully loaded by the summer of 1994, and overloaded by the summer of 1995.

Scope. The Westminster Switching Station should consist of a six circuit breaker ring bus. Four transmission line connections will be made initially: A loop through of the Sammamish-Kenilworth-Lakeside Line and a loop through of the Sammamish-North Bellevue Line. The remaining two line bay position should be reserved to allow the easterly Sammamish - Lakeside 115kV to be looped through the substation in the future. Capacity is added by allowing the Sammamish - Kenilworth - Lakeside line and the Sammamish - North Bellevue line to support each other. In addition, the Midlakes Substation is effectively placed on its own line. The remaining Sammamish - Kenilworth - Westminster line will be loaded to 76 MVA, leaving 34 MVA of capacity available for growth for new customers in the Evergreen/Spiritbrook/Bel-Red areas. The Microsoft Complex is only half complete; its future needs alone exceed half of that capacity.

The circuit breakers installed at Westminster Switching Station will also improve the reliability in major portions of Bellevue. The number of transmission line related outages to the North Bellevue Substation, which serves part of Bellevue's CBD, should drop to less than half of those experienced today. The number of transmission line outages to Interlaken, Lake Hills, and Midlakes substations should also drop by about half.

Future Considerations. Using the load growth forecasts based on the PSCOG data, an additional 49 MVA of capacity will be needed along the Sammamish

- Kenilworth - Lakeside line by the year 2020 (64 MVA growth based on PSRC data, minus 9 MVA demand-side reductions, minus 6 MVA additional conservation).

The Westminster Substation will not be able to manage the total load predicted for the year 2020. Additional facilities will also be required: a switching station at the Kenilworth Substation, a new distribution substation near Microsoft, and a new transmission line from the Lake Hills Substation to the Phantom Lake Substation. These proposed improvements are discussed later in this Electrical Facilities Plan.

BOEING COMPUTER SERVICES and the PHANTOM LAKE to LAKE HILLS TRANSMISSION LINE CONNECTION

Purpose. Boeing Computer Services is considering upgrading electric service to 115 kV at their office and research complex just north of I-90 in the Eastgate area. Upgrading service would substantially improve Boeing's power quality, provide them with additional capacity, and full backup capacity for any maintenance outages or equipment failures.

Scope. To supply such service, a 115 kV transmission line would be needed from the Lake Hills Substation, to a new Boeing Computer Substation, to the Phantom Lake Substation. The Boeing Computer Substation would probably include 115 kV circuit breakers to improve the reliability.

The Lake Hills to Phantom Lake Transmission Line Connection is the same line connection needed in the Kenilworth Substation expansion project discussed later in this Electrical Facilities Plan. Building the connection for Boeing only accelerates its construction and lengthens the line somewhat. But, it would benefit Puget Power's other customers in this area by providing backup capacity to the College, Phantom Lake and Lake Hills substations. Currently, all three of these substations are fed on a simple radial line. No backup line exists.

LOCHLEVEN SUBSTATION and SAMMAMISH - LOCHLEVEN #2 LINE

Purpose. The Lochleven Substation is proposed to be expanded to provide additional 34 kV distribution capacity for the Bellevue CBD. The North Bellevue and Center substations are currently the only sources of 34 kV for downtown Bellevue. With one of these sources out of service, the summer loading limit is 54 MVA. The 34 kV load during July 1990 reached 36.8 MVA.

At projected growth rates, the existing 34 kV distribution substation capacity will be fully utilized by the summer of 1996. At this point, a failure of either the Center or North Bellevue substation will cause an outage that cannot be picked up without overloading the other substation.

Scope. The Lochleven substation should be expanded to accommodate the installation of a 50 MVA 115-34 kV transformer. The existing transformer is a 25 MVA 115-12 kV transformer. It should remain, continuing to serve the 12 kV loads surrounding the CBD.

A 34 kV transformer at the Lochleven substation will also improve the reliability to the CBD. A double contingency failure of both the Center and North Bellevue substations would leave the entire CBD without electrical service and with no other possible source of supply. A transformer at Lochleven substation would result in a third source of 34 kV for the Bellevue CBD.

Reviewing historical data, the 1990 load was up 5.5% from 1989, even though the City of Bellevue effectively had a development moratorium in place from 1988 to 1990. Over the past four years, the load growth has averaged 6.6%. At that rate, the load will exceed 54 MVA by 1996.

Looking at future known development, as of February, 1991, the following major projects in the Bellevue CBD were before the City of Bellevue permitting staff:

Project Name	Square Feet	Load Estimate
First Interstate Plaza	561,213	2.4 MVA
Mastro	1,400,000	5.9
Pennyfarthing Phase II	225,683	1.2
Doll Art	11,578	0.1
Park Place	110,000	0.6
SECO Development	201,437	1.1
Pacific Center	366,777	1.8
Bellevue Convention Center	291,000	1.2
Total		**14.3 MVA**

In addition, there were numerous smaller projects in permit review, as well as projects such as the King County Library (0.5 MVA), Koll Bellevue Court (2.6 MVA), Bruce Stark's twin 500 foot condominium towers (0.4 MVA), and the Newtown development (0.3 MVA) which have been discussed, but were not in permitting at that time. Puget Power anticipates that approximately 21.7 MVA of additional electrical load would be placed on the power system if these projects were built.

It is not known when (or even if) all of these projects will actually be built and added to the electrical system load, however. In fact, it is likely that some of these customer projects will not be built.

But it is equally likely that other, currently unannounced, projects will be built. In any event, the load of all of the new projects (21.7 MVA) plus the existing load (36.8) will total 58.5 MVA. This load exceeds the 54 MVA normal-life capability.

Using the PSCOG data, the load projections for the CBD are for an increase of 37 MVA (39 from PSCOG data minus 1 MVA for demand-side improvements and minus 1 MVA for additional conservation) from 1990 to 2000, and 93 MVA from 1990 to the year 2020 (100 minus 4 demand-side minus 3 additional conservation). The 2000 load would be 36.8 + 37 or 73.8 MVA, well over the 54 MVA capacity limit.

Based on the above review, discussions with the developers and with the City of Bellevue, it is recommended that the expansion at Lochleven Substation and the line work be complete by the summer of 1996.

Transmission line work is also needed because the existing transmission system cannot handle the additional forecasted load, either. The Sammamish - Lochleven - Lakeside line is rated at 110 MVA in the summer, yet the load reached 91 MVA in July, 1990. Installing the second transformer at Lochleven Substation will transfer 15 to 20 MVA to the line. In addition, between now and 1995, 10 to 15 MVA of load growth is expected on this line (3% per year), increasing the total 1995 load to 116 to 126 MVA, over the 110 MVA limit.

To accommodate the additional load on the transmission system, the unenergized Eastside - Bellevue line should be connected to the Overlake Loop, and extended on both ends to connect Sammamish Transmission Substation to the Lochleven Substation. This reconfigured line will inject Sammamish 115 kV power into the middle of the Sammamish - Lochleven - Lakeside 115 kV line, and it will become the Sammamish - Lochleven #2 115 kV line. The Lochleven Substation, and a new section of line could be built for the Sammamish - Lochleven #1 line.

The lines should be connected at the Lochleven substation on 115 kV circuit breakers. This will allow the additional power to be injected without a decrease in reliability. In fact, the breakers will increase reliability significantly to the Lochleven and South Bellevue substations, which serve a large part of the Bellevue CBD. Over the last 6 years, the Lochleven substation has unexpectedly tripped out of service for transmission related problems three times. A fiber optics communications line will also be required.

LAKESIDE 230 kV DEVELOPMENT

Purpose. The purpose of the Lakeside 230 kV Development project is to add capacity to the 115 kV system in the North King County Subarea.

Today, the power consumed in the Greater Bellevue area comes from the Talbot Hill Transmission Substation (in Renton) on the two Talbot - Lakeside 115 kV lines, and from the Sammamish Transmission Substation (in Redmond) on the two Sammamish - Lakeside lines. The load will soon reach the point where if one of the 230/115 kV transformers at the Sammamish Transmission substation is out of service, the remaining transformer will load to beyond normal-life levels. Also, if one of the Talbot - Lakeside 115 kV lines is out of service, the other line will soon overload. And if a substation transformer and a line are out of service simultaneously, major portions of Bellevue would be without electrical service.

Computer load flow studies show a 20% margin before the loads will exceed the normal-life limits. This would indicate that the capacity would be fully utilized within 5 years at a growth rate of 3.6% per year. But, the exact timing of the overloads depends, in part, on figure changes to the regional transmission grid. BPA, Seattle City Light, and Snohomish County PUD all have plans that will have an impact on this timing.

The Lakeside 230 kV development will provide Bellevue with its own source of 115 kV power, relieving the 230 kV transformers in Redmond and Renton to serve future loads in their own areas. It is expected, however, to take up to five years to develop the substation and transmission lines.

Scope. The Lakeside 230 kV Development Project consists of expanding the Lakeside Switching Station to include a 230/115 kV transformer and rebuilding the Sammamish - Lakeside 115 kV lines and the Talbot - Lakeside 115 kV lines to single steel pole double circuit 230 kV. Initially only one side of the double circuit lilnes will be energized at 230 kV. The other will remain in operation at 115 kV until loads require that it too be energized at 230 kV.

FUTURE TRANSMISSION SYSTEM IMPROVEMENTS

The following section provides details regarding system projects planned for the future, but which are not currently in active development.

- KENILWORTH AND ARDMORE SUBSTATION
- VERNELL SUBSTATION
- CLYDE HILL SUBSTATION
- TRANSMISSION LINE REBUILDS

KENILWORTH AND ARDMORE SUBSTATION

Based on the projections using the PSCOG data, approximately 50 MVA, (63 PSCOG data, minus 8 demand-side improvements, minus 5 additional conservation) of new load is expected in the southeast Redmond/east Bellevue area by the year 2020. Both Microsoft and Boeing Computer Services have announced significant projects since the 1988 PSCOG estimates were published. Microsoft is steadily building on their complex and have recently purchased an additional large tract of land. An additional load of 20 MVA for Microsoft is likely. Boeing announced plans for four more large office buildings, more computer intensive loads, and more backup battery charging loads. This will result in a load increase of approximately 6 to 8 MVA.

Due to the existing heavy loads already being carried by the Spiritbrook and Evergreen substations, the Bridle Trails Substation will be able to handle less than half of this new load. The remainder of the new load should be met by a new distribution substation. This substation could be located almost exactly centered between the Kenilworth, Evergreen, and the Interlaken substations, and is adjacent to the south edge of Microsoft's complex. This proposed substation is called the Ardmore Substation.

A new transmission line segment will be required to serve the Ardmore Substation. It should extend from the Kenilworth Substation, to the substation site, and then to the Interlaken Substation.

After the completion of the previously discussed transmission and distribution system projects, the system serving the eastern part of Bellevue and the southwestern part of Redmond (the entire area from I-90 to SR 520 and from 140 Avenue SE to Lake Sammamish), will consist of one or the other of the two following systems, depending on whether or not the proposed improvements for Boeing are completed. If the 115 kV connection from the Phantom Lake Substation to the Boeing Computer Substation to the Lake Hills Substation is complete, the system will consist of two 115 kV lines, the Sammamish - Kenilworth line, and the Lakeside - Boeing - Westminster line (with a normally open switch to the Kenilworth Substation) If the 115 kV loop for Boeing is not constructed, the system will consist of the Sammamish - Kenilworth - Westminster 115 kV line, and the Lakeside - Phantom Lake 115 kV line.

Either way, the transmission lines will be loaded close to or over their capacity limits.

The preferred plan to resolve the capacity problems of either situation, and to provide for growth beyond 2020, is to construct a new three line switching station at Kenilworth Substation. This plan requires the construction of the Phantom Lake to Lake Hills connection (if not already built for Boeing), and the new line to serve the Ardmore Substation. The lines would be connected so as to form three transmission lines to the switching station at Kenilworth: Sammamish - Kenilworth, Lakeside - Kenilworth, Westminster - Kenilworth.

The reliability of the area would be enhanced by the installation of 115 kV breakers at the Kenilworth substation. And, a backup transmission line would finally be available for the Phantom Lake, Lake Hills and College substations.

VERNELL SUBSTATION

A new switching station to be known as the Vernell Substation is proposed. The purpose of this substation would be to create a method for connecting and allowing the capacity of the proposed Sammamish - Lochleven #2 line to assist with the loads on the Westminster - Lakeside line.

The Westminster - Lakeside line will need the added support to serve the overall projected load. The 2020 load growth projection for this area is about 90 MVA (100 MVA from PSCOG data, minus 6 demand-side improvements, minus 4 additional conservation). The existing load (Northup, North Bellevue, and Center) is 58 MVA. The total load, then, would be 148 MVA (90 + 58), exceeding the 110 MVA capacity limit. Without the Vernell substation addition, overloads would occur in the Lakeside - Center section with Northup - Westminster out of service and vice versa.

For the area to be fed on the resulting five lines (Sammamish - Westminster, Sammamish - Vernell, Sammamish - Lochleven, Lakeside - Vernell, and

Lakeside - Lochleven), the load growth projection is 177 MVA (187 based on PSCOG data, minus 15 demand-side improvements, minus 10 additional conservation). In addition, the Bridle Trails Substation will transfer up to 15 MVA of existing load from the Sammamish - Kenilworth line into this area. The 2020 load, on this five line area, then will be the existing load (150 MVA), plus the Bridle Trails transfer (15 MVA), plus the growth (177 MVA), or a total of about 342 MVA. This will be well within the capacity of the resulting five lines.

A distribution transformer should also be located here to eliminate the need for a separate distribution substation nearby. The load forecasts show that the distribution substation capacity will be needed in this commercial load area. In fact, it is likely that the need for the distribution transformer will drive the timing for the development of the substation.

The Vernell Substation will further increase reliability to Northup and North Bellevue as the additional 115 kV circuit breakers reduce the portions of the system effected by line or equipment failures.

CLYDE HILL SUBSTATION

The existing distribution substation at Clyde Hill should be expanded when: 1) with the Lochleven - Overlake line section of the Sammamish - Lochleven line out of service, the Sammamish - South Kirkland section overloads, and visa versa, or, 2) when additional 34 kV capacity is needed to serve the CBD.

To solve the transmission line capacity problem, a four-line switching station at the Clyde Hill Substation is proposed. The Vernell - Lochleven line should be looped through the expanded station, providing for a source of supply in the center of the Sammamish - Lochleven line. This segmentation and strengthening of the Sammamish - Lochleven line will eliminate the overload problems.

To increase the 34 kV distribution station capacity, a 115-34 kV transformer is proposed to be located at the Clyde Hill Substation. At this point, the three 50 MVA 34 kV transformers in service for the CBD are: North Bellevue, Center, and Lochleven. With one transformer out of service, the remaining two will have a normal-life capacity of 108 MVA. Yet by the year 2020, the CBD load is projected to be about 130 MVA (36.8 MVA existing, plus 100 MVA based on PSCOG data, minus 4 demand-side management improvements, minus 3 MVA additional conservation). The additional transformer at the Clyde Hill Substation will provide the additional capacity needed.

TRANMISSION LINE REBUILDS

The Overlake Loop contains wire less than 795 MCM in size. At some point this line will likely need to be reconductored or built to higher capacity.

All of the other tranmission lines in the Eastside area are 795 MCM in size. The conductor will be adequate in most cases, although some lines may need to be modified to allow operation at a higher temperature. Some sections of these lines may also likely be th first segments north and south of Sammamish and Lakeside substations.

The reconfiguration of the system into a grid will allow any major rebuild of the existing lines to be deferred for a long time. The eventual rebuild must be anticipated, however, and thus it is considered as part of the Electrical Facilities Plan.

FUTURE DISTRIBUTION SUBSTATIONS

The area served by a distribution substation is rather small, ranging from just under a square mile in commercial areas to approximately four square miles in purely single family residential areas. Because these areas are relatively small, the 30-year load estimates for these areas are not as accurate as the larger area forecasts used to develop the overall transmission system. It is also recognized that all of the areas will not build out at the same rate. Therefore, the Electrical Facilities Plan includes one or two substations that may not be needed until after 2020. They are considered part of the Electrical Facilities Plan, however, because it cannot be determined today which substations could be deferred beyond 2020.

It is expected that today's utilization factor of 75-80% (see Table 8) will remain roughly constant. This percentage is typical among utilities, and accounts for the fact that total capacity must always be greater than the total load. This is due to: 1) backup capacity must be available in every local area for equipment failures and maintenance outages, 2) capacity must be available to serve the higher loads caused by extreme weather conditions, and 3) substation capacity must be added in fixed and large amounts, whereas the load grows evenly.

The new distribution substations planned for the Eastside Subarea which have not been previously discussed include

- Belred
- Larsen
- Snyder
- Yarrow

These substations do not require any transmission lines work other than connecting the existing line through the substation.

The Belred Substation is proposed to serve part of the large commercial area between the Bellevue Redmond Road, NE 24th Street, and I-405. This substation should be located on the Westminster - Lakeside line and centered between the Interlaken, Northup, Bridle Trails, and Midlakes substations.

The Larsen Substation is proposed to serve the new condominiums and the small commercial businesses developing around the Lake Hills community. It would be connected to the Lakeside - Westminster line, and located between the Midlakes and College substations.

The Snyder Substation is proposed to serve the anticipated load for the eastern Kirkland area, and for the Redmond/Overlake area that is above the capabilities of Bridle Trails and Ardmore. It could be connected to either the Sammamish - Westminster line or to the Sammamish - Vernell line. Future power flow studies should be performed to see is there is an advantage to using one verses the other.

The Yarrow Substation is proposed to serve the loads along the western end of the SR 520 corridor. This substation is proposed to be located near Yarrow Bay, south of the Carillon Point development and north of SR 520. It would be connected to the Sammamish - Clyde Hill line.

Combined with the previously discussed Bridle Trails and Ardmore substations, and the new distribution facilities co-located in the switching stations, the above new distribution substations will fill out the new capacity needed to serve the load in the Eastside Subarea anticipated in 2020. The totals are listed in Table 8 on the next page.

Table 8 Eastside Subarea Distribution Substations 1990-2020 Capacity Increase

Substation	1990 Capacity	2020 Capacity	Capacity Added 1990-2020
Ardmore	0	25	25
Belred	0	25	25
Bridle Trails	0	25	25
Clyde Hill	25	75	50
Center	50	50	0
College*	12.5	12.5	0
Evergreen	25	25	0
Factoria*	12.5	12.5	0
Houghton	20	20	0
Interlaken	25	25	0
Kenilworth	25	25	0
Lake Hills	25	25	0
Larsen	0	25	25
Lochleven	25	75	50
Medina	25	25	0
Midlakes	25	25	0
North Bellevue	75	75	0
Northup	25	25	0
Overlake	25	25	0
Phantom Lake	25	25	0
Rose Hill	25	25	0
Snyder	0	25	25
South Bellevue	25	25	0
South Kirkland	20	20	0
Spiritbrook	25	25	0
Vernell	0	25	25
Yarrow	0	25	25
Total Capacity	**540 MVA**	**815 MVA**	**275 MVA**
Total Load	**407 MVA**	**583 MVA**	**176 MVA**
Utilization Factor	**75%**	**71%**	

* These substations are located near the border of the Eastside area. The capacity shown represents half of the substation's total actual capacity. The other half of the capacity is listed in the neighboring area's electrical facilities plan.

FUTURE CONSIDERATIONS

It becomes difficult to predict when, or if, the electrical load in the Eastside subarea will exceed 583 MVA, whether that is before or after the year 2020. It is valuable, however, to discuss system improvements that could be built to accommodate loads above 583 MVA.

There are major unknown factors in the future regarding electrical generation and customer demand. These major unknowns include

1) the availability of the relatively cheap hydroelectric generation that is depended upon today
2) the availability, cost, and location of future generation resources
3) the demand for electric transportation
4) the changes in federal and energy codes and policies
5) the availability of natural gas for home heating uses
6) the changes in the future living density of the Northshore area
7) the potential for interconnections between the various utilities.

If loads never exceed 583 MVA, there would won't be a need for increased capacity above those discussed. Reliability improvements, however, could still be appropriate. Technology improvements are also possibilities.

If loads increase to levels beyond 583 MVA, as continued changes to higher density living in the area would indicate, there are several things that can be considered.

In regards to the transmission lines, if necessary, they could be rebuilt to larger and/or bundled conductor lines, to add capacity. Another possibility would be to convert the entire system to 230 kV to increase the capacity of lines. This would double the capacity over the 115 kV system. For this reason, it is prudent to build all new facilities for future 230 kV even if they are energized at 115 kV for many years.

On the distribution substation side, in general, further load increases should be met by first constructing any of the distribution substations described in the Future Distribution Substation section that had not yet been built. If the loads in the CBD exceed projections, a second transformer at the Center Substation or a 34 kV transformer at Clyde Hill, could be installed, or the small 34/12 kV substation at Wilburton could be rebuilt.

V. NORTHSHORE ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

This section includes description and analysis of the existing power system, sources of power generation, growth projections, construction projects in progress, future transmission improvements, and future considerations beyond the projected 30 year time period for this Puget Power subarea.

The Northshore subarea is bounded approximately by the Redmond - Kirkland Road on the south, Snohomish County on the north, Lake Washington on the west, and Avondale Road on the east. The Northshore subarea includes the entire City of Bothell, major portions of Kirkland and Redmond, and parts of unincorporated King County. It also includes all of King County's Northshore Community Planning Area, with small portions of King County's Eastside Community Planning Area.

Meetings with staff members of the Cities of Bothell, Kirkland, and Redmond, were held to consider their concerns, as well as to verify the assumptions made in regard to forecasting, expected load densities, permitting issues, and timing.

Generation

Power supplied to customers in the Northshore subarea is delivered from distant generating stations on 230 kV transmission lines to the Sammamish Transmission Substation (in Redmond) and BPA Snohomish (in Snohomish County) transmission substations where the voltage is transformed (reduced) from 230 kV to 115 kV, (see Table 1, *Existing Transmission Substations*). Table 1 lists the actual peak loads on the Sammamish Transmission Substation. The 1990-91 winter peak, occurred on December 21, 1990, at 9 AM. The 1990 summer peak, occurred on July 12, 1990 at 4 PM. Within Puget Power's service area the winter peak has historically been the system peak.

Transmission Substations

Table 1 Existing Transmission Substations

TRANSMISSION SUBSTATIONS	WINTER LOAD MVA	SUMMER LOAD MVA
Sammamish Transformer #1	250	161
Sammamish Transformer #2	246	159

The Northshore area's current peak load of 262.8 MVA is part of the load supplied by these transmission substations. The nameplate rating of the transmission substation transformers is 325 MVA. Due to the temperature and humidity norms in the Puget Power service area, the normal-life rating of the transmission substations is somewhat higher, especially in the winter. Complex computer modeling is required, however, to determine the exact limits for each transformer. Normal-life limits are used for both normal conditions, and under equipment or line outage conditions. Emergency limits are used for double contingency outage conditions. The emergency limits load the transformers to where they sacrifice 0.1888% of their life per day. With decreasing temperature, the load on transformers often increases faster than the capacity increases, so that the winter failure scenarios usually determine when new transmission substation capacity is needed.

Two major 230-115 kV substations are located north of the Northshore study area in Snohomish County. Seattle City Light owns and operates SCL Bothell Substation, located just south and east of Mill Creek, and BPA owns and operates BPA Sno-King on Maltby Road in south Snohomish County. Bothell Substation serves Seattle City Light customers exclusively. Sno-King Substation serves Snohomish County PUD customers exclusively.

Transmission Lines

The power transformed at the Sammamish and BPA Snohomish transmission substations is delivered by several 115 kV transmission lines to distribution substations from Bellevue to Arlington. The distribution substations further reduces the voltage to 12 kV, which is the standard distribution voltage for Puget Power. The 12 kV feeders distribute the power from the distribution substations to the individual customers.

The highest voltage transmission lines currently in the Northshore area consists of a Seattle City Light (SCL) double circuit lattice steel tower 230 kV transmission line, and a Puget Power 230 kV *H-frame* line. Both facilities are regional in nature, serving various transmission substations which in turn provide subtransmission (i.e. 115 kV) service to the customers of the Northshore area. One circuit of the Seattle City Light double circuit line connects Seattle City Light's Bothell Substation to Bonneville Power Administration's (BPA) Maple Valley Substation. The other circuit of the SCL line currently serves as part of the existing Beverly - Kenmore 115 kV line. The Puget Power *H-frame* 230 kV line connects Seattle's Bothell Substation to Puget Power's Sammamish Substation.

The 115 kV electric system. The 115 kV system in the Northshore area includes a combination of radial and networked lines. A radial system is one in which one or more distribution substations are fed from a single transmission line. In a radial system, a transmission line failure, which could be caused by trees and limbs blowing into the line, a car/pole accident, or lightning striking the line, results in a service interruption to all of the substations served from that radial line. This causes an outage to all of the customers served from those substations. The radial lines in the Northshore area have a normally open switch which can tie to another radial line. Without circuit breakers and switching stations, this is the only way to keep line failures on one line from affecting the other. With this system, a transmission line failure will result in a service interruption to all of the customers served from the line until the failed section is isolated (by opening switches on both sides of the failure) and the normally open switch is closed, thus restoring power from the other direction. This system, however, requires that the line from the other direction has the capacity to feed its own load plus the load transferred to it from the faulted line. In addition, customer outages in this system last up to a couple of hours depending on the amount of line that needs to be manually patrolled and the extent of any automatic and/or supervisory switching available. As an area develops further and demands more power with higher levels of reliability, the simple radial system ultimately evolves into an interconnected network (or grid) system.

Table 2 lists the 115 kV transmission lines in the Northshore Subarea and their normal winter and summer peak loads.

Table 2 Existing Transmission Lines

Transmission Line or Section	SUMMER RATING (MVA)	WINTER RATING (MVA)
Beverly - Cottage Brook	110	176
Beverly - Kenmore		
Beverly - North Bothell	66	103
North Bothell to Kenmore	61	96
Cottage Brook - Wayne		
Cottage Brook - Kingsgate	110	176
Kingsgate - Wayne	73	115
Halls Lake Tie	61	96
Sammamish - Cottage Brook	110	176
Sammamish - Inglewood		
Sammamish - Juanita	110	176
Juanita - Inglewood	73	115
Sammamish - Lake Tradition	110	176
Sammamish - Vitulli	110	176

With decreasing temperature, the load on transmission lines often increases more slowly than the capacity increases, so that the summer failure scenarios often determine when new transmission line capacity is needed, (Note: One must be cautioned against assuming that the line rating is in fact the *capacity* of the line. Power flows in the path of least resistance and not according to the line ratings. Power flow studies are necessary to determine when a line will become overloaded).

Distribution Substations

There are 13 existing distribution substations in the Northshore Subarea which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of these substations with their associated capacity and loading level is shown in Table 3. The 1990-91 winter peak occurred on December 21, 1990 at 9 a.m. The 1990 summer peak, occurred on July 12, 1990 at 4 p.m. Within Puget Power's service area, the winter Peak has historically been the system peak.

Table 3 Distribution Substations

DISTRIBUTION SUBSTATIONS	WINTER LOAD (MVA)	SUMMER LOAD (MVA)
Avondale*	11.1	5.3
Cottage Brook*	7.5	2.0
Crestwood	18.1	8.4
Kenmore	26.3	9.9
Hollywood	20.5	9.7
Inglewood	28.8	7.0
Juanita	30.3	9.3
Lake Leota	29.7	11.4
Norkirk	16.9	9.3
North Bothell	14.2	9.2
Norway Hill	20.7	8.0
Totem	25.9	19.8
Wayne	12.8	7.1
Total Load	**262.8 MVA**	**116.4 MVA**

* These substations are located near the border of the Northshore Electrical Facilities plan area. The load shown represents half of the substations' actual load. The other half of the substations' total load is listed in a neighboring area's Electrical Facilities Plan.

The nameplate capacity of all of the distribution substation transformers is 25 MVA. The normal-life rating of the transformers is 27 MVA in the summer and 33 MVA in the winter. Puget Power usually uses the normal-life rating as a load limit under system normal conditions. Emergency limits for the 25 MVA transformers, which are used under single line or equipment failure or maintenance conditions, are 30.5 MVA summer and 36 MVA winter.

In residential areas, the winter failure scenarios usually determine when new distribution substation capacity improvements are needed. In commercial areas, the summer failure scenarios usually determine when new distribution substation capacity improvements are needed.

GROWTH PROJECTIONS

This section of the north King County Electrical Facilities Plan discusses the electrical load growth projections anticipated for the year 2020 in the Northshore Area. The total expected load growth projected from 1990 to 2020 using this forecasting method is shown in Table 4.[1]

Table 4 Northshore Subarea. 2020 Peak Load Growth Forecast

PSCOG Zone		1990	2020	1990-2020 Growth	Load Growth
Woodinville	Population	20933	68484	47551	90.7 MVA
	Employment	2261	8615	6354	16.4
Kenmore	Population	18453	32941	14488	27.6
	Employment	4009	8463	4454	11.5
Bothell	Population	10012	19003	8991	17.1
	Employment	5877	26804	20927	54.1
Juanita	Population	31540	52397	20857	39.8
	Employment	2919	7091	4172	10.8
Kingsgate	Population	19573	27664	8091	15.4
	Employment	3082	6883	3801	9.8
Kirkland+	Population	13351	17686	4335	8.3
	Employment	4241	8551	4310	11.1
Redmond+	Population	10992	20783	9791	18.7
	Employment	3587	10119	6532	16.9
Northshore Area	**Subtotal**				**348.2 MVA**

+ Only half of Kirkland's and Redmond's PSCOG zone is in the planning area, so the numbers shown are half of the PSCOG forecasts.
New residential load = 1.63 KVA/person during January average peak
New commercial load = 2.21 KVA/employee during January average peak
Extreme winter peak = 1.17 times January average peak

[1] Source: Puget Sound Council of Governments, PSCOG

The 348 MVA total is the NEW load predicted to be added between 1990 and 2020. To obtain the total load anticipated in 2020 that must be met by transmission and distribution facilities, the new load must be added to the existing load. Then reductions must be factored in for conservation and demand-side management.

Current Peak Load (from Table 3)	263 MVA
2020 PSCOG New Load (from Table 4)	348
Subtotal	611 MVA
Demand-Side Reductions (10% of 263)	-26
Subtotal	585 MVA
Additional Conservation (6.94% of 263)	-18
TOTAL	567 MVA

Note: The Electrical Facilities Plan, therefore, is based on a peak winter load of 567 MVA that is to be supplied by the transmission and distribution facilities. It is expected that this load will be reached in approximately the year 2020.

SYSTEM IMPROVEMENTS

System improvements required to serve the forecasted load for the next 30 years are listed in this section as construction projects that are in progress, or as plans for the future. A project is considered *in progress* if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

CONSTRUCTION PROJECTS IN PROGRESS

- MOORLANDS SUBSTATION EXPANSION
- DENNY PARK SUBSTATION
- TOTEM SUBSTATION

MOORLANDS SUBSTATION EXPANSION

Purpose. The Moorlands Substation is currently being proposed to increase the capacity of the three existing radial transmission lines in the study area. These lines are the Beverly - Kenmore, the Cottage Brook - Wayne, and the Sammamish - Inglewood 115 kV lines. By connecting the lines together, each line will support others. In particular, in the event of a failure of the Sammamish - Norkirk section of the Sammamish Inglewood line, neither the Cottage Brook - Wayne line nor the Beverly - Kenmore line could pick up the unfaulted sections of the Sammamish - Inglewood line without overloading. By connecting the lines together at the Moorlands Substation, both lines will share in picking up the unfaulted load, and neither will overload.

In the long term, Moorlands is may be a interconnection point for future transmission lines to Seattle City Light, Snohomish County PUD, and the Sammamish Transmission Station. These projects are discussed later in this report.

Scope. The Moorland Substation should be developed as a 6 breaker 115 kV ring bus, initially consisting of three breakers.

Reliability in the Kenmore - Inglewood area will also be substantially improved with construction of the Moorlands Substation. The installation of the circuit breakers will allow for improvements in the automatic switching scheme at the North Bothell, Kenmore, Wayne, Norway Hill, Inglewood, and

Juanita substations. The duration of most of the outages to these substations will be substantially reduced by these improvements.

DENNY PARK SUBSTATION

Purpose. The Denny Park Substation is needed in the near term to provide additional distribution substation capacity to the Inglewood/Juanita area. Currently, a failure or an emergency maintenance outage of either the Inglewood or the Juanita Substation could result in inadequate capacity to serve the customers. A lengthy outage to several thousand customers could result. If Puget Power attempted to restore power to the affected customers, the feeders and the remaining substations in service would overload. Loading the remaining facilities to above their ratings will either cause these facilities to trip off line due to the overload (widening the area of the power outage), or it will result in equipment loss-of-life, risking the customers on those facilities to the outage also.

A review of recent substation loads in the area reveals that the winter loads are more severe than summer loads, and that those winter loads are growing quickly. Even though the Crestwood substation was added to the system in 1988 which provided relief for Juanita and Inglewood substations, Juanita's and Inglewood's loads were over nameplate capacity during the winter of 1990-91.

The load growth is expected to continue. The forecast for the Juanita area (which is approximately the same area that the Denny Park and Juanita substations will serve) is for 20,857 more people and 4172 more employees. This is expected to increase the electrical demand by another 46 MVA by the year 2020 (51 MVA growth, minus 3 MVA demand-side reductions, minus 2 MVA additional conservation). This amount of load will require two new substations - the Denny Park substation is just the first one. The existing load justifies capacity improvements now; the future projections only indicate that without timely capacity additions, reliable service cannot be maintained.

Scope. The Denny Park Substation should be constructed as a standard double bank 25 MVA 115 kV-12 kV Substation. Initially, one transformer will be installed. However, space for future 115 kV circuit breakers should be reserved. The substation should be connected to the Sammamish-Moorlands 115 kV line.

Feeder additions are anticipated in 1992 to provide some relief for the Juanita and Inglewood substations. These improvements will transfer some load to the Norway Hill, Wayne, and Crestwood substations. These additions should provide sufficient capacity until 1994. The transfers are limited, however, because the other feeders are already heavily loaded, and the other substations are too distant to provide much help.

TOTEM SUBSTATION

Purpose. The Totem Substation is proposed to be expanded to provide additional distribution capacity for the Totem Lake and surrounding area. The Totem Substation was loaded to 25.9 MVA in 1990 with large load increases planned, including the York sewer pump and the Willows Ridge Technical Center.

Reviewing historical data, the 1990-91 load was up 15% from 1989-90 and 26% from 1986-87. Based on this review, it is recommended that the expansion at the Totem Substation be complete by the summer of 1996.

Scope. The Totem Substation should be expanded to accommodate the installation of a second 12 kV transformer. This would provide the additional 12 kV capacity needed in the area.

The Totem Substation is currently fed at 115 kV by a radial tap of the Sammamish - Vitulli 115 kV line. Coincident with the expansion, it is recommended that the substation be converted to 230 kV on the hi-side. The transmission line tap should be disconnected from the Sammamish - Vitulli line, reinsulated to 230 kV, and connected to the Bothell - Sammamish 230 kV line, which is physically adjacent to the Sammamish - Vitulli 115 kV line. Taking the Totem Substation off of the 115 kV system, reduces the load on the Sammamish 230-115 kV transformers, which in turn, defers the need for additional 230-115 kV transformation in the area.

With the existing tap out of service, (regardless of voltage) the substation (and the customers it serves) are out of service. To bring the reliability up to normal utility practice (i.e. maintaining service with one transmission line out of service), a second line should be constructed to loop the line through the station. The line would have to be built to 230 kV. The expansion of the Totem Substation is currently in the preliminary engineering stage.

FUTURE TRANSMISSION IMPROVEMENTS

The following section provides details regarding system projects planned for the future, but which are not currently in active development.[1]

- SAMMAMISH - BORDER 115 KV LINE AND BORDER SUBSTATION
- SAMMAMISH - MOORLANDS #2 115 KV LINE
- TRANSMISSION LINE REBUILDS
- TRANSMISSION LINES TO SNOHOMISH COUNTY PUD
- INTERCONNECTIONS WITH SEATTLE CITY LIGHT

SAMMAMISH - BORDER 115 kV LINE AND BORDER SUBSTATION

One of the new transmission lines that will be required to serve the expected growth within the Northshore Subarea is proposed to originate at the Sammamish Transmission Substation and extend to a new substation north of Bothell called Border. This line will 1) provide a source of power for the large area east of Hollywood Hills, 2) provide a source of power for the Woodinville community including the North Woodinville Industrial Park, and 3) provide a source of power so that the Border Substation can provide general maintenance and operations backup support for the existing 115 kV lines in the area in case one of them is out of service. The new line will be called the Sammamish - Border 115 kV line.

The new substation, called the Border substation, will be a 115 kV switching station. It will: 1) act as termination for the Sammamish - Border line, 2) interconnect the Sammamish - Border line with the existing 115 kV lines in the area increasing the capacity of the existing lines, 3) sectionalize the existing 115 kV lines in the area to substantially improve both the reliability of the existing lines, and 4) provide for location for co-locating an additional distribution substation to supply the 12 kV capacity needs in the industrialized north Woodinville area.

The substations must be appropriately spaced and located near the load that they will serve. They must be located in respect to the existing feeder system. The transmission line must start at Sammamish and end at Border. The Border Switching Station must be located near or on the existing Beverly - Cottage Brook 115 kV line in the North Woodinville Industrial Park. The

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[1] The load for the Northshore Electrical Facilities Plan area will require two additional transmission lines <u>within</u> the area, and additional lines will be required to get the power <u>to</u> the area.

line can then follow any route between Border and Sammamish but as long as it passes the future Emerald, Liberty, and Mallard substation sites.

SAMMAMISH - MOORLANDS #2 115 kV LINE

The other new line that will be required within the area to serve the expected growth is called the Sammamish - Moorlands #2 115 kV line. It is proposed to originate at the Sammamish Transmission Substation and extend to the Moorlands substation in the Kenmore area. This line will provide an additional connection to the Sammamish 115 kV source to serve the future loads in the area from Kirkland to Kenmore. Such a new connection will improve the capacity and the reliability of service in the area.

The proposal is to construct several new sections of line which, when connected to portions of the existing line, will create two separate lines: one feeding the Turtle, Juanita, Lilac, and Cherry substations, and the other feeding the Norkirk, Crestwood, Denny Park, and Inglewood substations.

The substation sites and routes are only approximate. Roads or other suitable corridors are limited. The substations must be approximately split between the resulting two lines. The substations must be appropriately spaced and located near the load. And they must be conveniently located in respect to the existing feeder system.

TRANSMISSION LINE REBUILDS

Table 2 listed five 115kV line segments that have wire less than 795 MCM in size. They are: Beverly to North Bothell, North Bothell to Kenmore, Kingsgate to Wayne, Juanita to Inglewood, and the Halls Lake tie.

The four line segments total 24 miles in length, and they were all built over 30 years ago when loads were considerably less than today.

The rebuild of all five segments can be deferred first with the construction of Moorlands, and again by the construction of the Sammamish - Moorlands #2 line. The eventual rebuild, however, must be anticipated.

All of the other transmission lines are 795 MCM in size. The conductor will be adequate in most cases, although some lines may need to be modified to allow operation at a higher temperature. Some sections of these lines may also have to be reconductored.

Transmission Lines to Snohomish County PUD

Lines to BPA Sno-King: As stated earlier, the power consumed in the Northshore area today comes from the Sammamish Transmission Substation (in Redmond) and on two 115 kV lines from BPA's Snohomish substation in the City of Snohomish via the Beverly Park substation in Everett. Part of the regional plans involve converting the two lines to BPA Snohomish to 230 kV. To continue to supply the 115 kV power currently flowing on these two lines, two new lines to connect to Snohomish County PUD and/or to SCL Bothell, are proposed.

Without the transmission line support of either the new lines to Snohomish County, if one of the 230-115 kV transformers at the Sammamish Transmission Substation is out of service, the remaining transformer will over load. If a substation transformer and a line are out of service simultaneously, major portions of Northshore would be without electrical service.

Line to SPUD Halls Lake: In addition, a line from Moorlands to the Snohomish County PUD's Halls Lake Substation provides the SPUD with another source of supply for their Halls Lake substation. Physically, the line mostly exists, but is currently de-energized, and it may need rebuilding.

Interconnections with Seattle City Light

The line to Halls Lake substation could also be interconnected to one (or more) of the Seattle City Light 115 kV lines from the Bothell substation. Such an interconnection could potentially allow 230-115 kV transformer capacity at SCL Bothell, BPA Sno-King, and Puget Power's Sammamish substations to all back up each other. There is no mutual backup capability among these transmission substations today. Such an interconnection would also reduce loading on Seattle's Bothell 115 kV lines by approximately 50 MVA. The 115 kV lines are heavily loaded so any reduction would be of great benefit to Seattle City Light. More importantly, the interconnection substation could be a future 230-115 kV transformation point for the entire south Snohomish County / Northshore / North Seattle area. This could be a first step to the rebuilding of two or more of the Seattle City Light lines to 230 kV and a 230 kV connection back to Moorlands. See *Beyond 567 MVA*.

A detailed study would be required between Seattle City Light, Snohomish County PUD, and Puget Power to determine if such an interconnection would make sense. There is the potential, however, of significant benefits to all of the utilities.

FUTURE DISTRIBUTION SUBSTATIONS

The area served by a distribution substation is rather small, ranging from just under a square mile in commercial areas to about four square miles in mostly single family residential areas. Because these areas are relatively small, the 30-year load estimates for these areas are not as accurate as the larger area forecasts used to develop the overall transmission system. It is also recognized that all of the areas will not build out at the same rate. Thus the Electrical Facilities Plan likely includes one or two substations that may or may not be needed until after 2020. They are considered part of the Electrical Facilities Plan, however, because it cannot be determined today which substations could be deferred beyond 2020.

It is expected that the utilization factor will fluctuate between 75-85%. This percentage is typical among utilities, and accounts for the the fact that total capacity must always be greater than the total load. This is due to: 1) backup capacity must be available in every local area for maintenance outages and equipment failures, 2) capacity must be available to serve the higher loads caused by extreme weather conditions, and 3) substation capacity must be added in fixed and large amounts, whereas the load grows evenly. Although Table 5 shows the distribution substation utilization factor in 1990 was 88%, in 1991, 25 MVA was added at Redmond, and 50 MVA was installed at Vitulli, lowering the utilization factor to approximately 72%.

In addition to adding a distribution substation transformer at Border substation, 8 new distribution substations are proposed. With the completion of the transmission system discussed in this report, these substations will not require any further transmission line work other than connecting the line through the substation. In addition, a distribution substation transformer is planned to be installed at the Sammamish Transmission Substation.

The new distribution substations planned for the Northshore Subarea are

- Cherry
- Lilac
- Emerald
- Harmony
- Spruce
- Squirrel
- Turtle
- Liberty

Chickadee Substation is proposed to serve part of the large commercial / industrial area of Kenmore. This substation should be located on the Sammamish - Moorlands line, centered between the existing Kenmore, Wayne, and Inglewood substations.

Lilac Substation is proposed to serve the expected higher density development around Juanita. This would include the community business center centered on 98th Avenue NE and NE 116th, and the multi-family developments along 100 Ave NE.

Emerald and Harmony Substations are proposed to serve the new businesses and apartments around Woodinville. (The Woodinville area is designated to absorb considerable commercial and multi-family development.) Harmony should be located on the 230 kV Beverly - Sammamish right-of-way. This will keep the load off of the 115 kV system, helping to defer the rebuild of the 115 kV system, or constructing another 230-115 kV transmission substation in the area. The Emerald Substation should be connected to the Sammamish - Border line, and preferably just on the south side of the commercial area. This will result in 12 kV capacity being available from the Border Substation on the north side of town, the Harmony Substation on the east side of town, and the Emerald Substation on the south side. This would be adequate to reliably serve the area for the projected loads.

Spruce Substation is proposed to help serve both Bothell and Kenmore. Both areas will need additional capacity, especially under distribution substation outage conditions. By locating the Spruce substation in the middle, both areas can be helped with one substation.

Squirrel Substation is proposed to be located east of Cottage Lake to serve the residential load increases on the eastern edge of the planning area. In fact, Squirrel substation would serve both the Northshore planning area, as well as the Bear Creek / East Sammamish planning area. It could be connected to the existing transmission line on the Woodinville - Duvall road.

Turtle Substation is proposed to be located in the North Rose Hill neighborhood of Kirkland to serve the predominately single family load in the neighborhood as well as a portion of the commercial load alon NE 85th. It would be connected to the future Sammamish - Moorlands #2 115 kV line.

Liberty Substation is proposed to serve the predominantly single family new loads east of Hollywood Hills. It should be connected to the new Sammamish - Border transmission line.

Installing a second transformer is planned at North Bothell. Combined with the previously discussed Border substation, these new substations will fill out the new capacity needed to serve the load anticipate in 2020.

Education Hill is propsed to serve the north Redmond area around the Woodinville Redmond Road. This would include the Maingate and Riverpointe area.

Kingsgate Substation is proposed near the existing Puget Power Cottage Brook-Wayne 115kV. This will serve the surrounding area including the Kingsgate neighborhood shopping center.

Mallard Substation is proposed to serve predominately rural area north of the Education Hill Substation. This substation would likely feed the York sewer pumping plant, a large user of electricity.

Table 5 Future Distribution Substations

SUBSTATION	1990 CAPACITY	2020 CAPACITY	CAPACITY ADDED 1990-2020
Avondale*	12.5	12.5	0
Cottage Brook*	12.5	12.5	0
Crestwood	25	25	0
Denny Park	0	25	25
Education Hill*	0	12.5	12.5
Hollywood	25	25	0
Inglewood	25	25	0
Juanita	25	25	0
Kenmore	25	25	0
Kingsgate	0	25	25
Lake Leota	25	25	0
Norkirk	25	50	25
North Bothell	25	50	25
Norway Hill	25	25	0
Turtle	0	25	25
Totem	25	50	25
Vituli	0	50	50
Wayne	25	25	0
Mallard	0	25	25
Cherry	0	25	25
Border	0	25	25
Lilac	0	50	50
Emerald	0	25	25
Harmony	0	25	25
Spruce	0	25	25
Squirrel*	0	12.5	12.5
Liberty	0	25	25
Total Capacity	**300 MVA**	**750 MVA**	**475 MVA**
Total Load	**263 MVA**	**567 MVA**	**304 MVA**
Utilization Factor	88%	76%	

* Border Substations. Only half of the total load and capacity of these substations is serving the Northshore planning area.

It is important to note that although approximately 304 MVA of new load is planned to be added, additional 230-115 kV transformation can be deferred. This can only be accomplished, however, with the construction of ALL of the following projects: 1) the development of Novelty Substation to include a 230 kV transformer and two 115 kV lines to Cottage Brook (see the Bear Creek / East Sammamish Subarea), 2) the construction of the 230 kV Lakeside project (see the Greater Bellevue Subarea), the construction of the two line connections to BPA Sno-King via Snohomish County PUD, and 3) the placement of Totem, Vitulli, and Harmony distribution substations directly on the 230 kV system.

If any of these projects are not built as proposed, it is anticipated that the 230-115 kV transmission substation at Moorlands, and a new 230 kV line from Eagle to Moorlands will be needed.

Installing 230-115 kV transformer capacity is not easy in the Northshore area. To install a transmission substation, two 230 kV lines are required to supply power to the substation, and at least four 115 kV lines are necessary to get the power out of the substation. Nowhere along the existing 230 kV corridors are there adequate 115 kV lines in the vicinity to get the power out. And where there are planned to be four 115 kV lines, (Moorlands, Border, and Cottage Brook) there are no convenient 230 kV sources.

In considering the entire area from Everett to Seattle to Redmond, it seems that maybe the next 230-115 kV transformation point should not be in the Northshore area anyway, but perhaps at the previously mentioned the Ballinger substation, or some other location suitable to Seattle City Light, Snohomish County PUD, and Puget Power. Such a inter-utility transformation point could provide backup and relieve load from the existing transformers at Sno-King, SCL Bothell, Sammamish, and the SCL Broad Street transmission Substations.

FUTURE CONSIDERATIONS

BEYOND 567 MVA

It becomes difficult to predict when, or if, the electrical load in the Northshore area will exceed 567 MVA, whether that occurs before or after 2020. It is valuable, however, to discuss system improvements that could be built to accommodate loads above 567 MVA.

There are major unknowns in the future regarding electrical generation and customer demand. Many of the unknowns will ultimately influence price which will influence customer demand. The major unknowns include

- the availability of the relatively cheap hydroelectric generation that is depended upon today
- the availability, cost, and location of future generation resources
- the demand for electric transportation
- the changes in federal and energy codes and policies
- the availability of natural gas for home heating uses
- the changes in the future living density of the Northshore area
- the potential for interconnections between the various utilities.

All that is certain, is that the power system must have the flexibility to accommodate whatever load the customers demand in the future. Nevertheless, some things seem reasonable, and a look at what may come is useful for planning purposes.

If loads never exceed 567 MVA, there would be no need for capacity improvements above those discussed in the Electrical Facilities Plan. Reliability improvements, however, could still be appropriate; for example, 115 kV circuit breakers could be added at various substations. Improvements taking advantage of new technologies are also possibilities.

If loads increase to levels beyond 567 MVA, as continued changes to higher density living in the area would indicate will happen eventually, or if highrise building were allowed in downtown Woodinville, there are several things that can be considered.

On the transmission substation side, additional ties between Snohomish County PUD, Seattle City Light, and Puget Power should be investigated. Such interconnections may result in greater efficiency in the use of the capacity of the power system. Reliability may improve as well.

Assuming all of the projects to bring 115 kV capacity into the area from the Sno-King, Novelty, Sammamish, and Bothell substations are complete, to increase 115 kV capacity even further, the installation of a 230-115 kV transformer at an inter-utility site such as Ballinger should be considered. One of the 115 kV lines to SCL Bothell on the Seattle City Light right-of-way could possibly be rebuilt to supply one 230 kV source, a line to the east on the Seattle water right-of-way could supply a second source.

Installing the previously discussed 230 kV transformer at Moorlands is also possible. Although Puget Power owns adequate property at Moorlands, most of the existing site is considered wetlands under today's laws.

In regards to the transmission lines, those lines not previously identified as having to be reconductored, could also be be rebuilt to larger and/or bundled conductor lines This would add transmission line capacity.

On the distribution substation side, in general, further load increases should be met by first considering any of the distribution substations described in the Future Distribution Substation section that had not yet been built. A distribution substation could also be added to the Sammamish Transmission substation. Beyond that, the then current comprehensive plan will have to be studied to determine the cause and location of the increased loads before a decision can be made as to whether an existing substation should be double-banked, or a new substation constructed.

VI. BEAR CREEK/EAST SAMMAMISH ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

This section includes description and analysis of the existing power system, sources of power generation, growth projections, construction projects in progress, future transmission improvements, and future considerations beyond the projected 30 year time period for this Puget Power subarea.

The Bear Creek / East Sammamish study area approximately bounded by Avondale Road and Lake Sammamish on the west, Snohomish County PUD on the north, I-90 on the south. The Bear Creek/East Sammamish Subarea includes a portion of the City of Redmond, King County's Bear Creek/East Sammamish Community areas, and all of the City of Duvall. Also included is the Ames Lake area served by Tanner Mutual Electric Cooperative.

Meetings with staff members of the Cities of Bothell, Kirkland, and Redmond, were held to consider their concerns, as well as to verify the assumptions made in regard to forecasting, expected load densities, permitting issues, and timing.

Generation

The power consumed by the customers in the Bear Creek/East Sammamish area is generated from various sites outside of the Bear Creek/East Sammamish Subarea. It is delivered on 230 kV transmission lines to transmission substations at Sammamish (in Redmond) and Talbot Hill (in Renton), where the voltage is transformed to 115 kV, (see Table 1, *Existing Transmission Substations*). Table 1 lists the actual peak loads on Puget Power's Sammamish and Talbot transmission substations. The 1990-91 winter peak, occurred on December 20, 1990 at 9 AM. The 1990 summer peak, occurred on July 20, 1990 at 4 PM. The winter peak has historically been the system peak within Puget Power's service area.

Table 1 Existing Transmission Substations

TRANSMISSION SUBSTATIONS	WINTER LOAD MVA	SUMMER LOAD MVA
Sammamish Transformer #1	250	161
Sammamish Transformer #2	246	159
Talbot Transformer #1	346	193
Talbot Transformer #2	340	191

The Bear Creek / East Sammamish area peak load of 132.5 MVA is part of the peak load supplied by these transmission substations.

The manufacturer's nameplate rating of each transmission substation transformer is 325 MVA. The actual load-ability of the transformers depend several factors, including the load factor, the temperature, and the humidity norms of the area. *Normal-life* and *emergency* ratings of the transmission substation transformers, which can be calculated, are somewhat higher than the manufacturer's nameplate rating, especially in the winter. Complex computer modeling is required, however, to determine the exact limits of each transformer. Normal-life limits are used for both normal conditions, and under equipment or line outage conditions; emergency limits are used for double contingency outage conditions.

As temperature decreases, the load on transformers often increases faster than the capacity increases, thus the winter failure scenarios usually determine when new transmission substation capacity is needed.

Transmission Lines

After the power is transformed to 115 kV at the transmission substations, it flows on several 115 kV transmission lines to distribution substations serving the area from Kent to Bothell. These distribution substations further transform the voltage to 12 kV, which is Puget Power's standard distribution voltage. The 12 kV feeders distribute the power from the distribution substations to the individual customers.

The highest voltage transmission line currently within the Bear Creek / East Sammamish is a BPA lattice tower 345 kV transmission line running roughly north and south on a 150 foot right-of-way through the East Sammamish Plateau area. This line is a power transmission line connecting the BPA Monroe, BPA Sno-King, Sammamish, and the BPA Monroe Substations together. The line runs through the development of Klahanie. Puget Power leases the line, and operates it at 230 kV. From an interconnection at the proposed Novelty site, Puget Power owns a double circuit 230 kV lattice tower transmission line to the Sammamish Substation. These transmission circuits do not directly serve the customers in the Bear Creek/East Sammamish area, but rather supply power as needed to the Sammamish Transmission Substation and provide backup support to the BPA Monroe and BPA Maple Valley transmission substations. See *Future Transmission System Improvements,* for information on the future plans for this line.

The 115 kV electric system. The 115 kV system consists of only two lines: the Sammamish - Lake Tradition 115 kV line, providing power to the Redmond, Ames Lake, Sahalee, and Pine Lake distribution substations, and the Snoqualmie - Cottage Brook 115 kV line, providing power to the Duvall, Tolt, and Fall City distribution substations. Table 2 lists the actual peak loads on Puget Power's transmission lines. The 1990-91 winter peak, occurred on December 20, 1990, at 9 AM. The winter peak, occurred on July 20, 1990, at 4 PM. The winter peak has historically been the system peak, within Puget Power's service area).

Table 2 Existing Transmission Lines

TRANSMISSION LINES	PEAK LOAD	(MVA)
Sammamish - Lake Tradition	115 kV	88
Snoqualmie - Cottage Brook	115 kV	39

The Sammamish - Lake Tradition line is rated at 110 MVA in the summer and 176 MVA in the winter. The Snoqualmie - Cottage Brook line at 69 MVA in the winter and 44 MVA in the summer.

In a transmission network One must be cautioned against assuming that the line rating is in fact the *capacity* of the line. Power flows in the path of least resistance and not according to the line ratings. Power flow studies are necessary to determine when a line will become overloaded.

Distribution Substations

There are 8 existing distribution substations in the Bear Creek/East Sammamish subarea which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of these substations with their associated capacity and loading level is shown in Table 3.[1]

[1] The 1990-91 winter peak occurred on December 21, 1990 at 9 AM. The 1990 summer peak, occurred on July 12, 1990 at 4 PM. Within Puget Power's service area, the winter Peak has historically been the system peak.

Table 3 Existing Distribution Substations

DISTRIBUTION SUBSTATIONS	WINTER LOAD (MVA)
Ames Lake (Tanner)	5.5
Avondale*	11.1
Cottage Brook*	7.5
Duvall	17.9
Pine Lake	31.4
Redmond	26.9
Sahalee	23.8
Tolt	8.4
Total Load	**132.5 MVA**

** These substations are located near the border of the Bear Creek / East Sammamish area. The load shown represents half of the substation's total actual load. The other half of the load is listed in a neighboring area's Electrical Facilities Plan.*

The nameplate capacity of the transformers at the Duvall and Tolt substations is 20 MVA. The remaining substations have 25 MVA nameplate rating transformers. The normal-life rating of the 25 MVA transformers in Puget Power's service area is 27 MVA in the summer and 33 MVA in the winter. In predominantly residential areas, such as the Bear Creek/East Sammamish area, the winter failure scenarios usually determine when new distribution substation capacity improvements are needed. In commercial areas, such as downtown Redmond, the summer failure scenarios usually determine when new distribution substation capacity improvements are needed.

GROWTH PROJECTIONS

This section of the North King County Electrical Facilities Plan discusses the electrical load growth projections anticipated for the year 2020 in the Bear Creek/East Sammamish Subarea. The total anticipated load growth from 1990 to 2020 is projected by the population and employment methodology shown in Table 4.[1]

Table 4 East Sammamish/Bear Creek 2020 Peak Load Growth Forecast Using PSCOG Data

PSCOG ZONE		1990	2020	1990-2020 GROWTH	LOAD GROWTH (MVA)
Redmond/Bear Creek	Population	14708	49803	35095	66.9 MVA
	Employment	1614	17965	16351	42.3
Carnation Duvall	Population	8560	19362	10802	20.6
	Employment	669	2532	1863	4.8
East Sammamish	Population	26161	75625	49464	94.3
	Employment	2110	16092	13982	36.2
Redmond+	Population	10993	20784	9791	18.7
	Employment	3587	10119	6532	16.9
East Sammamish / Bear Creek Area *Subtotal*					300.7 MVA

+ Only half of Redmond's PSCOG zone is in the planning area, so the numbers shown are half of the PSCOG forecasts.
New residential load = 1.63 KVA/person during January average peak
New commercial load = 2.21 KVA/employee during January average peak
Extreme winter peak = 1.17 times January average peak

Note: Population and employment forecasts from PSCOG, 1988. The PSCOG name has been changed and the organization is currently known as the Puget Sound Regional Council (PSRC).

The 300.7 MVA total is the NEW load predicted to be added between 1990 and 2020. To obtain the total load anticipated in 2020 that must be met by

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[1]Source: Puget Sound Council of Governments Forecasts

transmission and distribution facilities, the new load must be added to the existing load, then reductions factored in for company-sponsored demand-side management activities:

Current Peak Load (from Table 3)	132 MVA
2020 PSCOG New Load (from Table 4)	+301
Subtotal	433 MVA
Demand-Side Reductions (10% of 132)	-13
Subtotal	420 MVA
Additional Conservation (6.94% of 132)	-9
Peak Load to be Served by T&D Facilities	411

This Electrical Facilities Plan, therefore, is based on a peak winter load of 411 MVA that is to be supplied by the transmission and distribution facilities. It is expected that this load will be reached in approximately the year 2020.

SYSTEM IMPROVEMENTS

System improvements required to serve the forecasted load for the next 30 years are listed in this section as construction projects that are in progress or plans for the future. A project is considered *in progress* if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

CONSTRUCTION PROJECTS IN PROGRESS

- EAST SAMMAMISH TRANSMISSION LINE PROJECT, KLAHANIE SUBSTATION, BELVEDERE SUBSTATION
- NOVELTY SUBSTATION PROJECT
- UNION HILL SUBSTATION
- PRESTON SUBSTATION
- STILLWATER SUBSTATION
- LAKE TRADITION 230 KV DEVELOPMENT
- STERLING SUBSTATION
- DOGWOOD SUBSTATION

EAST SAMMAMISH TRANSMISSION LINE PROJECT, KLAHANIE SUBSTATION, BELVEDERE SUBSTATION

Purpose. The East Sammamish Plateau is served by the Pine Lake and Sahalee substations from the existing Sammamish - Lake Tradition 115 kV line. Both substations are at (or over) nameplate loading, and the line is also heavily loaded, serving Redmond and Ames Lake substations in addition to the Sahalee and Pine Lake substations. Without new distribution substations and a new transmission line, reliability will suffer, overloads would become common, and eventually, rolling blackouts would become necessary.

Scope. The new substations should be Klahanie and Belvedere, in that order. Both substations should be constructed for a double banked 230-12 kV 25 MVA substation with up to three 230 kV breakers. Initially, a single transformer will be installed in each substation.

The new transmission line needs to extend from Lake Tradition to the Sammamish substation and will be built in phases. The first phase includes construction from Lake Tradition to the Klahanie substation. The line should be extended by 1996 through the Belvedere Substation to the proposed Novelty. The final phase will include extending the line to Sammamish.

The transmission line will become part of Puget Power's 230 kV grid in the Electrical Facilities Plan, so it should be constructed for 230 kV with bundled 795 KCM conductors with a hot sag design temperature of 100 degrees C. See *Future Transmission System Improvements.*

NOVELTY SUBSTATION PROJECT

Purpose. The Novelty Substation is proposed to initially provide 115 kV line sectionalizing for Puget Power's northeast King County service area. This will substantially increase the electrical capacity and reliability to the entire area east and north of Lake Sammamish. Ultimately, the substation will include 230 kV lines and a 230/115 kV transformer to handle growth in the future.

Scope. The initial development of the Novelty Substation should consist of a four line bay 115 kV bus. Both the Cottage Brook-Snoqualmie Switch 115 kV line and the Sammamish - Lake Tradition 115 kV line should be looped onto the bus. This will effectively split them, creating four lines from the existing two lines: Sammamish-Novelty, Novelty-Lake Tradition, Novelty-Cottage Brook, and Snoqualmie Switch-Novelty.

Reliability will be improved substantially to the Redmond, Ames Lake, Sahalee, Pine Lake, Duvall, Tolt, and Fall City substations by sectionalizing the existing Sammamish - Lake Tradition 115 kV line and the Snoqualmie - Cottage Brook 115 kV line at Novelty Substation. Currently, these areas experience approximately 2-4 outages a year due to 115 kV transmission line outages. With the construction of the Novelty Substation, the average number of transmission outages a customer experiences is expected to be significantly reduced because of the reduced line exposure. The average outage length is expected to be reduced by at least a factor of three, due to automatic switching improvements. For the Redmond and Sahalee substation customers, the typical power outage due to a transmission line failure will be reduced to just a few seconds.

If loads continue to grow, 230 kV lines and a 230-115 kV transformer will be added to the Novelty Substation, (see Future System Improvements). Novelty will then become an integral part of the long term system serving the entire Bear Creek / East Sammamish area, serving the area's customers, relieving load from the Sammamish Substation, and providing backup capacity for a transformer failure at the Sammamish Transmission Substation.

UNION HILL SUBSTATION

Purpose. The Union Hill Substation should be built in the Union Hill / 208 Ave NE area to provide additional 12 kV capacity in the area to relieve overloads on the Sahalee, Avondale, and Redmond substations, as well as relieving Sahalee circuit 17, Avondale circuit 15, and Redmond circuit 15.

Scope. The Union Hill Substation should be designed for an ultimate layout of two 25 MVA 230-12 kV delta - wye transformers and eight 12 kV breakers. Breakers or future line bays are not planned here.

The load in the area grew 12% annually from the winter of 1988-89 to the winter of 1990-91. If that grow rate continues, the substation will be needed before the winter of 1994-95. Although the load growth is expected to continue at a high rate, it is possible at this time that the substation can be delayed until 1995.

The key to the timing is the load growth, and the largest developments planned in the area are Northridge, a Quadrant/Weyerhaeuser Master Planned Development, (MPD), and Blakely Ridge, a Port Blakely Tree Farm/Blackhawk, (MPD). Between these two developments almost 8,000 housing units and almost 4 million sq. ft. of office/business uses are planned.

PRESTON SUBSTATION

Purpose. A new substation is needed in Preston to provide the necessary capacity to allow the continued development of the Preston Industrial Park. It will also substantially improve the voltage as well as the reliability of the Preston and Upper Preston area.

The Preston substation will also provide additional capacity to Lake Alice and to Snoqualmie Ridge. See the Snoqualmie / North Bend Electrical Facilities Plan.

The Preston area is 3 1/2 miles from the Fall City substation. The area is currently fed at 12 kV on Fall City circuit 15, which carries a peak load of 340 amps. Backup is provided by Snoqualmie Distribution, about 5 miles away. Both substations are simply too far away to handle the Industrial Park's planned load at 12 kV. The existing feeders deliver only marginal voltage at present. A line rebuild and a new voltage regulator were recently completed just south of Preston due to the poor voltage, and additional feeder work is also planned to handle the short-term needs. Losses are also substantially reduced with the construction of Preston Substation.

Scope: The ultimate layout for the Preston Substation should include two 25 MVA 230-12 kV delta - wye transformers and eight 12 kV circuit breakers. The 230 kV highside bus should include breakers and line bays for up to four 230 kV lines.

Two of the line bays are to loop the existing Snoqualmie - Lake Tradition #2 line in and out to supply the power to the Preston Substation. (The existing Snoqualmie - Lake Tradition #1 line, on the south side of the Snoqualmie Right-of-Way, should not be used, because this line also serves Snoqualmie Distribution and it is planned to serve the Mario Tap.) The remaining two line bays are for future use.

STILLWATER SUBSTATION

Purpose. The proposed Stillwater Substation would integrate Seattle City Light's Tolt River generation into Puget Power's transmission system.

It will connect Seattle City Light's (SCL) Tolt River generation to the then existing Novelty-Cottage Brook 115 kV line south of Duvall. This line is now known as the Snoqualmie-Cottage Brook 115 kV line. The generation will be on the south fork of the Tolt River, and the output will total 26 MW.

Scope. Initial construction should be a three-breaker 115 kV ring bus with provisions for a future fourth line bay. Energization will be at 115 kV.

LAKE TRADITION 230 kV DEVELOPMENT

Purpose. The expansion of the switching station at the Lake Tradition Substation to include a 230/115 kV transformer is needed to terminate the IP Line.

The existing layout is already built to accommodate 230 kV. Then, all construction will be inside the existing fence.

Scope. Construction of the 230 kV bus at Lake Tradition will be required. This should be built as a breaker-and-a-half layout. The transformer should be Puget's standard 325 MVA and 230/115 kV Transformer.

STERLING SUBSTATION

Purpose. The Sterling Substation needs to be built in the Northridge development to provide the 12 kV capacity necessary to serve the Master Planned Developments of Northridge and Blakely Ridge. Blakely Ridge is proposed to be an Active Senior MPD on 1080 acres. A partnership of Port Blakely Tree Farms and Ken Behring's Blackhawk is the developer. Blakely Ridge is planned to include 2268 residential units, and a Village Center with about 317,000 square feet of recreational, commercial, office, and retail space.

Northridge is proposed to be the largest community ever planned in King County. It is planned to consist of 5182 residential units, and 2,666,000 square feet of business park. Northridge is being proposed by Quadrant Corporation, a Weyerhaeuser company. Northridge is predicted to have a population of 12,835 people and 6598 employees when complete.

To serve the developments, several Puget Power projects must be constructed. First is the completion of the the Novelty Hill Transmission Substation Project and the Union Hill distribution substation, already discussed. The Sterling distribution substation should be the second, and Dogwood, the third.

Scope. The Sterling Substation should be designed for an ultimate layout of two 25 MVA 230-12 kV delta - wye transformers and eight 12 kV breakers. The transmission line, construction of which is part of the Novelty project, should be looped into the substation from the Sammamish right-of-way.

The Sterling Substation will need to be on line before the combined Northridge/Blakely Ridge area load reaches 10 MW. This is expected to be between 1995 and 1997.

DOGWOOD SUBSTATION

Purpose. The Dogwood Substation is proposed to be the second distribution substation predominantly serving the Master Planned Developments of Northridge and Blakely Ridge.

Scope. The Dogwood Substation should be designed for an ultimate layout of two 25 MVA 230-12 kV delta - wye transformers and eight 12 kV breakers. Space for three 230 kV lines ultimately with circuit breakers should be included.

A new transmission line should be constructed to serve this substation. The resulting line will become the Novelty - Cottage Brook #2 115 kV line. The need for the new line is three-fold:

• It creates a second line from Novelty to Cottage Brook. This defers the need to rebuild the low capacity portion of the Novelty - Stillwater and Stillwater - Cottage Brook line.

• It improves reliability by not having Union Hill, Dogwood and Sterling all on the same transmission line.

• It prevents overloads on the Sammamish - Novelty 115 kV line. Without the new line, the Sammamish - Novelty 115 kV line would have the Redmond, Augusta, Union Hill, Dogwood, and Sterling substations connected to it. This would likely overload the line.

The Dogwood Substation should be on line about the time that the combined Northridge / Blakely Ridge area load reaches 20 MW. This is projected to be between 1997 and 2000.

FUTURE TRANSMISSION SYSTEM IMPROVEMENTS

The following section provides details regarding system projects planned for the future, but which are not currently in active development.

- HAWK SUBSTATION
- NOVELTY 230 kV DEVELOPMENT
- MITCHELL SUBSTATION, NOVELTY-MITCHELL AND LAKE TRADITION- MITCHELL 230 kV LINES
- TRANSMISSION LINE REBUILDS

HAWK SUBSTATION

Hawk is located in the currently underdeveloped Redmond Heavy Industrial area, and should also include a double banked distribution substation.

This new line configuration will

- breakup the long and heavily loaded Sammamish - Novelty line
- provide dual feed capability for Augusta.

Breaking up the Sammamish - Novelty line is important to improve the capacity of the line (to serve higher demands in downtown Redmond, as well as the Heavy Industrial area) and to improve the reliability of service to the same area. Providing dual feed capability for Augusta will significantly improve the reliability of service to that area.

NOVELTY 230 kV DEVELOPMENT

The construction of the 230 kV portion of the Novelty Substation and the installation of a 230-115 kV transformer will be needed at Novelty to provide the additional 115 kV capacity that will be needed if growth projections similar to those of PSCOG become a reality.

The 230 kV source is assumed to be the East Sammamish transmission line. The third phase of this project now needs to be completed. Additionally 230 kV lines from the north are also anticipated at this time.

MITCHELL SUBSTATION, NOVELTY - MITCHELL and LAKE TRADITION - MITCHELL 230 kV LINES.

The second 230 kV line needed to serve the total projected load for the East Sammamish area should be the Novelty - Mitchell and the Lake Tradition - Mitchell line. This line would serve the substations in the eastern part of the plateau: Grand Ridge, Heritage, and Mitchell. The Grand Ridge and Heritage substations are discussed further in the Future Distribution Substation section.

TRANSMISSION LINES REBUILDS

The Snoqualmie - Cottage Brook Line contains a significant amount of low capacity 2/0 copper wire. At some point this line will need to be reconductored.

The Sammamish - Lake Tradition 115 kV line is 795 MCM in size. The conductor should be adequate, although portions of it may need to be modified to allow operation at a higher temperature.

FUTURE DISTRIBUTION SUBSTATIONS

The area served by a distribution substation is rather small, ranging from just under a square mile in commercial areas to about four square miles in purely single family residential areas. Because these areas are relatively small, the 30-year load estimates for these areas are not as accurate as the larger area forecasts used to develop the overall transmission system. It is also recognized that all of the areas will not build out at the same rate. Therefore, the Electrical Facilities Plan includes one or two substations that may not be needed until after 2020. They are considered part of the Electrical Facilities Plan, however, because it cannot be determined at this point in time which substations could be deferred beyond 2020.

It is expected that today's utilization factor of 75-80% (see Table 5) will remain roughly constant. This percentage is typical among utilities, and accounts for the the fact that total capacity must always be greater than the total load. This is due to: 1) backup capacity must be available in every local area for equipment failures and maintenance outages, 2) capacity must be available to serve the higher loads caused by extreme weather conditions, and 3) substation capacity must be added in fixed and large amounts, whereas the load grows evenly.

The new distribution substations already mentioned in System Improvements in Progress or in Future Transmission Transmission Improvements are:

- Klahanie
- Union Hill
- Belvedere
- Sterling
- Dogwood
- Hawk
- Preston
- Mitchell

In addition there are substations that do not require any transmission lines work other than connecting the existing line through the substation. These are: Myers, Harris, Augusta, Ruby, Rainbow, and Maple Lake.

The **Myers Substation** is proposed to serve part of the large rural area between the Snoqualmie - Cottage Brook 115 kV line and the Snohomish County border.

The **Harris Substation** is proposed to serve the rural area south and east of Duvall, especially around Lake Marcell and Harris Creek.

The **Augusta Substation** is proposed to to serve the part of the east Redmond area. This area is zoned for multi-family development. It should be connected to the Novelty - Hawk - Cottage Brook 115 kV line.

The **Ruby Substation** is proposed to serve the loads in the southern portion of Northridge and the surrounding area.

The **Rainbow Substation** is proposed to help the Sahalee substation serve a portion of the East Sammamish Plateau.

The **Maple Lake Substation** is proposed to serve the loads between NE 8th and Pine Lake.

The **Grand Ridge Substation** is proposed to serve the Grand Ridge area if it develops.

The **Heritage Substation** is proposed to serve the east side of the East Sammamish Plateau near the Duthie Hill and the Issaquah-Fall City roads. Located in this area are the Trossachs, Belvedere Park, Brighton's Landing, Beaver Lake Estates, High County, the eastern part of Grand Ridge and other developments.

The total Electrical Facilities Plan distribution substation list is shown in Table 5.

Table 5 Bear Creek/East Sammamish Area Distribution Substations 1990 - 2020 Capacity Increase

SUBSTATION	1990 CAPACITY	2020 CAPACITY	CAPACITY ADDED 1990-2020
Ames Lake	11.2	11.2	0.0
Augusta	0.0	25.0	25.0
Avondale*	12.5	12.5	0.0
Belvedere	0.0	25.0	25.0
Cottage Brook*	12.5	12.5	0.0
Dogwood	0.0	25.0	25.0
Duvall	20.0	25.0	5.0
Education Hill*	0.0	12.5	12.5
Grand Ridge	0.0	25.0	25.0
Harris	0.0	25.0	25.0
Hawk	0.0	25.0	25.0
Heritage	0.0	25.0	25.0
Klahanie	0.0	25.0	25.0
Maple Leaf	0.0	25.0	25.0
Myers	0.0	25.0	25.0
Pickering*	0.0	12.5	12.5
Pine Lake	25.0	25.0	0.0
Preston*	0.0	12.5	12.5
Rainbow	0.0	25.0	25.0
Redmond	25.0	50.0	25.0
Sahalee	25.0	25.0	0.0
Squirrel*	0.0	12.5	12.5
Sterling	0.0	25.0	25.0
Tolt	20.0	25.0	5.0
Union Hill	0.0	25.0	25.0
Total Capacity	**151.2 MVA**	**561.2 MVA**	**410.0 MVA**
Total Load	132.5 MVA	410.9 MVA	
Utilization Factor	88%	73%	

*Border substations. These substations are located near the border of the Bear Creek / East Sammamish area. The capacity shown represents half of the substation's total actual capacity. The other half of the capacity is listed in a neighboring area's Electrical Facilities Plan.

FUTURE CONSIDERATIONS

BEYOND 411 MVA

It becomes difficult to predict when, or if, the electrical load in the Bear Creek / East Sammamish area will exceed 411 MVA. It is valuable, however, to discuss system improvements that could be built to accommodate loads above 411 MVA.

There are major unknowns in the future regarding electrical generation and customer demand. Many of the unknowns will ultimately influence price which will influence customer demand. The major unknowns include:

- the availability of the relatively cheap hydroelectric generation that is depended upon today
- the availability, cost, and location of future generation resources
- the demand for electric transportation
- the changes in federal and energy codes and policies
- the availability of natural gas for home heating uses
- the changes in the future living density of the Bear Creek / East Sammamish area

All that is certain, is that the power system must have the flexibility to accommodate whatever load the customers demand in the future. Nevertheless, some things seem reasonable, and a look at what may come is useful for planning purposes.

If loads never exceed 411 MVA, there would be no need for capacity improvements above those discussed in the Electrical Facilities Plan. Reliability improvements, however, could still be appropriate; for example, one or two 115 kV circuit breakers could be added at various substations. Improvements taking advantage of new technologies are also possibilities.

If loads increase to levels beyond 411 MVA, as continued changes to higher density living in the area would indicate will happen eventually, there are several things that can be considered.

On the transmission substation side, a second 230/115 kV transformer could be installed at the Novelty and Lake Tradition Transmission Substations.

In regards to the transmission lines, the Novelty - Lake Tradition 115 kV line could be split: routing the existing south end of the line up 244th to Novelty, and routing the existing northern part of the line down Inglewood Hill Road and across Lake Sammamish to the Kenilworth Substation. This would result in a Novelty - Ruby - Sahalee - Rainbow - Kenilworth line, and a Novelty - Maple Lake - Pine Lake - Lake Tradition line. The existing lines with could also be rebuilt with larger and/or bundled conductors to add capacity. Two more lines from Preston could also be built to provide additional capacity in the Upper Preston and Grand Ridge/Mitchill Hill Area.

The entire system could also be converted to 230 kV to increase capacity. This could double the capacity over the 115 kV system. For this reason, the plans for all new facilities should be reviewed to determine if construction at 230 kV is appropriate even if energization at 115 kV is anticipated for many years. Connections to Snohomish County should also be anticipated, especially to the Paradise Valley and Maltby area.

On the distribution substation side, in general, further load increases should be met by first considering any of the distribution substations described in the Future Distribution Substation section that had not yet been built. Beyond that, the current comprehensive plan will have to be studied to determine the cause and location of the increased loads before a decision can be made as to whether an existing substation should be double-banked, or a new distribution substation constructed.

VII. SNOQUALMIE/NORTH BEND ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

Geographically, this is the area of King County east of Preston, and between the Cedar River Watershed and the Tolt River Watershed. It includes the Fall City area, but not Carnation or Duvall. Also included is the North Bend area served by Tanner Mutual Electric Cooperative.

This section includes description and analysis of the existing power system, sources of power generation, growth projections, construction projects in progress, and future transmission improvements for the 30 year time period in this Puget Power subarea.

Generation

In the Snoqualmie / North Bend area there are four small hydroelectric developments. The generating plants within this planning area are: Snoqualmie Falls, Cedar Falls, Weeks Falls, and Twin Falls. At Snoqualmie Falls, a proposal has been submitted to the Federal Energy Regulatory Commission to make a number of improvements.

Transmission Substations

A 115 kV transmission switching station called Snoqualmie Switch is located next to Snoqualmie Falls. This substation integrates the Snoqualmie Falls generation into the power system as well as providing an interconnection point for the transmission lines in the area.

Transmission Lines

Main Grid The highest voltage transmission line currently within the Snoqualmie / North Bend area is the Raver - Monroe 500 kV line owned by BPA. It connects the BPA Raver substation, located east of Kent, to the BPA Monroe substation, near Monroe. A double circuit loop of the Raver - Monroe line also traverses easterly to connect to the BPA's Maple Valley Transmission Substation in Renton. BPA also owns a 345 kV line on the north flank of Rattlesnake Ridge. This line, connecting Rocky Reach (on the Columbia River) to Maple Valley (in Renton) traverses the area east and west.

Both of the high voltage lines supply power to the Puget Sound area electric transmission system. As such, they do not directly serve the customers in the Snoqualmie / North Bend area, but rather supply power as needed throughout the main power grid. See Main Grid Improvements, for information on the future plans for these lines.

Local Transmission. The Snoqualmie Switch 115 kV substation is the ***hub*** of the transmission system serving the local study area. Here two lines connect to the two power houses that make up the Snoqualmie Falls generation complex. A third line extends to the Fall City substation and beyond to the Cottage Brook substation, a fourth extends to Seattle's Cedar Falls generation and beyond to the Berrydale substation. Finally there are two lines to the Lake Tradition substation in Issaquah. These two lines supply most of the power to the Snoqualmie area when the area load exceeds the area generation.

The existing Cedar Falls - Snoqualmie transmission line actually extends from the Snoqualmie Switching Station to the Berrydale Transmission Substation. Along this line is a tap the Weyerhaeuser Snoqualmie Branch Substation (feeding the Weyerhaeuser lumber mill), the North Bend Substation, a normally-open tap to the Hyak Substation, Cedar Falls (generation owned by Seattle City Light), the Fairwood Substation, and finally, it connects to the Talbot-Berrydale #1 115 kV Line. The entire line from Snoqualmie Switch to the Berrydale Transmission Substation is 37.8 miles long.

The following tables list the transmission lines and their capacity, and the actual ~~peak~~ loads on the distribution substations. The 1990-91 winter ~~peak~~, occurred on December 20, 1990, at 9 AM. The winter peak has historically been the system peak.

Table 1 Existing Transmission Lines & Capacity

TRANSMISSION LINE Or Section	SUMMER RATING MVA	WINTER RATING MVA
Snoqualmie-Lake Tradition #1	110	176
Snoqualmie-Lake Tradition #2	110	176
Snoqualmie - Cottage Brook		
Snoqualmie to Tolt	110	176
Tolt to Cottage Brook	44	69
Cedar Falls - Snoqualmie	72	114

Distribution Substations

Four distribution substations are located in the Snoqualmie/North Bend Subarea. The distribution substations reduce the voltage to 12 kV, which is Puget Power's standard distribution voltage. The 12 kV feeders distribute the power from these distribution substations to the individual customers. Table 2 lists the distribution substations with their capacities and loading during the 1990-91 winter peak. Tanner Mutual takes 12kV power from Puget Power's North Bend Substation, and their load is included in North Bend's load below.

Table 2 Distribution Substations

DISTRIBUTION SUBSTATIONS	CAPACITY MVA	WINTER LOAD MVA
Fall City	20.0	12.5
North Bend	25.0	17.9
Snoqualmie Distribution	25.0	14.9
Weyerhaeuser (Snoq. Branch)	18.8	4.1
Totals	**88.8**	**49.4 MVA**

The 25 MVA transformers in Puget Power's service area can normally be loaded to 27 MVA in the summer and 33 MVA in the winter. In residential areas, such as is predominate in the Snoqualmie/North Bend area winter failure scenarios usually determine when new distribution substation capacity improvements are needed.

GROWTH PROJECTIONS

The population and employment forecast method indicates that there will be a peak winter system demand of 70 MVA by the year 2020 in the planning area. This is the load that will need to be supplied by the transmission and distribution system. In comparison, the load today is 49.4 MVA. This represents a thirty year compounded growth rate of 1.2% per year.

Therefore, this plan is 70 MVA Plan . It is simply anticipated that the 70 MVA load level will be reached in about the year 2020.

Meetings with staff members of the Cities of North Bend, Snoqualmie, and King County were held to consider their concerns, as well as to verify the assumptions made in regard to expected load densities, permitting issues, and timing.

The total anticipated load growth from 1990 to 2020 predicted by the population and employment methodology is shown in Table 3.[1]

Table 3 Puget Sound Council of Governments Forecasts
2020 Peak Load Growth Forecasting Data, Snoqualmie/North Bend Subarea

PSCOG ZONE		1990	2020	1990-2020 GROWTH	LOAD GROWTH
N. Bend /Snoqualmie	Population	15017	2647	111454	21.8
	Employment	3078	5794	2716	7.0
Snoqualmie / North Bend Area *Subtotal*					28.8 MVA

New residential load = 1.63 KVA/person during January average peak
New commercial load = 2.21 KVA/employee during January average peak
Extreme winter peak = 1.17 times January average peak

The 28.8 MVA total is the NEW load predicted to be added between 1990 and 2020. To obtain the total load anticipated in 2020 that must be met by transmission and distribution facilities, the new load must be added to the existing load, then reductions factored in for company-sponsored demand-side management activities:

[1]Source: Puget Sound Council of Governments, (PSCOG), 1988. Note: PSCOG has been replaced by the Puget Sound Regional Council, PSRC.

Current Peak Load	49 MVA
2020 PSCOG New Load	+29
Subtotal	78 MVA
Demand-Side Reductions (10% of 263)	-5
Subtotal	73 MVA
Additional Conservation (6.94% of 263)	-3
TOTAL	70 MVA

Note: This Electrical Facilities Plan, therefore, is based on a peak winter load of 70 MVA that is to be supplied by the transmission and distribution facilities. It is expected that this load will be reached in approximately the year 2020.

Load Growth Discussion

There is significant concern, however, that the above methodology understates the future growth. Since 1988, when the PSCOG made the last forecasts, Snoqualmie Ridge was annexed into the City of Snoqualmie and Nintendo located a major commercial facility in North Bend. Tanner Mutual has already exceeded their contractual demand limit at Puget Power's North Bend Substation and are asking for more capacity.

The Snoqualmie Ridge Development is anticipated to include 2000 single-family and multi-family residential units on approximately 385 acres, a business park of a maximum of 150 acres, neighborhood business uses on 10 acres, and schools. A waste-water treatment facility will we needed as well as sewer and water pumps. The total power needs for such a development would be 8 to 25 MVA.

Load growth for Tanner Mutual has been high in the past, and it could be equally significant in the future. In 1989, Tanner hired a consultant to predict their future load. The consultant, forecasted a load of 14,305 kW in 1998-99, representing a predicted increase of 10,453 kW. This growth is equivalent to a compound growth rate of 14% over the 10-year period from 1989 to 1999. Although high, this is a credible growth rate, since the predominant growth in the area will be around the North Bend/I-90 interchange where 500 acres of commercially-zoned property is located. Included in this area, which was recently annexed by the City of North Bend, is a Safeway, a Dairy Queen, a series of factory outlet stores, a motel, a service station and store, and other commercial developments in various stages of planning or construction.

Several of the factory outlet stores were opened in the Spring of 1990. On the south side of I-90, 500 single-family housing units are anticipated at a development called Forester Wood. In addition, the Wiley Creek Apartments are planned, with 69 units initially. It should be noted that the consultant's load projections were made before Nintendo announced plans for a very large regional warehouse and distribution center. Additional spin-off commercial and residential activity is likely to occur in Tanner's area due to the Nintendo development, so it is quite possible that the load-growth estimates above will be too low.

The Nintendo development covers 123 acres, and a load of 13.9 MW is possible on the site if fully developed. Nintendo's first building, a 880 foot x 340 foot x 40 foot high distribution warehouse, was connected to the system early in 1991. The demand is currently approximately 700 kVA. A second building, a two-story assembly plant with a demand of 1500 kVA, is possible. Three other buildings could follow later.

Other possible major developments in the area are: 1) a 2,000- to 3,000-home development called The Villages, located on the north flank of Rattlesnake Mountain, and 2) a corporate business park and multi-family development by the Pendleton Miller Estate. The Villages' developer, Century Real Estate Advisors, hope to incorporate the area into the City by 1992 and to develop the site over an extended period of time.

The existing Weyerhaeuser facility is undergoing corporate review. Their loads are down substantially since the plywood plant burned down, but that facility could be rebuilt.

SYSTEM IMPROVEMENTS

The various system improvements required to serve the forecasted load for the next 30 years are listed in this section as construction projects that are in progress, or as plans for the future. A project is considered *in progress* if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

There are three major long-range problems to handling the growth in the Snoqualmie - North Bend area which the Electrical Facilities Plan addresses:

1) The existing Cedar Falls-Snoqualmie 115 kV transmission line is inadequate to serve the projected load increases of the subarea
2) The lack of capacity to get power into the area when the local generation is inadequate to serve the local load
3) The lack of adequate 115-12 kV substation transformer capacity.

The Mt. Si - Lantern 115 kV line will address the first problem. The Mt. Si transmission substation will address the second problem and the new distribution substations will address the third.

CONSTRUCTION PROJECTS IN PROGRESS

- MARIO SUBSTATION AND 115KV TRANSMISSION LINE
- MT. SI TRANSMISSION SUBSTATION
- ADDITIONAL SMALL HYDRO
- SNOQUALMIE FALLS IMPROVEMENTS
- TRANSMISSION LINE REBUILDS
- RATTLESNAKE - LAKE TRADITION 230KV LINE
- LANTERN SUBSTATION AND 115KV TRANSMISSION LINE

MARIO SUBSTATION AND 115kV TRANSMISSION LINE

Electric load growth in the North Bend area is anticipated to require the construction of a distribution substation. No existing transmission lines exist in the area to supply power to this proposed substation. In oder to the operate the substation, a transmission line tap (extension) would need to be constructed from the existing Snoqualmie - Lake Tradition Line #1 to the site of the proposed substation in the vicinity of the Nintendo facility.

Initially, the line will be a tap from the Mt. Si Substation site to the Mario Substation. The line should be extended to the Lantern Substation in the future.

MT. SI TRANSMISSION SUBSTATION

The ultimate development of the Mt. Si Transmission Substation could include three components. A distribution substation is proposed to serve local area electric load growth. A 115kV switching station is proposed to allow for power flow between area transmission lines looped through the station. Also, a 230kV transmission substation is proposed to allow the Rattlesnake - Lake Tradition 230kV Line to increase the capacity of the local 115kV system.

ADDITIONAL SMALL HYDRO

There are numerous proposals for small hydroelectric generation plants in the North Bend / Snoqualmie area. Most of these are located on the North Fork of the Snoqualmie River and its tributaries. The Black Creek, Hancock Creek, and Calligan Creek are furthest along in planning. In addition, there are possibilities for others along the Middle Fork and the South Fork of the Snoqualmie River. As potential energy resources, Puget Power may purchase the energy output from these projects when completed in the future. As such, Puget Power may need to construct facilities to interconnect these generation plants to the electric transmission system.

The initial generation output of Black Creek could be connected to the system grid at 12 kV. Any generation above this initial level will require integration at 34 or 115 kV. One proposal is for a 115 kV line and a three line bay 115 kV switching station to connect it to the Snoqualmie- Cedar Falls line. This switching station is called the Reinig Substation.

SNOQUALMIE FALLS IMPROVEMENTS

The Puget Power Snoqualmie Falls Project (FERC No. 2493) re-license application was submitted Nov. 19, 1991. The relicensing is a proposal to increase the power generation of the facility. No major transmission system work is necessary to accommodate the increased generation.

TRANSMISSION LINE REBUILDS

The Snoqualmie - Cottage Brook 115 kV line and the Cedar Falls-Snoqualmie 115 kV line contain a significant amount of low capacity 2/0 copper or 397 ACSR wire. At some point these lines would need to be reconductored.

The Snoqualmie-Lake Tradition 115 kV lines are 795 MCM in size. The conductor should be adequate, although portions of the line may need to be modified to allow operation at a higher temperature.

RATTLESNAKE - LAKE TRADITION 230KV LINE

The Rattlesnake -Lake Tradition Transmission Line is a proposed new line which would connect the existing IP Line near Rattlesnake Lake southeast of North Bend to the existing Lake Tradition Substation near Issaquah. This line would allow power generated in Eastern Washington to be supplied to King County.

A new 230kV interconnection from the Columbia River to Puget Sound is needed to:

- Provide firm wheeling of company contracted Mid-Columbia power to Puget Sound customers
- Provide transmission access to potential new power purchase contracts
- Increase the transmission capacity into the Puget Sound region, thereby reducing the potential for Western Washington power outages due to voltage instability
- Save system losses.

Scope

The preferred way to create this new 230kV interconnection is to construct a new section of 230kV line across the Columbia River to Grant County PUD's Wanapum Substation, construct a new section of 230kV line from Rattlesnake to the Lake Tradition Substation and to convert the IP line to

230kV. In addition, a separate project is planned to provide microwave and two-way radio communications to key sites along the IP route. The communications project will:

significantly improve mobile communications along the route
provide reliable and low cost power control circuits
provide Puget enhanced telephone service
enable high-speed (transfer-trip) protective relaying.

LANTERN SUBSTATION AND 115KV TRANSMISSION LINE

The Lantern Substation would provide electric power to customers in the southeast North Bend area. The 115kV line tap to the planned Mario Substation should be extended to Lantern. The SCL Snoqualmie - Cedar Falls Line could also be interconnected with the line from Mario to Lantern.

FUTURE DISTRIBUTION SUBSTATIONS

At present, the timing of future distribution substations cannot be determined due to the uncertainty of load growth in this subarea, an island of urban development in a rural area. Therefore, it is likely that the Electrical Facilities Plan for the Snoqualmie/North Bend includes a substation that may not be needed until after 2020.

The new distribution substations planned for the area are

- Mario
- Preston
- Mt. Si
- Lantern

MARIO SUBSTATION

Mario Substation is proposed to provide additional capacity for Tanner Mutual, Nintendo, the Pendleton Miller Estate, and the surrounding growth. Reliability to all of the North Bend area will improve.

PRESTON SUBSTATION

A new substation is needed in Preston to primarily provide the necessary capacity to allow the continued development of the Preston Industrial Park (see the electrical facilities plan for the Bear Creek/East Sammamish area). It will also provide additional capacity to the Lake Alice and Snoqualmie Ridge area.

MT. SI

Depending on local area load growth, the initial development of the Mt. Si Transmission Substation may be either a distribution substation or a 115kV switching station.

LANTERN SUBSTATION

The Lantern Substation, as discussed earlier, should be located and built to also provide the distribution capacity needed to serve this southeast part of North Bend.

Table 4 Snoqualmie/North Bend Area Distribution Substations

SUBSTATION	1990 CAPACITY	2020 CAPACITY	CAPACITY INCREASE 1990-2020
Fall City	20	25	5
Lantern	0	25	25
Mario	0	25	25
Mt. Si	0	25	25
North Bend	25	25	0
Preston*	0	12.5	12.5
Snoqualmie Dist	25	25	0
Weyerhaeuser	18.8	18.8	0
Total Capacity	88.8 MVA	181.3 MVA	92.5 MVA

* This substation is located near the border of the Snoqualmie/North Bend area. The capacity shown represents half of the substation's total actual capacity. The other half of the capacity is listed in the Bear Creek/Sammamish Electrical Facilities Plan.

VIII. SKYKOMISH ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

This section includes description and analysis of the existing power system, sources of power generation, growth projections, construction projects in progress, future transmission improvements, and future considerations beyond the projected 30 year time period for this Puget Power subarea.

The Skykomish study area is the portion of King County served by the existing McKenzie - Beverly 115 kV line. Geographically, this is the Northeast part of King County including the town of Skykomish and portions of unincorporated King County.

Generation

There are no significant generation plants currently in the area.

Transmission Lines

Regional Transmission:

The highest voltage facility currently within the Skykomish area is the Chief Joseph - Monroe 500 kV line owned by BPA. A BPA double circuit 345 kV line is located adjacent to the 500 kV line. These high voltage lines supply power to the Puget Sound area electric transmission system. As such, they do not directly serve the customers in the Skykomish area, but rather supply power as needed throughout the regional power grid.

Local Transmission:

The McKenzie - Beverly 115 kV line supplies the power serving the local study area. This line extends from McKenzie on the Columbia River to Beverly, in Everett. The entire line is 127 miles long and is constructed predominantly with 2/0 and 4/0 copper wire.

The McKenzie - Beverly line is rated for 44 MVA in the summer and 69 MVA in the winter. The load on the line during the 1990-91 winter peak was 56 MVA.

Distribution Substations

Two distribution substations are located in the area: Skykomish and Scenic. Their capacity and peak loads are shown below.

Table 1 Existing Distribution Substations

DISTRIBUTION SUBSTATIONS	CAPACITY MVA	WINTER LOAD MVA
Skykomish	9.4	2.5
Scenic	4.2	.5
Totals	**13.6**	**3.0**

GROWTH PROJECTIONS

This section of the North King County Electrical Facilities Plan discusses the electrical load growth projections anticipated for the year 2020 in the Skykomish subarea. The total anticipated load growth from 1990 to 2020 is projected by the population and employment methodology shown in Table 2.[1]

Table 2 2020 Peak Load Growth Forecast Using PSCOG Data, Skykomish Subarea

PSCOG ZONE		1990	2020	1990-2020 GROWTH	LOAD GROWTH
East King	Population	2149	3513	1364	2.6
	Employment	673	1081	408	1.1
	Area Subtotal				3.7 MVA

New residential load = 1.63 KVA/person during January average peak
New commercial load = 2.21 KVA/employee during January average peak
Extreme winter peak = 1.17 times January average peak

Note: Population and employment forecasts from PSCOG, 1988. Note: PSCOG has been replaced by the Puget Sound Regional Council.

The 3.7 MVA total is the new load predicted to be added between 1990 and 2020. To obtain the total load anticipated in 2020 that must be met by transmission and distribution facilities, the new load must be added to the existing load, then reductions factored in for company-sponsored demand-side management activities:

Current Peak Load (from Table 3)	3.0 MVA
2020 PSCOG New Load (from Table 4)	+3.7
Subtotal	6.7 MVA
Demand-Side Reductions (10% of 3.0)	- 0.3
Subtotal	6.4 MVA
Additional Conservation (6.94% of 3.0)	- 0.2
Peak Load To Be Served By T&D Facilities	6.2 MVA

This Electrical Facilities Plan, therefore, is based on a peak winter load of 6.2 MVA that is to be supplied by the transmission and distribution facilities. It is expected that this load will be reached in approximately the year 2020.

[1]Source: Puget Sound Council of Governments, 1988.

FUTURE TRANSMISSION SYSTEM IMPROVEMENTS

The following section provides details regarding system projects planned for the future, but which are not currently in active development.

- UPGRADE OF THE McKENZIE - BEVERLY 115kV LINE
- REBUILD OF THE McKENZIE - BEVERLY LINE TO 230 kV
- ADDITIONAL SMALL HYDRO

Upgrade of the McKenzie - Beverly 115kV line:

The capacity of this line needs to be upgraded to avoid overloads during certain conditions. This can be accomplished by increasing the tension of the wire and/or by increasing the clearance of the line.

Rebuild of the McKenzie - Beverly line to 230 kV:

Eventually, however, the McKenzie - Beverly line will be rebuilt to 230 kV. A rebuild to 230 kV provides many benefits: firm wheeling of our Mid-Columbia power, transmission access to new power purchase contracts, increased transmission capacity into the Puget Sound region to reduce the potential for regional power outages due to voltage instability, and loss savings.

Such a rebuild would also require conversion of the existing distribution substations to 230 kV.

Additional Small Hydro:

There are numerous proposals for small hydroelectric generation plants in the Skykomish River basin. These plants will generally need a 115/future 230 kV switching station to connect this generation to the McKenzie - Beverly line. These generating plants will also likely trigger the upgrade or rebuild of the McKenzie - Beverly Line.

FUTURE DISTRIBUTION SUBSTATION

There are no new distribution substations anticipated for the area. Improvements at the existing substations are possible to increase reliability or capacity.

IX. HIGHLINE/GREEN RIVER ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

The Highline/Green River Subarea of the King County Electrical Facilities Plan consists of approximately 86 square miles and eight Puget Sound Council of Governments (PSCOG)[1], forecast analysis zones, (FAZ). It includes the cities of Renton, Kent, Des Moines, SeaTac, and the unincorporated areas of King County such as Redondo and Vashon Island. In 1990, the population for the Highline/Green River Subarea was 150,337 and the employment was 145,277.

Generation

Puget Power's transmission facilities in the Highline/Green River Subarea are interconnected to a larger transmission grid throughout the Western United States. Power flows North and South and East and West through the area as the loads and the generation patterns of the system change. Power is supplied to the subarea through the larger regional transmission grid at 500 kV and 230 kV voltages from distant generating plants in Canada or Grand Coulee and Rocky Reach along the Columbia River. The power is then transformed into lower voltages at the Talbot and O'Brien substations which are connected to the regional grid. The lower voltages are then used to serve subarea distribution substations, (see Table 1, *Transmission Substations*).

Power Sources:

- Hydro-based generation located on the Columbia River in Eastern Washington
- Hydro-based generation located in British Columbia
- Hydro-based and thermal generation located in Western Washington

Transmission Substations

The highest voltage facility in the Highline/Green River Subarea is the Bonneville Power Administration (BPA), 500 kV Raver to Tacoma line. This facility serves the subarea by transmitting energy to Puget Power and other utility transmission substations. The Puget Power substations in the subarea

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[1] The PSCOG name has been changed and is currently known as the Puget Sound Regional Council, PSRC.

consist of both 230 kV for transmission and 115 kV to serve the subtransmission system and the connected distribution substations, (see Table 1, *Transmission Substations*).

Table 1 Transmission Substations

TRANSMISSION SUBSTATION	NAMEPLATE (MVA)	WINTER LOAD 12/21/90(MVA)	PERCENT LOADING
Talbot Hill Bank #1	325	345	106%
Talbot Hill Bank #2	325	340	105%
O'Brien Bank #1	325	266	82%
O'Brien Bank #2	325	273	84%
Total	**1300 MVA**	**1224 MVA**	

The Talbot Hill and the O'Brien Substations receive power from the transmission grid, transform it, and reduce the voltage for distribution to the 115 kV switching and distribution substations.

Note:

The subarea's peak load of 620.8 MVA in 1990 is part of the load supplied by the transmission substations listed in Table 1. These Transmission Substations also serve other subareas. The nameplate rating of the transmission substation transformer is 325 MVA. Due to the temperature and humidity in the Puget Power service territory, the normal life rating of these transmission substation transformers is somewhat higher. The highest normal life rating is for winter. Computer modeling is required to determine the exact limits for each transformer.

The capacity of these transformers is a measure of their ability to serve the connected load. Using the planning guidelines, the system is designed so that one of these large transformers can be taken out of service, single contingency, without causing a customer outage. If a 230 kV-115 kV transformer were to require replacement, it would take approximately 30-40 working days to complete the task. Therefore, it is essential to maintain the number of transformers necessary for supporting the power system and its ability to serve the connected load, even when one transformer is out of service.

As these transmission substation transformers reach their loading limit, three options exist to increase the ability of the system to carry load.

Options

1) The construction of 115 kV lines to substations in adjacent areas. This option assumes that excess capacity exists in neighboring areas.

2) The construction of new switching stations within the area along with their associated source and distribution lines which would increase the ability to serve load in the area. This option assumes that existing transmission substations are underutilized and have spare capacity. In this subarea this would require additional transformers at the Talbot Hill and O'Brien substations, the associated 230 kV transmission lines for capacity and additional 115 kV lines to distribute the power.

3) The addition and or conversion of a switching station to transmission substations. The Christopher switching station is scheduled in 1997 to have a transmission transformer added to the station. This option generally provides the highest capacity, reliability and diversity factors to the network. Diversity is to spread capacity around the subarea. Diversity in the transmission system can be developed in a combination of methods. Physical diversity would be to use different corridors for transmission lines so a single event such as car pole accidents do not affect two lines. Electrical diversity can be provided by designing systems that reduce the impact of system component failures. An example is to design transmission stations with bus sectionalizing. Bus sectionalizing restricts one bus section failure from affecting the entire bus.

Transmission Lines

Transmission Line Configuration [1]. The 115 kV system in the Highline/Green River Subarea is a combination of radial lines and networked lines. A radial line tap is one in which distribution substations are fed from a single transmission line. In a radial system, a transmission line failure, which could be caused by trees and limbs blowing into the line, a "car-pole"accident, or lightning striking the line, results in a service interruption to all of the substations served from that radial line.

The distribution substations on a 115 kV networked system can generally be restored very quickly after an outage because power is either automatically or by a supervisory control system switched to an alternate source. Networked systems are preferred over radial systems.

1.The maximum number of distribution stations that Puget Power allows on a networked line is four. This planning quideline reduces the number of customers affected from a single transmission line event.

Networked 115 kV lines are connected together at main stations or 115 kV switching stations. The switching stations are used to consolidate and coordinate 115 kV lines, which:

- keep line failures on one line from affecting another
- allow higher utilization of existing transmission system capacity
- reduce the number of radial lines and to support the network during line outages.
- reduce system losses

There are three 115 kV switching stations in the Highline/Green River Subarea. They are the Christopher, Midway and Asbury substations. As the area develops and customers demand more power with higher reliability, the need for switching and transmission substations could increase. The switching stations could evolve into future transmission substations because of their central location in the grid and to the load centers.

1) There is a need for more bulk transmission lines at 230 kV and above, to support this system.

The existing 115 kV and 55 kV lines in the subarea were originally designed to serve only distribution substation loads. As a result, distribution and regional power flow across the county are impeded by the conductor sizes and voltage levels of the lines. The existing regional transmission system is therefore dependent upon the Bonneville Power Administration (BPA) transmission lines, which have an upper loading limit. As the load in this area continues to grow, additional transmission lines will have to be built and existing lines upgraded to raise the transfer capability of the transmission system.

2) The main station 230-115 kV transformers, serving the study area, at Talbot Hill and O'Brien exceed their loading criteria for some single contingency events.

Loss of a 230-115 kV transformer at Talbot or O'Brien, during Puget Power system loading of 4600 MW, will load the adjacent transformer to approximately 127% of the nameplate. Additional 230-115 kV transformers at existing or future sites will be needed.

3) **The 230 kV transmission system needs increased capacity and more diversity to support the existing and future loads.**

Capacity is generally considered for the transmission system as the ampacity of a certain line due to its wire (conductor) size and temperature ratings. There are also other factors that can affect a transmission line design and ampacity. These are physical designs such as wood pole, steel pole or towers for transmission lines which have limits on weight and tension loading from the wire sizes. This limits the conductor size and ampacity of the line. Higher ampacity lines, when fully loaded, generally have higher EMF levels. therefore, choosing bigger and bigger wire sizes for higher ampacities may not be desirable or feasible.

Other capacity limiting factors associated with 230 kV transmission systems are bus, breaker and 500-230 kV and 230-115 kV transformer ratings. Bus work and breakers at 230 kV with ratings above 3000 amperes are expensive to build and maintain.

The reliance on, or to build a system on higher and higher single component ampacities, does not provide the transmission system with diversity. Diversity is required to meet reliability requirements of N-1, N-2, and N-1 with maintenance. Planning criteria, N-1 and N-2 are descriptions of a normal system with one or two components of the system out of service with no loss of customers or damage to equipment. This type of analysis is used to determine the system performance and reliability. If a high capacity piece of equipment fails, it generally has a high impact on the system. For example, if the system needs and uses a single 230 kV line rated at 3,000 amperes, loss of that line would require the alternate paths/sources to be rated at that ampacity. System diversity reduces the impact of single system component failures, and the dependency upon large components which may be approaching design limits. Diversity also allows the system to be operated at a higher efficiency level. For instance if you have two lines into a station, each rated at 75 MVA, the total installed capacity is 150 MVA. The effective use of that system using N-1 criteria is 75 MVA. The system is being reliably used at 50% capacity. If three lines at 50 MVA were installed the same station would have 150 MVA of installed capacity and 100 MVA of reliable capacity. The effective use of capacity is 66%. The point is diversity of components provides reliability and effective loading of parallel equipment.

Upgrading to larger transmission substation transformers and associated equipment is not always a solution to relieving the overloading of existing equipment. Three phase 230-115 kV transformers currently have design limits of approximately 500 MVA. Transformers larger than this may not be transportable over city or county roads to the substation sites. Higher capacity transformers, if desired, may have to be of single phase design. Higher capacity transformers would increase the number of components by approximately three, but they would also increase construction costs and the yard space required for a substation. In addition, increased components could decrease reliability. One advantage to using a single phase design transformer is that spare equipment requirements may be less.

Substation transformers and other station equipment failures have a generally lower probability than line outages, but have larger impacts. These impacts can sometimes be mitigated by design such as ringbus or double breaker-double bus designs. Building additional buses will create diversity and reduce the impact of station equipment failures.

230 kV CAPACITY PROBLEMS

- Loss of the 230 kV O'Brien-Christopher Tap during 1991 winter conditions, loads the 230 kV Talbot-O'Brien line to 100% of the continuous no wind winter rating and the 230-115 kV Bank #1 at Talbot to 106% of the nameplate rating.
- Loss of the Maple Valley-Talbot Hill 230 kV south bus during 1991 winter conditions, loads the 230 kV Christopher-O'Brien tap to 118% of the continuous no wind winter rating.
- These lines need to be upgraded to a higher capacity

230 kV DIVERSITY PROBLEMS

- Loss of the O'Brien 230 kV north bus, overloads the the transformer banks at the Talbot substation to 114% of nameplate and the remaining bank at the O'Brien substation to 120% of nameplate.
- Loss of Talbot Hill 230 kV south bus overloads the north bus Bank #2 to 147% of nameplate and the Christopher-O'Brien tap to 102% of the continuous no wind winter rating.
- The network needs additional 230 kV buses to provide diversity.

4) There is a need for new distribution substations due to existing and future loads.

The existing distribution substations in this area, when considered as a group, are well utilized. They have a high 78% utilization factor (load vs. capacity). Any additional load in the subarea should be accompanied by additional distribution and associated transmission system capacity.

Utilization factor analysis assumes that the load is spread evenly around the subarea. Any spare capacity indicated in the utilization factor may not always be available for use during equipment outages. Some geographic areas tend to have higher load densities and utilization factors than others. Some distribution substations border natural or service territory barriers and these substations may not be able to provide or utilize neighboring substation capacity. Specific distribution substation siting looks at this and other criteria to evaluate the need for new capacity.

5) Additional 115 kV lines and switching stations are needed to improve reliability and strengthen the existing 115 kV network between stations.

Nelson Cable Station or Renton Junction

The 115 kV transmission lines, Shuffleton-O'Brien, Talbot-O'Brien and Talbot-Christopher are physically close to each other near the Renton Junction Substation and the Nelson Cable Station. These lines could be routed to a new switching station. This would allow for greater use of existing line capacity to serve future distribution substations. In addition, switching stations and a strong transmission network will allow for higher loading without sacrificing N-1 reliability.

SEA-TAC Airport Switching Station

Additional substation capacity will be required to serve the new commercial and industrial load associated with the airport on the property south of the airport.

The SEA-TAC Airport requires special considerations for reliability. One way to improve the reliability would be to construct a switching station near the south end of the airport. The switching station would make the lines shorter with lower exposure.

6) **During some loading and outage conditions, there are voltage and capacity problems on line segments of the O'Brien to Asbury, the O'Brien to Midway #2, and the Midway to Asbury 115 kV lines. This is due to smaller 397.5 ACSR (Aluminum Conductor Steel Reinforced) conductors on these lines.**
   The loss of the line section O'Brien to Harvest will overload the Midway to Sweptwing line section to 111% of its continuous no wind winter rating and the voltage at Harvest is reduced to 95% of pre-outage levels.

7) **Substations on Radial lines.**

   - The 115 kV line and cable, Talbot to Asbury is normally operated open, affecting capacity and reliability to Asbury and adjacent substations. The Southcenter Substation is fed radially form Asbury because of the open line.
   - A breaker operation at Asbury on the Asbury to Talbot line will drop Southcenter customers. There is no reclosing on this line.
   - If one line, line section or breaker were out for maintenance at Asbury or at the source ends, O'Brien or Midway, single contingency events could cause extensive loss of load.
   - The North Normandy Substation is fed radially from a 1.4 mile tap of the O'Brien to Midway #2 line. Single contingency events will cause loss of load.
   - The Olympic Renton Substation is fed radially from a 2.4 mile line section from Talbot Hill. Single contingency events will cause loss of load.

8) **The load at the SEA-TAC Airport is increasing beyond the capability of the existing distribution system.**

   The existing and planned new loads may require a distribution substation or a new point of service with an emphasis on reliability and redundancy for this critical load. Specific timing, sizing and location will be determined after specific load information, reliability requirements and other information is developed and exchanged with the Port of Seattle.

9) **Substation Bus Designs**

   Bus designs and layouts are important to system reliability and the ability to perform maintenance. Traditional single bus and single breaker bus designs have higher system impacts if the bus or equipment connected to the bus fails. This is because all lines connected to the bus must open to clear faults on the bus. Sometimes, during a maintenance period, system reliability is sacrificed because of the process for removing the bus or associated piece of equipment from service. System reliability could be improved during this maintenance period by:

- using bus designs such as ringbus, double breaker-double bus, breaker and half, and bus sectionalizing, (Note: These designs generally have higher costs and require more yard space).
- reducing the number of circuit breakers that have to open for a bus fault
- providing an alternate, spare, backup or parallel breaker.during maintenance

The 115 kV bus design at the Midway Substation needs to be modified to allow for bus sectionalizing and breaker maintenance.

- During breaker and associated switch maintenance, the existing bus design requires that the line section associated with that breaker to be open at the Midway terminal. This condition puts those substations being served from that line section on a radial tap. Single contingency events will cause loss of load .
- A bus or breaker failure will cause all breakers at Midway to open. This can, under certain loading conditions cause voltage problems.

The 115 kV bus design at Shuffleton needs to be modified to allow for breaker maintenance.

- The existing bus design requires that during breaker and associated switch maintenance that the line section associated with that breaker is open at the Shuffleton terminal. This condition puts those substations being served from that line section on a radial tap. Single contingency events will cause loss of load
- A bus or breaker failure will cause all breakers at Shuffleton to open. This can, under certain loading conditions cause voltage problems.

10) The O'Brien to South Bremerton line exceeds planning criteria for the number of substations being served from a line.

- The number of substations on this line section needs to be reduced from five to four or lower to meet criteria and allow for growth. Reducing the number of substations will reduce the number of customers out of service during a transmission line outage. The length of the line between circuit breakers increases the exposure of outages to those customers connected to the line. Customers in Bremerton are affected by events in the Kent Valley and vice versa.

Distribution Substations

There are twenty seven existing distribution substations in the Highline/Greenriver Subarea of King County which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of the existing distribution substations with associated nameplate capacity and 1990 loading are shown in Table 2.

Table 2 Distribution Substations

DISTRIBUTION SUBSTATION	NAMEPLATE RATING (MVA)	1990 WINTER LOAD 12/21/90 (MVA)	
Asbury	25	17.0	
Bow Lake	25	27.1	
Des Moines	25	17.6	
Earlington	25	21.4	
East Valley	25	24.1	
Falcon	25	NEW	
Freeway	20	17.9	
Grady	25	19.9	
Harvest	25	23.2	
Kent II	25	26	
Kent III	25	26.2	
Manhatten	25	18.9	
Meridith	25	31	
Norpac	25	17.1	
North Normandy	20	11.2	
Orchard	25	14.6	
Orillia	25	20.4	
Redondo	25	17.3	
Renton Junction II	25	19.3	
Renton Junction III	25	11.4	
Rolling Hills	25	19.5	
South Center	25	20	
Sweptwing	25	21.1	
Vashon I	20	10.6	
Vashon II	20	14.1	Resid./Comm.
Victoria Park	25	22.7	Utilization
Zenith	25	21.6	Factor =78%
Totals	**655 MVA**	**511.2 MVA**	

Industrial Substations		
Boeing 1,2,3,4	93.0	35.8
Boeing Aerospace	42.4	24.8
Liquid Air	18.8	13.6
Metro	50.0	9.2
Olympic	9.4	5.5
Total Existing Load	**252 MVA**	**109.6 MVA**

Note: The winter rating of a distribution transformer for continuous load is 132% of nameplate. In residential areas, the winter loading and equipment ratings are used to determine when substation capacity improvements are needed. In commercial load areas, the summer transformer rating of 103% is used. The utilization factor, load versus nameplate capacity, indicates that the system was well loaded and the existing capacity well used. A high utilization factor, however, may not leave much room for growth or equipment outages in the study area.

In industrial load areas, customer owned substation loading and capacity have a lower utilization factor. This is due to different needs for expansion and reliability required by industrial customers.

GROWTH PROJECTIONS

The total anticipated load demand from 1990 to 2020 is shown in Table 3. Table 3 describes the FAZ contained within the Highline/Green River Subarea. Population and employment forecasts for the next 30 years are converted to demand in MVA. These demand figures can then be used to determine the amount of new facilities which will be needed in this subarea.

Table 3 Highline/Greenriver Subarea, 2020 Peak Load Growth Forecast
Source: Population & Employment Data

PSCOG ZONE		1990	2020	GROWTH	GROWTH
Des Moines,Seatac	Population	41595	48737	7142	54.22 MVA
3700	Employment	21729	37437	15708	
Kent East Hill	Population	28241	37821	9580	51.32
3500	Employment	11987	24771	12784	
Kent Industrial	Population	11922	23530	11608	78.30
3600	Employment	28773	50499	21726	
Redondo	Population	31504	46060	14556	45.15
3040	Employment	5235	11962	6727	
Renton Airport CBD	Population	10303	11819	1516	26.82
4130	Employment	33985	43242	9257	
Renton Industrial	Population	14732	20102	5370	36.78
4110	Employment	12079	22346	10267	
Tukwila	Population	4172	6525	2353	57.36
3900	Employment	29956	50410	20454	
Vashon	Population	7868	9729	1861	7.07
6930	Employment	1533	2897	1364	
TOTAL	Population	150337	204323	53986	357.02 MVA
	Employment	145277	243564	98287	

INDUSTRIAL LOAD ADDITIONS

PSCOG ZONE	
Kent Industrial	59.9 MVA
Renton Airport CBD	75.7
Renton Industrial	6.6
Industrial Subtotal	142.22 MVA
Total	499.22 MVA

Note:
New residential load = 1.63 KVA/person for January average peak.
New commercial load = 2.21 KVA/employee for January average peak.
Extreme winter peak = 117% of January average peak.
Population and employment forecasts from PSCOG[1], 1988.

The 499.22 MVA total load figure from Table 3 is the new load predicted to be added to the Puget Power electrical system in the Highline/Green River Valley area. Due to the effects of conservation and demand side management the existing residential and commercial load is estimated to be reduced by 6.94% and 10% respectively. Demand side management reductions do not apply to existing industrial loads. These customers are considered to practice demand management already. To calculate the total future load load in this subarea, the total existing load from Table 2. must be reduced by the conservation and demand management factors and then added to the total new load from Table 3.

Table 4 30 Year Load Increase

Total Load Additions	Residential/Commercial	Industrial
Existing Load Table 2.	511.20	109.60
Conservation - (6.94%)	-35.47	-7.60
Demand Mgmt. - (10%)	-51.12	NA
Expected New Load Table 3.	357.02	142.20
Subtotal Area Load	781.63 MVA	244.20 MVA
2020 Forecasted Load Totals		**1025.83 MVA**
1990 Peak Load		**-620.83 MVA**
30 Year Forecasted Load Increase		**405.03 MVA**

1 The PSCOG name has been changed and is currently known as the Puget Sound Regional Council, PSRC.

The 405.03 MVA from Table 4. of new forecasted load increase in the FAZs includes a conservation (6.94%), and demand side management (10%) reduction of the existing FAZ loads from Table 3. The analysis of this geographic area assumes that the new additional load will be supplied by the transmission and distribution systems in area of study. It is expected that the new total study area system load 1025.83 MVA will be reached in approximately 2020.

SYSTEM IMPROVEMENTS

System improvements required to serve forecasted load growth for the next 30 years are listed as construction projects that are in progress or plans for the future.

CONSTRUCTION PROJECTS IN PROGRESS

This section discusses system improvement projects in the study area that are currently in progress. A project is considered in progress, if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

CHRISTOPHER WEST RELIABILITY

Purpose The purpose of the Christopher West Reliability project is:

1) to reduce the number of substations on 115 kV lines served on a single line between transmission stations
2) to provide a loop feed to the Cambridge and Weyerhaeuser substations
3) to provide additional 115 kV to 12.5 kV transformation capacity in the Federal Way area. This will increase the 115 kV system reliability and capacity for existing and future loads.

Scope This project describes five new 115 kV lines using new and existing routes going west and then north and south from the Christopher Substation.

RENTON RELIABILITY 115 kV IMPROVEMENTS

Purpose There are three system improvements planned in the Renton service area. Individually, each improvement will directly benefit customers within the service area. Collectively performed, customers in a larger area outside of Renton will also benefit due to the improved overall performance of system capacity and diversity.

Scope System improvements:

1) Boeing-Renton Substations Rebuild

This project will take four older 55-13.8 KV substations and convert them to 115-13.8 kV. The number of substations will then be reduced from four to two. This will allow the removal of the last 55 kV lines in the Renton area and improve the reliability to the Boeing-Renton Plant. This is the result of; installing new equipment, by serving them at a higher and more reliable voltage, and by installing 115 kV line sectionalizing to reduce substation outages due to transmission line faults. It will also improve the 115 kV system capacity and reduce overall system losses.

2) Shuffleton-Renton Tower Line Upgrade

This project is being planned to improve reliability and increase capacity in the Renton area. The 55 kV to 115 kV rebuild uses an existing right-of-way between the Talbot Hill Substation and the Shuffleton Substation. This will provide two new lines to Shuffleton and provide a line bay and freeway crossing for the future Talbot-Lakeside #3 line*. The two new lines will be used to support Shuffleton and allow for new loads to be served from these lines. This construction will improve service to the Boeing and PACCAR plants in Renton and reduce the number of substations on the Shuffleton-O'Brien line from five to three. The alternatives studied required new routes and right-of-way and easements.

* Discussed in the future considerations in the Newcastle Subarea

3) PACCAR Substation

The PACCAR Substation is a customer owned substation being constructed to serve new industrial customer load. This substation will provide additional 115 -12.5 kV transformer capacity in Renton for load growth and reserve capacity in the event of an outage to neighboring substations.

CHRISTOPHER-O'BRIEN 230 kV LINE

Purpose The existing section of this line overloads during some loading and outage conditions. Increasing the capacity of this line will correct the problem.

Scope This project consists of upgrading an existing 230 kV line section called the Christopher-O'Brien 230 kV line. This is an existing tower line with double circuit capability. One side has not been used. Bundled 1272 ACSR will be installed on the unused side and the existing circuit will be replaced with this new circuit. The old circuit will be deenergized and at a later date rebuilt from 795 ACSR to bundled 1272 ACSR and used as a O'Brien - White River line. This line section is part of the larger regional transmission grid. The line generally carries Puget Power load and provides capacity for regional bulk power flow, north and south.

ASBURY- MIDWAY LINE

Purpose To prevent the overload of existing conductors during outage conditions.

Scope This project is to reconductor the line sections Midway-Sweptwing and Sweptwing-Asbury from 397.5 ACSR to bundled 795 AAC for additional capacity.

DISTRIBUTION SUBSTATION ADDITIONS

Purpose In order to serve existing and future customers in the Highline/Greenriver Subarea, additional distribution substations and transformers will be required.

Scope

1) Cambridge Substation

This substation is being constructed to serve new and existing customers along the east hill of Kent. This will also provide reserve capacity in case of an outage to neighboring substations.

2) Meeker Substation

This substation is being constructed to serve new and existing customers in the Kent area. This will also provide reserve capacity in case of an outage to neighboring substations. Alternatives studied for this substation were upgrading capacity at neighboring substations or the construction of Russell substation.

3) Highridge Substation

This substation is being constructed to serve new and existing customers on the east hill of Kent. This will also provide reserve capacity in case of an outage to neighboring substations.

4) Vashon Substation (Existing Substation)

This project is to increase capacity at the existing Vashon substation site from 40 MVA to 50 MVA. The existing transformers will be replaced with higher capacity transformers.

CHRISTOPHER 230 kV DEVELOPMENT

Purpose The purpose of this particular expansion is to provide additional 230-115 kV transformer capacity to the study area. This is necessary for a 230-115 kV transformer outage at the White River Substation.

Scope The scope of this project is the development of a 230 kV substation and 115 kV expansion at the existing Christopher 115 kV Substation. Basic design of the substation will be a ringbus, allowing for conversion to a breaker and half scheme with three line bays and a 230-115 kV transformer. The 230 kV lines planned for, are the existing Christopher-O'Brien line and terminating the existing three terminal line BPA Covington-Christopher Tap-Tacoma #4 line into two, two terminal lines at Christopher. A 42 MVAR capacitor is planned on the Christopher 115 kV bus. The alternatives studied such as a third bank at White River did not provide the system with as high a degree of reliability or system loading limits.

WHITE RIVER to CHRISTOPHER #1 230 kV LINE

Purpose This project is planned to provide capacity at Christopher and needed reliability for 230 kV line or bank outages at Christopher or White River. This line would also be part of the larger transmission grid carrying north and south regional power flow. The White River to Christopher #1 230 kV line would provide redundancy as well as capacity. This redundancy would allow the system to operate at full capacity for forced or unforced outages on the adjacent lines (N-1).

Scope This project would use existing right-of-way for most of the construction from White River to Christopher. Some easements may be required. This line will be approximately 8 miles long and built with bundled 1272 ACSR.

FUTURE TRANSMISSION IMPROVEMENTS

In addition to the planned 115 kV and 230 kV line and station projects, future transmission improvements will be required. Some of the plans for future improvement are regional, (They would provide system support within and outside of the subarea). The capacity, need, and timing may depend upon other facilities outside of the subarea. The timing, sizing, and routing will be performed on a narrower time frame of 5-10 years. Plans for future transmission improvements follow:

O'BRIEN SUBSTATION ADDITIONS

1) <u>O'Brien-White River 230kV Line</u>

Construct an O'Brien to White River 230 kV line for capacity and reliability to O'Brien and adjacent substations. This line addition would provide a strong source to the O'Brien Substation and allow for outages during maintenance periods. The need for this addition also depends upon import and export levels during north and south transfers between the Northwest, Canada and California.

2) <u>O'Brien-Talbot Hill #2 230 kV Line</u>

Construct a second O'Brien to Talbot Hill 230 kV line for capacity and reliability for the O'Brien, Talbot Hill and Christopher substations. This will also be the tapped line to serve future Tukwila Substation.

3) <u>Reconductor the Talbot-O'Brien 230 kV line</u>

The existing line overloads under some conditions and needs to be reconductored from 795 ACSR to bundled 1272 ACSR to solve the problem.

NEW SWITCHING STATIONS

1) <u>The Renton Junction Switching Station</u>

Create a 115 kV station at or near the Renton Junction Substation or the Nelson Cable Station. The purpose of this plan would be to connect the Shuffleton-O'Brien, Talbot-O'Brien, Talbot-Asbury lines for greater existing line capacity and reliability. The three lines are physically close to each other near the Renton Junction Substation. They could be routed to this substation or a to new switching station.

The need for this plan could be driven by new industrial and commercial loads in the area, and Puget Power's reliability criteria. This criteria limits the maximum number of substations on a line to four. When new load requires additional substations, one alternative to constructing new lines in an area is to use the existing lines and route them into a switching station. The lines can then be broken up into smaller lines to provide support for each other.

2) The Sea-Tac Switching Station

Create a 115 kV station at or near the Sweptwing Substation or S. 208th St. and Des Moines Way to connect the Midway to Asbury and the Midway to O'Brien #2 lines for improved capacity, reliability, and greater use of existing line capacities. The need for this project will be driven by new industrial and commercial loads in the Sea-Tac area, and Puget Power's reliability criteria. The reliability criteria limits the maximum number of substations on a line to four, thereby reducing the number of customers out of service for transmission line outages.

The Midway to O'Brien line will have the maximum number of substations when the Memorial distribution substation is built. This line configuration does not allow for any new load that might occur near the airport without some additional lines. A switching station that is correctly located can break the longer loaded lines into shorter lines. This improvement would provide increased utilization of existing line routes and more reliability to customers. The need for this construction may be accelerated depending upon growth in and around Sea-Tac Airport.

MODIFY 115 kV BUS DESIGNS

Purpose This improvement would reduce the system impact and exposure during 115 kV bus maintenance and bus component failures

Scope Modify the Midway and Shuffleton 115 kV buses from single bus, single breaker to some other design such as Main bus, Auxiliary bus with a bus sectionalizing and bus tie breaker.

WHITE RIVER to O'BRIEN #3 115 kV LINE

Purpose To provide a 115 kV source to existing and proposed distribution substations in Kent and Auburn. The White River to O'Brien #3 115 kV line also eliminates a 1.5 mile radial line tap to Ellingson on the White River - O'Brien #2 line.

Scope This project, 13.5 miles in length, primarily on an existing right of way, is an upgrade of a 55 kV line.

FUTURE DISTRIBUTION SUBSTATIONS

There are eleven new distribution substations that would be needed to serve the 30 year forecasted load in the Highline/Green River study area.

Generally the area served by a distribution substation, can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon growth patterns in a local area.

The specific site selection is an iteration process that examines:

- Growth in the area. (The best electrical performance is to site the substation in the center of the load area).
- The existing Distribution System. (If located properly, cost can be reduced and performance improved by selecting a site that improves support in a weak area or uses the strength of an existing system such as good wire size with sufficient switching capability.)
- Transmission line routing. (The lowest impact would be a site which is on or near an existing highline).
- Environmental impact of the site.
- Transportation access (The site has to be accessible during all weather conditions for routine and emergency switching or maintenance.)
- Existing zoning in an area.
- Security of the site.
- Physical arrangement of the site for station equipment arrangement.
- Site potential. (The site should not exclude any future plans).

Future Distribution Substations, (listed by FAZ)

- Des Moines FAZ
  - Memorial
  - Grandview
  - Sea-Tac
- Kent East Hill FAZ
  - Thomas
  - Jason
- Kent Industrial FAZ
  - Russell
- Redondo FAZ
  - Lake Fenwick
- Renton CBD FAZ
  - Powell
  - Houser Way
- Tukwila FAZ
  - Tukwila
- Vashon FAZ
  - Maury

• **Des Moines FAZ**

Proposed substations that would be necessary to serve the forecasted load:

1. Memorial The Memorial Substation is proposed to serve customers in the areas of south Normandy Park, south Sea-Tac, and north Des Moines. This substation will provide capacity to the area and serve as a backup to the Sweptwing, Des Moines, Freeway and Manhatten substations.

2. Grandview The Grandview Substation is proposed to serve future customers near the Kent-Des Moines Road from Interstate 5 east. It will provide capacity to the area and backup to the Freeway, Redondo, and Kent substations.

3. Sea-Tac The Sea-Tac substation is proposed to serve Sea-Tac Airport load. The existing system capacity in the area is fully utilized. This substation would provide capacity to the area by freeing capacity at existing substations to serve non airport load.

•**Kent East Hill FAZ**

The Kent Hill FAZ has one in-progress and two proposed substations to serve the forecasted load. The in-progress substation is described in the System Improvements In-Progress section. The proposed substations are:

1. Thomas The Thomas Substation is proposed to serve customers in the area of S 277th and the East Valley Highway. It will provide capacity to the area and provide a backup to the Meridith, Kent, and West Auburn substations.

2. Jason The Jason Substation is proposed to serve customers in the area of James Street and North Central Avenue in Kent. It will provide capacity in the area and provide backup to the Kent, Orchard and Harvest substations.

•**Kent Industrial FAZ**

The Kent Industrial FAZ zone has two substations currently in progress and one proposed substation to serve the forecasted load. The in-progress substations are described in the System Improvements In-Progress section. The proposed substation is:

Rusell The Russell Substation. This substation is proposed to serve customers in the area of S.288th and the West Valley Highway. It will provide capacity in the area and provide backup to the Kent, Freeway and Harvest substations.

•Redondo FAZ

The Redondo FAZ has one proposed substation to serve forecasted load. This proposed substation is:

Lake Fenwick The Fenwick Substations is proposed to serve customers in the area of Reith Road and 36th Ave. S. It will provide capacity to the area and provide a backup to the Redondo and Marine View substations.

•Renton CBD FAZ

The Renton CBD FAZ has two proposed substations to serve forecasted load. The proposed substation are:

1. Powell The Powell Substation is proposed to serve customers in the area of S. Grady Way and Powell Ave. SW. This substation will provide capacity to the area and provide backup for the Earlington, Metro Renton, Olympic Renton and Renton Junction substations.

2. Houser Way The Houser Way Substation is proposed to serve customers in the area of Highlands Substation.

•Tukwila FAZ

The Tukwila FAZ has one proposed substation to serve forecasted load in the area:

Tukwila The Tukwila Substation is proposed to serve customers in the area of Interurban and South Center Boulevard. It will provide capacity to the area and provide a backup to the Asbury, Southcenter and Renton Junction substations.

•Vashon FAZ

The Vashon FAZ has one proposed substation to serve forecasted load in the area:

Maury. The Maury Substation is proposed to serve customers in the area of 91st Ave SW and SW 216th ST. It will provide capacity to the area and provide backup for the Vashon Banks 1&2.

Note: *The area served by a distribution substation can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon growth patterns in a local area. It is expected that a utilization factor, load versus capacity, will be maintained in the 75-85% range. This percentage allows for the need that capacity must always be greater that the total load. This is due to: 1)Backup capacity that must be available in every local area for equipment failures and equipment maintenance, 2)Capacity must be available to serve higher loads caused by extreme weather conditions, 3)Capacity must be added in fixed and large amounts, whereas the load grows evenly.*

Table 5. - Future Distribution Substations

FAZ	Name	Future Substation	Capacity	In-Progress Substation	Capacity
3700	Des Moines	Memorial	25 MVA		
		Grandview	25		
		Seatac	25		
3500	Kent East Hill	Thomas	25	Highridge	25
		Jason	25		
3600	Kent Industrial	Russell	25	Cambridge	25
				Meeker	25
3040	Redondo	Lake Fenwick	25		
4130	Renton Airport CBD	Powell	25		
		Houser	25		
3900	Tukwila	Tukwila	25		
6930	Vashon	Maury	25	Vashon Upgrade	10
	Future Total		**275 MVA**	**In Progress Total**	**85 MVA**

The in progress and future distribution substations will add approximately 360 MVA of capacity to serve an estimated 270 MVA increase in load. The total distribution capacity in the study area will increase from a 1990, 655 MVA to a 2020 capacity of 1015 MVA. This increase corresponds from an existing residential and commercial customer 511 MVA load to a forecasted 781 MVA load. The distribution equipment utilization factor, load versus capacity, will change from 78% to 77%.

Future Industrial Substations

Boeing and the Seattle Times have indicated a need for substation capacity in the area. Loads for these sites have not been estimated.

1. Boeing Longacres Substation
2. Seattle Times Substation

Future industrial substations are difficult to project for timing and location. Only the existing industrial customers were assumed to grow, (the existing customers were classified as petroleum, paper, lumber, chemical or other. The growth rates assumed for these groups were established by Puget Power's Economic and Forecast Group.

The estimated increase in industrial load is from 109.6 MVA in 1990 to 252 MVA in 2020. The future industrial load will most likely be served by the 115 kV system. The location of this new load will most likely be near existing industrial loads.

FUTURE CONSIDERATIONS

This section contains additions that could be expected in the future. The purpose of future projection is to present an overview of possibilities for this time period, especially, for those concerned with system development beyond a 30 year study period.

Since the future is uncertain, long range planning efforts must be flexible. One method that is used to project system requirements 20-30 years in the future is a zoning density analysis. This type of forecasting of the long range or ultimate electrical system load, examines the land use zoning in the area. The total square miles in each zoning category is multiplied by an estimated electrical load per square mile for that category.

The ultimate electrical demand per square mile of single family, multi-family, central business districts (CBD) and commercial zones can be determined by measuring the actual electrical load in areas of similar zoning where build-out is complete. Using Puget Power information, Table 6 shows ultimate loads by the type of building.

Table 6. Zoning Categories

ZONING CATEGORY	MVA per Square Mile, (if fully built out)
Single Family	8
Multi Family	17
Commercial	29
CBD	250
Park/Open Space	0

Note: At this time it has not been possible to examine the study area and calculate the total number square miles in each zoning category. Until this information is developed for each subarea, Puget Power is using an average of 12 MVA per square mile for those subareas along the I-5, I-405 corridors.

A zoning density analysis will develop only 1032 MVA of (commercial+residential) load. It will not help to predict industrial loads or assume that land use densities almost always increase with time. To obtain the ultimate load, industrial loads would have to be added separately.

To predict the Ultimate Load, add to the 1032 MVA, (commercial + residential) load, the total forecasted industrial load of 244 MVA, calculated from the Puget Power Industrial Load Forecast Program, to obtain a total of 1276 MVA, or ultimate load, for this subarea.

Winter power flow data shows that not all of the capacity available in the main substations in the subarea, flow in to serve the subarea. About 50% of Talbot Hill Substation capacity and 100% of O'Brien and 50% of planned Christopher capacity will serve the subarea.

Table 7 230 kV Capacity Zoning Analysis

230/115 kV Substation	%Capacity Assigned to Subarea	Nameplate Capacity	MVA Available
Talbot Hill	50	650MVA	325
O'Brien	100	650MVA	650
Christopher	50	325MVA	162
		Total Available Capacity	*1137MVA

*This assumes that all transformers are in service.

The total available capacity will be 1137 MVA. The ultimate build-out predicts a required capacity of 1276 MVA. The planned capacity does not meet the load requirements of the zoning analysis. Another transformer in the subarea or bordering the subarea would be needed. If we use Puget Power's reliability criteria for N-1 and with no loss of customer load, this subarea would require two more 230-115 kV transformers.

Table 8 500 kV Capacity Zoning Analysis

500/230 kV Substation	%Capacity Assigned to Subarea	Nameplate Capacity	MVA Available
Covington	25	1800MVA	450
Maple Valley	25	2200MVA	550
		Total Available Capacity	*1000MVA

*This assumes that all transformers are in service. An N-1 was not considered for the 500-230 kV transformers. The winter power flow data shows, that not all of the capacity available from the main substations in the subarea, flow in to serve the subarea. Approximately, 25% of the Covington

Substation capacity and 25% of the Maple Valley Substation capacity will serve the subarea.

This type of analysis of the capacity of the 500 kV system indicates that additional 500-230 kV transformers will be required to serve this subarea when the capacity reaches 1000 MVA near the end of the 30 year study period. 500-230 kV transformers could be required earlier due to additional load outside of the subarea.

Future Considerations:

MIDWAY SUBSTATION 230 KV

1) Construct two 230 kV lines into Midway from two sources such as the O'Brien or the Christopher Substation.

2) Construct a 230-115 kV substation at Midway. The purpose of this substation would be to increase capacity and reliability for Midway and neighboring substations. The decision to locate a 230-115 kV transformer at Midway will depend upon the specific area load densities and improvement to capacities at other substations such as Christopher. If a transformer bank is not required, the 230 kV line could go directly to the Port Orchard area.

3) Construct a Midway to Port Orchard area 230 kV line for capacity and reliability to the South Bremerton and adjacent substations. The timing and scope of this plan would depend upon existing regional transmission projects being completed. These include the Tacoma City Light to Henderson 230 kV line, the Whidbey Island to Kitsap at 230 kV, or the deterioration of the existing 115 kV cable. If these plans are not completed, this plan may need to be accelerated.

CHRISTOPHER SUBSTATION ADDITIONS

1) Christopher Substation 230 kV Additions

Construct a second 230-115 kV bank at Christopher Substation for capacity and reliability. The addition of a second bank at Christopher would depend upon load growth and possible system additions in the area such as the Berrydale 230-115 kV Substation construction.

2) Christopher Substation 500-230 kV Additions

Construct a 500-230.kV substation at Christopher. See the 500 kV zoning analysis. There is approximately 405 MVA of new load in this service area being served at 230 kV and 115 kV. The delivery system for the 230 kV and 115 kV system is the 500 kV main grid. The 500-230 kV transformers in the service area are near capacity. This means there will need to additional 500-230 kV transformation in the area. This proposal would provide regional system support. The need and timing for this construction would depend upon load growth inside the subarea and system additions outside but near the subarea. This would be for capacity and reliability for the 230 KV system near the Christopher, White River, Talbot Hill and O'Brien Substations.

3) White River to Christopher 230 kV #2

This plan would be to energize a second 230 kV line from Christopher to White River. The second line would provide additional capacity between the two stations for reliability and support. When the 500 kV is energized at Christopher, this additional tie line at 230 kV is needed to distribute the power in the area.

4) Christopher to BPA-Tacoma #3 and to Covington #3.

This project would be in conjunction with 500 KV being energized at Christopher. This connection would help support the Puget Power 230 kV system as well as the BPA system. The need for this project would depend on regional transmission construction such as increased 500-230 kV transformer capacity at BPA's Covington and Tacoma Substations.

X. BENSON/TAHOMA/RAVEN HEIGHTS ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

The Benson/Tahoma/Raven Heights geographic subarea in the South and Central King County Electrical Facilities Plan consists of approximately 117 square miles and contains five Puget Sound Council of Governments (PSCOG)[1] Forecast Analysis Zones (FAZ). This subarea is bordered approximately on the north by the Renton Issaquah Rd. and Interstate 90, on the south by SE 240th and the Cedar River, on the east by Hobart and Mirrormont, and to the west by the East Renton and Kent city limits. In 1990, the population for this subarea was 92,307, and the employment was 7145.

Generation

The Puget Power transmission facilities in the Benson\Tahoma\Raven Heights Subarea are interconnected to a larger transmission grid throughout the Western United States, (see Main Grid discussion). Power flows North and South and East and West through the area as the loads and the generation patterns of the system change. Power is supplied to the subarea through the larger regional transmission grid at 500 kV and 230 kV voltages from distant generating plants in Canada or Grand Coulee and Rocky Reach along the Columbia River. The power is then transformed into lower voltages at the Talbot and O'Brien substations which are connected to the regional grid. The lower voltages are then used to serve subarea distribution substations, (see Table 1, *Transmission Substations*).

- hydro-based generation located on the Columbia River in Eastern Washington
- hydro-based generation located in British Columbia
- hydro-based and thermal generation located in Western Washington

[1] The PSCOG name has been changed and is currently known as the Puget Sound Regional Council, PSRC.

Transmission Substations

The Puget Power transmission substations connected to the regional transmission grid in this area are the Talbot Hill Substation, the Lake Tradition and Berrydale Switching Stations. Sources of power exist outside of this subarea which supply the area load. Power from distant generating plants in Canada or Grand Coulee and Rocky Reach along the Columbia River is delivered through the larger regional transmission grid at 500 kV and 230 kV voltages to these substations.

The Talbot Hill Substation contains both 230 kV for transmission and 115 kV to serve the sub-transmission system and the connected distribution substations, (see Table 1, Benson/ Tahoma/ Raven Heights, page 32). The Talbot Hill Substation takes power from the transmission grid and transforms it, reduces the voltage, to distribute it to 115 kV switching and distribution substations. One of the problems in this area is a lack of bulk transmission lines 230 kV and above, to support this system. The existing 115 kV lines that exist in the subarea were designed to serve distribution substation loads. As a result, the conductor size and voltage levels are not large enough to serve both distribution and allow regional power flow across the county.

The existing regional transmission system is dependent upon the Bonneville Power Administration (BPA) transmission lines which have an upper loading limit. As the load in this area continues to grow, additional transmission lines will have to be built to raise the transfer capability of the transmission system.

Table 1 Transmission Substations

Transmission Substation	Nameplate MVA	Winter Load 12/21/90 MVA	Percent Loading
Talbot Hill Bank 1	325	345	106%
Talbot Hill Bank 2	325	340	105%
Totals	**650 MVA**	**685 MVA**	

Note:

The subarea's 1990 peak load of 164.6 MVA is part of the load supplied by the transmission substations listed in Table 1. This transmission substation also serves other subareas. The nameplate rating of the transmission substation transformer is 325 MVA. Due to the temperature and humidity in the Puget Power service territory, the normal life rating of these transmission substation transformers is somewhat higher. The highest normal life rating is for winter. Computer modeling is required to determine the exact limits for each transformer.

The capacity of these transformers is a measure of their ability to serve the connected load. Using the planning guidelines, the system is designed so that one of these large transformers can be taken out of service, (single contingency, N-1), without causing a customer outage. If a 230-115 kV transformer were to be replaced, it would take approximately 30-40 working days to complete the task. Therefore, it is essential to maintain the number of transformers necessary for supporting the power system and its ability to serve the connected load, even when one transformer is out of service.

Transmission Line Configuration. The 115 kV system in the Benson/Tahoma/Raven Heights subarea is a combination of radial line taps and networked lines. A radial line tap is one in which distribution substations are fed from a single transmission line. In a radial system, a transmission line failure, which could be caused by trees and limbs blowing into the line, a "car-pole" accident, or lightning striking the line, results in a service interruption to all of the substations served from that radial line tap.

Networked 115 kV lines are connected together at main substations or 115 kV switching stations. Distribution substations on a networked line can generally be restored very quickly after an outage. This is because power is either automatically or by a supervisory control system switched to an alternate source. The maximum number of distribution stations Puget Power allows on a networked line is four. This planning guideline reduces the number of customers affected from a single transmission line event.

Switching stations are used to consolidate and connect 115 kV lines to keep line failures on one line from affecting another. Switching stations allow for higher utilization of existing system capacity. They are used to reduce the number of radial lines and to support the network during line outages.

As an area develops and demands for more power with higher reliability, the need for switching and transmission substations increases. Switching stations can evolve into transmission substations because of their central location in the grid and their proximity to the load centers.

Analysis of the Existing System

1) The main substation 230-115 kV transformers, serving the study area, at Talbot Hill, exceed their loading criteria for some single contingency events.

Loss of a 230-115 kV transformer at Talbot during a Puget Power system load of 4,600 MW, will load the adjacent transformer to approximately 127% of the nameplate rating. Some 230-115 kV transformers at existing or future sites will need to be added.

2) The 230 kV transmission system needs to have improved capacity and diversity to support the existing and future loads.

Capacity is generally considered for the transmission system as the ampacity of a certain line due to its wire (conductor) size and temperature ratings. There are also other factors that can affect a transmission line design and ampacity. These are physical designs such as wood pole, steel pole or towers for transmission lines which have limits on weight and tension loading from the wire sizes. This limits the conductor size and ampacity of the line. Higher ampacity lines, when fully loaded, generally have higher EMF levels. Therefore, choosing bigger and bigger wire sizes for higher ampacities may not be desirable or feasible.

Other capacity limiting factors associated with 230 kV transmission systems are bus, breaker and 500-230 kV and 230-115 kV transformer ratings. Bus work and breakers at 230 kV with ratings above 3000 amperes are expensive to build and maintain.

The reliance on, or to build a system on higher and higher single component ampacities, does not provide the transmission system with diversity. Diversity is required to meet reliability requirements of N-1, N-2, and N-1 with maintenance. Planning criteria, N-1 and N-2 are descriptions of a normal system with one or two components of the system out of service with no loss of customers or damage to equipment. This type of analysis is used to determine the system performance and reliability. If a high capacity piece of equipment fails, it generally has a high impact on the system. For example, if the system needs and uses a single 230 kV line rated at 3,000 amperes, loss of that line would require the alternate paths/sources to be rated at that ampacity. System diversity reduces the impact of single system component failures, and the dependency upon large components which may be approaching design limits. Diversity also allows the system to be operated at a higher efficiency level. For instance if you have two lines into a station, each rated at 75 MVA, the total installed capacity is 150 MVA. The effective use of that system using N-1 criteria is 75 MVA. The system is being reliably used at 50% capacity. If three lines at 50 MVA were installed the same station would have 150 MVA of installed capacity and 100 MVA of reliable capacity. The effective use of capacity is 66%. The point is, diversity of components provides reliability and effective loading of parallel equipment.

Upgrading to larger transmission substation transformers and associated equipment is not always a solution to relieving the overloading of existing equipment. Three phase 230-115 kV transformers currently have design limits of approximately 500 MVA. Transformers larger than this may not be transportable over city or county roads to the substation sites. Higher capacity transformers, if desired, may have to be of single phase design. Higher capacity transformers would increase the number of components by approximately three, but they would also increase construction costs and the yard space required for a substation. In addition, increased components could decrease reliability. One advantage to using a single phase design transformer is that spare equipment requirements may be less.

Substation transformers and other station equipment failures have a generally lower probability than line outages, but have larger impacts. These impacts can sometimes be mitigated by design such as ringbus or double breaker-double bus designs. Building additional buses will create diversity and reduce the impact of station equipment failures.

230 kV CAPACITY PROBLEMS

- Loss of the 230 kV O'Brien-Christopher Tap during 1991 winter conditions, loads the 230 kV Talbot-O'Brien line to 100% of the continuous no wind winter rating and the 230-115 kV Bank #1 at Talbot to 106% of the nameplate rating.
- Loss of the Maple Valley-Talbot Hill 230 kV south bus during 1991 winter conditions, loads the 230 kV Christopher-O'Brien tap to 118% of the continuous no wind winter rating.

230 kV DIVERSITY PROBLEMS

- Loss of the Talbot Hill 230 kV south bus overloads the north bus Bank 2 to 147% of nameplate and the Christopher-O'Brien tap to 102% of the continuous no wind winter rating.

3) Berrydale-Lake Tradition #1 Line

There are four existing substations being served from this line. Puget Power guidelines do not allow additional substations to be served from this line. Any additional load and substations will need additional 115 kV lines in the area.

4) There is a need for new distribution substations due to future and existing loads.

The existing distribution substations in this area, when considered as a group, are well utilized from a capacity point of view. They have a high 82.3% utilization factor (load/capacity), see Table 2. A high utilization factor may not allow for growth or contingencies. Any additional load in the subarea should be accompanied by additional distribution and associated transmission system capacity.

Utilization factor analysis assumes that the load is spread evenly around the subarea. The spare capacity indicated in the utilization factor may not always be available for use. Specific geographic areas have higher load densities and utilization factors than others. Some distribution substations border natural or service territory barriers and these substations may not be able to provide or use neighboring substation capacity. Specific distribution substation siting looks at this and other criteria to evaluate the need for new capacity.

- Loss of either Lake Meridian or Panther Lake will overload the other to 144% of the nameplate rating.

5) Substation Bus Designs

Bus designs and layouts are important to system reliability and the ability to perform maintenance. Traditional single bus and single breaker bus designs have higher system impacts if the bus or equipment connected to the bus fails. This is because all lines connected to the bus must open to clear faults on the bus. Sometimes, during a maintenance period, system reliability is sacrificed because of the process for removing the bus or associated piece of equipment from service. System reliability could be improved during this maintenance period by

- using bus designs such as ringbus, double breaker-double bus, breaker and half, and bus sectionalizing, (Note: These designs generally have higher costs and require more yard space).
- reducing the number of circuit breakers that have to open for a bus fault
- providing an alternate, spare, backup or parallel breaker.during maintenance

The 115 kV bus design at the Berrydale Substation needs to be modified to allow for bus sectionalizing and breaker maintenance.

1. The existing bus design requires that during breaker and associated switch maintenance that the line section associated

with that breaker is open at the Berrydale terminal. This condition puts those substations being served from that line section on a radial tap. Single contingency events will cause loss of load .

2. A bus or breaker failure will cause all breakers at Berrydale to open. This can, under some loading conditions cause voltage problems.

- The 115 kV bus design at the Lake Tradition Substation may need to be modified to allow for bus sectionalizing and breaker maintenance.

1. The existing bus design requires that during breaker and associated switch maintenance that the line section associated with that breaker is open at the Berrydale terminal. This condition puts those substations being served from that line section on a radial tap. Single contingency events will then cause loss of load .
2. A bus or breaker failure will cause all breakers at the Lake Tradition Substation to open.This can under some loading conditions cause voltage problems.

6) Talbot Hill-Fairwood-Berrydale #1 Three Terminal 115 kV Line.

The Talbot Hill-Fairwood-Berrydale #1 115 kV line is a three terminal line. Three terminal lines are generally more difficult to protect, operate and maintain. Transmission line outages on a three terminal line take longer to restore to service because there are more switches and line segments to check. Three terminal lines should be eliminated when possible.

There are four existing substations being served from this line. Puget Power guidelines do not allow additional substations to be served from this line. Any additional load and substations will need additional 115 kV lines in the area.

The Lake Meridian Substation is fed radially from a .98 mile tap of the Talbot Hill- Berrydale-Fairwood #1 line. A transmission line failure on this line segment will take longer to restore service.

7) Loss of the Talbot Hill 115 kV North Bus, using winter 1991 loads, overloads the Talbot Hill-Berrydale #2 115 kV line to 129% of the continuous no wind, winter rating.

There is a possibility of conductor damage and extended outages if this occurs.

8) During some loading and outage conditions there are voltage and capacity problems on some line segments of the Talbot Hill-Berrydale-Fairwood and the Berrydale-Krain Corner 115 kV lines. This is due to higher loading on these conductors, the length of the lines and their weaker source impedances.

Loss of the White River 115 kV bus, overloads the Talbot Hill-Fairwood-Berrydale #1 line to 1 118% of the continuous no wind, winter rating.

9) Lake McDonald Substation

The Lake McDonald Substation is fed radially from a 1.8 mile tap. A transmission line failure on this line segment will take longer to restore service because no alternate source is available.

Distribution Substations

There are eight existing distribution substations in this subarea of the South King County which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of the existing distribution substations with associated nameplate capacity and 1990 loading in shown in Table 2.

Table 2 Distribution Substations

Distribution Substation	Nameplate Rating MVA	1990 Winter Loads 12/21/90 MVA	
Fairwood	25	28.2	
Hobart	25	15.3	
Lake McDonald	25	16.3	
Lake Meridian	25	26.3	
Lake Wilderness	25	23.5	
Maplewood	25	22.9	
Mirrormont	25	14.5	Utilization
Panther Lake	25	17.6	Factor=82.3%
Totals	**200 MVA**	**164.6 MVA**	

Note: The winter rating of a distribution transformer for continuous load is 132% of the nameplate rating. In residential areas the winter loading and equipment ratings are used to determine when substation capacity improvements are needed. In primarily commercial load areas the summer transformer rating of 103% is used. The utilization factor, load versus nameplate capacity, indicates that the system was well loaded and the existing capacity well used. A high utilization factor may not leave much room for growth or equipment outages.

GROWTH PROJECTIONS

Forecast area zones, FAZ, contained within this subarea are located in King County. Population and employment forecasts for the next 30 years are converted to demand in MVA. These demand figures can then be used to determine the number of new facilities which will be needed in this subarea.

Table 3. - Benson/Tahoma/Raven Heights Subarea, 2020 Peak Load Growth Forecast
Source: Population & Employment Data

PSCOG ZONE		1990	2020	1990-2020 GROWTH	LOAD GROWTH
Benson 3411	Population	37163	81589	44426	105.02 MVA
	Employment	2800	10652	7852	
East Renton 4210	Population	11928	25063	13135	31.95 MVA
	Employment	1002	3671	2669	
Fairwood 3412	Population	21774	47470	25696	61.67 MVA
	Employment	1655	6626	4971	
Maple Valley 3330	Population	11898	26152	14254	36.10 MVA
	Employment	1176	4627	3451	
Renton Plateau 4230	Population	9544	18385	8841	21.64 MVA
	Employment	512	2361	1849	
Total	Population	92307	198659	106352	256.56 MVA
	Employment	7145	27937	20792	

Note:
New residential load = 1.63 KVA/person for January average peak.
New commercial load = 2.21 KVA/employee for January average peak.
Extreme winter peak = 1.17 times January average peak.
Population and employment forecasts form PSCOG, 1988.

The 256.56 MVA total load growth figure from Table 3. is the predicted new load to be added to the Puget Power Electrical system in the Benson/Tahoma/Raven Heights area. Due to the effects of conservation and demand side management in the future, the existing load must be reduced by 6.94% and 10% respectively. To calculate the total future load load in this subarea, the total existing load from Table 2. must be reduced by the conservation and demand management factors and then added to the total new load from Table 3.

Table 4 30 Year Load Increase

Total Load Additions	Residential/Commercial
Existing Load Table 2.	164.60
Conservation - (6.94%)	-11.42
Demand Mgmt. - (10%)	-16.46
Expected New Load, Table 3.	256.56
Subtotal Area Load	393.28 MVA
2020 Forecasted Load Totals	**393.28MVA**
1990 Peak Load	**-164.60MVA**
30 Year Forecasted Load Increase	**228.68MVA**

SYSTEM IMPROVEMENTS

The new power system improvements required to serve forecasted load growth for the next 30 years are shown on Map 3. These improvements are described as construction projects in progress or planned for the future. Schematic diagrams of the transmission system are included with the text to visually describe the transmission system as each improvement takes place.

CONSTRUCTION PROJECTS IN PROGRESS

In this section is a list of system improvement projects in the study area that are in progress. A project is considered *in progress*, if specific site selection, preliminary engineering, permitting, or construction activities are currently underway.

BERRYDALE 230 kV DEVELOPMENT

Purpose This project is the development of a 230 kV substation and 115 kV expansion at the existing 115 kV Berrydale Switching Station. This 115 kV expansion will provide increased capacity to the study area which is necessary for a 230-115 kV transformer outage at the White River Substation or the Talbot Hill Substation.

Scope This project consists of upgrading an existing 115 kV line section called the Talbot Hill-Berrydale #2 115 kV line to a double circuit 230 kV line. The line will initially be operated as a single circuit. This line section will provide a 230 kV line source to Berrydale for the 230-115 kV transformer.

LAKE TRADITION 230 kV DEVELOPMENT

Purpose This development is part of a larger project called the IP line Rebuild. The IP line rebuild, to be completed in 1996, is the rebuild of an existing line that originates near Wannapum in Eastern Washington. This 115 kV line will be upgraded to 230 kV and reconductored for higher ampacity.

Benefits Derived from the Lake Tradition 230 kV Development:

- Improved service and reliability which comes with new line construction
- Regional benefits from additional transfer capability from Eastern Washington to Western Washington
- Lower overall system losses. The customers being served from lines in and around Lake Tradition will have improved service because the new 230-115 kV transformer provides a strong reliable source of power. This project may also upgrade the 115 kV bus from a main bus, single breaker, to main bus-auxilliary bus with bus tie and bus sectionalizing breaker. This 115 kV bus design will be determined after additional studies have been done.

GLENCARIN SUBSTATION

Purpose. To serve new and existing customers along the Benson Highway corridor east to Lake Youngs and from Kent Kangley north to Panther Lake. This new substation will also provide reserve capacity to the neighboring Panther Lake, Meridian, Fairwood and Orchard substations, in the event of an outage.

Berrydale-Fairwood-Talbot Hill Three Terminal Line

Purpose. This is part of the Glencarin Substation development. This system development will take an existing three terminal line, and route and construct two new sections to create two terminal lines, Berrydale-Talbot Hill #1, and the Berrydale-Fairwood line. This will reduce the number of substations on a line from five to four.

FUTURE TRANSMISSION IMPROVEMENTS

In addition to the planned 115 kV and 230 kV line and station projects, future transmission improvements will be required. Some of the plans for future improvement are regional, (They would provide system support within and outside of the subarea). The capacity, need, and timing may depend upon other facilities outside of the subarea. The timing, sizing, and routing will be performed on a narrower time frame of 5-10 years. Plans for future transmission improvements follow:

BERRYDALE SUBSTATION 230 kV ADDITIONS

Purpose The construction on the Talbot Hill-Berrydale 230 kV line, by itself, does not solve reliability problems. Without additional 230 kV lines into Berrydale, the Talbot Hill-Berrydale Line is considered a radial tap with a transformer at the end of it. Radial lines are subject to outages of extended duration. This radial system can be eliminated by routing additional 230 kV lines to Berrydale.

Scope Construct a new double circuit from the Berrydale Substation to a proposed 230 kV substation called Newakum. This double circuit could connect to one side of the Talbot Hill-Berrydale 230 kV double circuit to create the Talbot Hill-Berrydale, Talbot-Newakum and Berrydale-Newakum lines. This would eliminate radial line configurations from Talbot Hill or Berrydale. The exact line configuration and routing into Berrydale will depend upon 230 kV and 115 kV development outside of the subarea.

LAKE TRADITION 230 SUBSTATION ADDITIONS

Purpose The construction of the IP 230 kV line, by itself, does not solve reliability problems. Without additional 230 kV lines into Lake Tradition, the Lake Tradition IP line is considered a radial tap with a transformer at the end of it. Radial lines are subject to extended duration of outages. A radial system can be eliminated by routing additional 230 kV lines to Lake Tradition.

Scope Construct a new 230 kV line to Berrydale-Lake Tradition. Lake Tradition will become a 230 kV source of power when the IP line is upgraded and terminated at the Lake Tradition 230 kV bus. This source can provide the reliability needed at Berrydale for a bus fault at Talbot Hill. This line construction is an important part of the 230 kV reliability at Berrydale. This line section will also support Lake Tradition for transmission line faults on the new Wannapum-Lake Tradition line.

LANDSBURG SWITCHING STATION

Purpose There is a need to increase the number of lines in the area in order to serve new load. One way to do this using existing line routes and line sections is to build a switchyard in the area. This construction, using existing and some new line routes would break up longer 115 kV lines into shorter lines with less distribution substations being served per line. This would improve reliability, reduce the number of customers affected by line outages and allow for new distribution substations to be served from the existing lines. The proposed Landsburg switching station would allow for better utilization of existing 115 kV lines and their capacity.

Scope
1) Construct a new switching station called Landsburg. Route the existing Berrydale-Lake Tradition #1 line into this station. This would break up the line into two sections with two distribution substations per section. This reduces the number of customers affected by line outages and these new sections can accept new distribution substations without exceeding Puget guidelines.

2) Route the Fairwood-Cedar Falls line into this switchyard. This breaks up a long line into two smaller sections providing better reliability to those customers served from the line. The termination of the Cedar Falls line at Landsburg will provide better reliability for the Seattle City Light generation at Cedar Falls.

LINE SECTION LAKE McDONALD to LANDSBURG or BERRYDALE

Purpose To eliminate the Lake McDonald radial tap and provide a line which can serve new distribution substations in the subarea. This line section will also provide a second north to south tie for reliability between Berrydale and Lake Tradition or Landsburg.

Scope Create a new line section from Lake McDonald to Landsburg or Berrydale. The termination of this line section will depend upon timing and location of Landsburg and load growth in the area.

LANDSBURG to KRAIN CORNER 115 kV

Purpose To eliminate Cumberland from being served from a radial tap and to provide redundancy, reliability, and capacity to Krain Corner.

Scope Create a new line Landsburg to Krain Corner routing the line from Landsburg to Cumberland to Krain Corner.

FUTURE DISTRIBUTION SUBSTATIONS

There are twelve new distribution substations that would be required to serve the 20-30 year forecasted load in the Benson/Tahoma/Raven Heights study area.

Generally, the area served by a distribution substation can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon the growth patterns in a local area.

The specific site selection is an iteration process that examines:

- Growth in the area. (The best electrical performance is to site the substation in the center of the load area).
- The existing Distribution System. (If located properly, cost can be reduced and performance improved by selecting a site that improves support in a weak area or uses the strength of an existing system such as large wire size with sufficient switching capability.)
- Transmission line routing. (The lowest impact would be a site which is on or near an existing highline).
- Environmental impact of the site.
- Transportation access (The site has to be accessible during all weather conditions for routine and emergency switching or maintenance.)
- Existing zoning in an area.
- Security of the site.
- Physical arrangement of the site for station equipment arrangement.
- Site potential. (The site should not exclude any future plans).

Future Distribution Substations Listed by FAZ

- Benson FAZ
  Glencarin (in progress)
  Kentridge
  Youngs
  Springbrook
  Tahoma
- Fairwood FAZ
  Cedar River
  Shadow
- Maple Valley FAZ
  Maxwell
  Carey
- East Renton FAZ
  Aqua
  Coal Field
- Renton Plateau FAZ
  Grove

- **Benson FAZ**

There are four proposed substations and one in progress substation that would be necessary to serve forecasted load. They are:

1. Glencarin The Glencarin Substation is in progress to serve customers in the area of Kent East Hill and along the Benson corridor.
   Purpose. To provide capacity to the area and serve as a backup to the Panther Lake, Lake Meridian and Rolling Hills substations.
2. Kentridge The Kentridge Substation is proposed to serve customers in the area west of Lake Youngs.
   Purpose. To provide capacity to the area and serve as a backup to the Panther Lake, Lake Meridian and Rolling Hill substations.
3. Youngs The Youngs Substation is proposed to serve customers south of Lake Youngs.
   Purpose . To provide capacity to the area and serve as a backup to the Lake Wilderness and Lake Meridian substations.
4. Springbrook The Springbrook Substation is proposed to serve customers in the area of Carr Rd. and Talbot Rd. in SE Renton.
   Purpose. To provide capacity to the area and serve as a backup to the Victoria Park, Rolling Hills and Norpac substations.
5. Tahoma The Tahoma Substation is proposed to serve customers in the area south and west of Lake Youngs.
   Purpose. To provide capacity to the area and serve as a backup to the Lake Meridian and Lake Wilderness substations.

- **Fairwood FAZ**

The Fairwood FAZ has two proposed substations to serve the forecasted load. The proposed substations are:

1. Cedar River The Cedar River Substation is proposed to serve customers in the area of Cedar Mountain.
   Purpose. To provide capacity to the area and serve as a backup for the Lake McDonald and Fairwood substations.
2. Shadow Lake The Shadow Substation is proposed to serve customers in the area of Shadow Lake and Otter Lake.
   Purpose. To provide capacity in the area and serve as a backup to the Fairwood and Hobart substations.

- **East Renton FAZ**

The East Renton FAZ has two proposed substation to serve the forecasted load. The proposed substations are:

1. Aqua The Aqua Substation is proposed to serve customers in the area of Cedar River Park.
   Purpose. To provide capacity in the area and serve as a backup to the Fairwood, President Park and Maplewood substations.
2. Coal Field The Coal Field Substation is proposed for the area of Coal Field along the Renton Issaquah Rd.
   Purpose. To provide capacity in the area and serve as a backup to the President Park and Maplewood substations.

- **Maple Valley FAZ**

The Maple Valley FAZ has two proposed substations to serve forecasted load. The proposed substations are:

1. Maxwell The Maxwell Substation is proposed to serve customers in the area of Maple Valley near the intersection of Maple Valley Road and Highway 18.
   Purpose. To provide capacity to the area and serve as a backup for the Earlington, Metro Renton, Olympic Renton and Renton Junction substations.
2. Carey The Carey Substation is proposed to serve customers in the area of SE 156th and the Issaquah Hobart Rd.
   Purpose. To provide capacity to the area and serve as a backup to the Mirromont and Hobart Substations.

- **Renton Plateau FAZ**

The Renton Plateau FAZ has one proposed substation to serve forecasted load. The proposed substation is:

Grove The Grove Substation is proposed to serve customers in the area of Cedar Grove Airport and Friends Lake.

Note: *The area served by a distribution substation can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon growth* *patterns in a local area. It is expected that a utilization factor, load versus capacity, will be maintained in the 75-85% range. This percentage allows for the need that capacity must always be greater that the total load. This is due to: 1)Backup capacity that must be available in every local area for equipment failures and equipment maintenance, 2)Capacity must be available to serve higher loads caused by extreme weather conditions, 3)Capacity must be added in fixed and large amounts, whereas the load grows evenly.*

The distribution substation future additions are shown on drawing 2 with approximate geographic locations. The substations are:

Table 5 Future Distribution Substations

FAZ	Name	Future Substation	Capacity	In-Progress Substation	Capacity
3411	Benson	Kentridge	25 MVA	Glencarin	25 MVA
		Lake Youngs	25		
		Springbrook	25		
		Tahoma	25		
3412	Fairwood	Cedar River	25		
		Shadow Lake	25		
4210	East Renton	Aqua	25		
		Coal Field	25		
3330	Maple Valley	Maxwell	25		
		Carey	25		
4230	Renton Plateau	Grove	25		
		Future Total	**275 MVA**	**In progress**	**Total 25MVA**

The in progress and future distribution substations will add approximately 300 MVA of capacity to serve an estimated 228.68 MVA increase in load. The total distribution capacity in the study area will increase from a 1990, 200 MVA to a 2020 capacity of 500 MVA. This corresponds from an existing residential and commercial customer 164.6MVA load to a forecasted 393.28 MVA load. The distribution equipment utilization factor, load versus capacity, will change from 82.3% to 78.6%.

FUTURE CONSIDERATIONS

This section contains a discussion of system development and facilities development that could be expected in the Newcastle study area over the future time, 20-30 years, or beyond.

Since the future is uncertain, long range planning efforts must be flexible. One method that is used to project system requirements 20-30 years in the future is a zoning density analysis. This type of forecasting of the long range or ultimate electrical system load, examines the land use zoning in the area. The total square miles in each zoning category is multiplied by an estimated electrical load per square mile for that category.

The ultimate electrical demand per square mile of single family, multi-family, central business districts (CBD) and commercial zones can be determined by measuring actual electrical load in areas of similar zoning where build-out is complete. Using Puget Power information, Table 6. shows ultimate loads for the type of buildings available.

Table 6 Zoning Categories

ZONING CATEGORY	MVA per Square Mile, (if fully built out)
Single Family	8
Multi Family	17
Commercial	29
CBD	250
Park/Open Space	0

Note: At this time it has not been possible to examine the study area and calculate the total number of square miles in each zoning category. Until this information is developed for each subarea, Puget Power is using an average of 12 MVA per square mile for those subareas along the I-5, I-405 corridors.

Zoning density analysis forecasts 708 MVA (commercial+residential) load. It does not predict industrial loads or assume that land use densities almost always increase with time.

Winter power flow data shows that not all of the capacity available from the main stations in the subarea, flow in to serve the subarea. About 25% of

Talbot Hill substation capacity and 50% of planned Lake Tradition and 50% of planned Christopher capacity will serve the subarea.

Table 7 230 kV Capacity Zoning Analysis

230/115 kV Substation	%Capacity Assigned to Subarea	Nameplate Capacity	MVA Available
Talbot Hill	25	650MVA	81
Lake Tradition	50	325MVA	162
Christopher	50	325MVA	162
	Total Available Capacity		*406 MVA

*This assumes that all transformers are in service.

The total available capacity will be 406 MVA. The ultimate build-out predicts 708 MVA capacity required. The planned capacity does not meet the zoning analysis load requirements. Another transformer in the subarea or bordering the subarea would need to be added. If we use the Puget Power reliability criteria for N-1 and no loss of customer load, this subarea would require two more 230-115 kV transformers.

Table 8 500 kV Capacity Zoning Analysis

500-230 kV Substation	%Capacity Assigned to Subarea	Nameplate Capacity	MVA Available
Monroe	5	1000MVA	50
Maple Valley	15	2200MVA	330
	Total Available Capacity		*380 MVA

*This assumes that all transformers are in service. An N-1 was not considered for the 500-230 kV transformers. The winter power flow data shows, that not all of the capacity available from the main stations in the subarea, flow in to serve the subarea. Approximately, 5% of the Monroe Substation capacity and 15% of the Maple Valley Substation capacity will serve the subarea.

This type of analysis of the capacity of the 500 kV system indicates that additional 500-230 kV transformers will be required to serve this subarea when the capacity reaches 380 MVA near the end of the 30 year study period. 500-230 kV transformers could be required earlier due to additional service outside of the subarea.

Future Considerations:

BERRYDALE 230 kV TRANSFORMER ADDITION

Construct a second 230-115 kV bank at the Berrydale Substation for capacity and reliability. The timing and need for this transformer would depend upon specific load growth in this subarea and the surrounding subareas and system capacity developed outside the subarea.

LANDSBURG 230 kV

Construct a 230-115 kV bank at the proposed Landsburg Switching Station for capacity and reliability. The timing and need for this transformer would depend upon specific load growth in this subarea and the surrounding subareas and system capacity developed outside the subarea. This would require the routing of 230 kV lines into the switchyard for reliability, diversity and capacity.

LANDSBURG 500 kV

Construct a 500-230 kV substation at Landsburg. The purpose of this new facility would depend upon regional load growth and the development of additional 500 kV lines in the area. Landsburg could be an advantageous location because the system would use existing 115 kV and proposed 230 kV transmission to distribute the energy out. This new facility would be sited near the edge of the service area. It should present a lower cost to obtain and construct the substation and right of way.

XI. NEWCASTLE ELECTRICAL SUBAREA

THE EXISTING POWER SYSTEM

The Newcastle subarea of South and Central King County is bordered on the north by the Bellevue city limits and Lake Sammamish, on the south by the May Valley road and east Renton, on the east by the Issaquah/Hobart road, and to the west to include Mercer Island. The subarea contains approximately 48 square miles and five Puget Sound Council of Governments (PSCOG)[1], forecast analysis zones (FAZ). In 1990, the population in this subarea was 90,301, and the employment was 29,837.

Generation

The Puget Power transmission facilities in the Newcastle subarea are interconnected to a larger transmission grid throughout the Western United States, (see Main Grid discussion). Power flows North and South and East and West through the area as the loads and the generation patterns of the system change. Power is supplied to the subarea through the larger regional transmission grid at 500 kV and 230 kV voltages from distant generating plants in Canada or Grand Coulee and Rocky Reach along the Columbia River. The power is then transformed into lower voltages at the Talbot Hill and Sammamish substations which are connected to the regional grid. The lower voltages are then used to serve subarea distribution substations, (see Table 1, *Transmission Substations*).

Power Sources:

- hydro-based generation located on the Columbia River in Eastern Washington
- hydro-based generation located in British Columbia
- hydro-based and thermal generation located in Western Washington

Transmission Substations

The Puget Power transmission substations connected to the regional transmission grid in the Newcastle Subarea are the Talbot Hill and the Sammamish Substations. Also, the Lake Tradition, Lakeside, and Shuffleton Switching Stations. The Talbot Hill and the Sammamish Substations shown

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[1] The PSCOG name has been changed and is currently known as the Puget Sound Regional Council, PSRC.

in Table 1. contain both 230 kV for transmission and 115 kV to serve the subtransmission system and the connected distribution substations.

Both the Talbot Hill and the Sammamish substations take power from the transmission grid, transform it, reduce the voltage, and distribute it to 115 kV switching and distribution substations. The distribution substations further reduce the voltage to 12 kV, which is the standard distribution voltage for Puget Power. The 12 kV feeders distribute the power from the distribution substations to the individual customers.

Table 1 Transmission Substations

Transmission Substation	Nameplate MVA	Winter Load 12/21/90 (MVA)	Percent Loading
Sammamish Bank #1	325	250	77%
Sammamish Bank #2	325	246	76%
Talbot Hill Bank #1	325	345	106%
Talbot Hill Bank #2	325	340	105%
Totals	**1300 MVA**	**1181 MVA**	

Note:

The subarea's peak load of 208.82 MVA in 1990 is part of the load supplied by the transmission substations listed in Table 1. These transmission substations also serve other subareas. The nameplate rating of the transmission substation transformer is 325 MVA. Due to the temperature and humidity in the Puget Power service territory, the normal life rating of these transmission substation transformers is somewhat higher. The highest normal life rating is for winter. Computer modeling is required to determine the exact limits for each transformer.

The capacity of these transformers is a measure of their ability to serve the connected load. Using the planning guidelines, the system is designed so that one of these large transformers can be taken out of service, (single contingency), without causing a customer outage. If a 230-115 kV transformer were to require replacement, it would take approximately 30-40 working days to complete the task. Therefore, it is essential to maintain the number of transformers necessary for supporting the power system and its ability to serve the connected load, even when one transformer is out of service.

As these transmission substation transformers reach their loading limit, three options exist to increase the ability of the system to carry load.

Options

1) The construction of 115 kV lines to switching substations from other areas. This option assumes that excess capacity exists in neighboring areas.
2) The construction of new switching stations within the area along with their associated source and distribution lines which would increase the ability to serve load in the area. This option assumes that existing transmission substations are underutilized and have spare capacity. In this subarea this would require additional transformers at the Talbot Hill and O'Brien Substations, the associated 230 kV transmission lines for capacity and additional 115 kV lines to distribute the power.
3) The third option is to add capacity to existing transmission substation and/or convert switching substations to transmission substations. In the Newcastle subarea, this would require additional transformers at the Talbot Hill Substation, the associated 230 kV transmission lines for capacity, and additional 115 kV lines to distribute the power. In 1995, the Lakeside Substation is scheduled to have transmission transformers at 230 kV added. In 1996, transmission transformers at 230 kV will also be added to the Lake Tradition Substation. Shuffleton is scheduled in 1994 to have two new 115 kV lines from Talbot terminated in the switchyard for capacity and reliability. This option generally provides highest capacity,reliability and diversity to the network. Diversity is used to spread capacity around the subarea. Diversity in the transmission system can be developed in a combination of methods. Physical diversity would be to use different corridors for transmission lines so a single event such as car pole accidents do not affect two lines. Electrical diversity can be provided by designing systems that reduce the impact of system component failures. An example is to design transmission stations with bus sectionalizing. Bus sectionalizing restricts one bus section failure from affecting the entire bus.

Transmission Lines

One of the problems in the Newcastle subarea is the absence of bulk transmission lines 230 kV and above, to support this system. The existing 115 kV lines in this subarea were designed to serve distribution substation loads. As a result, the conductor size and voltage levels are not large enough to serve both distribution and allow regional power flow across the county. The existing regional transmission system is dependent upon the Bonneville Power Administration (BPA) transmission lines, which have an upper loading limit. As the load in this subarea continues to grow, additional transmission lines will be necessary to raise the transfer capability of the transmission system.

Transmission Line Configuration.[1] The 115 kV system in this subarea is a combination of radial line taps and networked lines. A radial line tap is one in which distribution substations are fed from a single transmission line. In a radial system, a transmission line failure, which could be caused by trees and limbs blowing into the line, a "car-pole" accident, or lightning striking the line, results in a service interruption to all of the substations served from that radial line tap.

Networked 115 kV lines are connected together at main stations or 115 kV switching stations. The distribution substations on a 115 kV networked system can generally be restored very quickly after an outage because power is either automatically or by a supervisory control system switched to an alternate source. Networked systems are preferred over radial systems.

Networked 115 kV lines are connected together at main stations or 115 kV switching stations. The switching stations are used to consolidate and coordinate 115 kV lines which:

- keep line failures on one line from affecting another
- Allow higher utilization of existing transmission system capacity
- reduce the number of radial lines and to support the network during line outages.
- reduce system losses

There are three 115 kV switching stations serving this subarea. They are Lakeside, Shuffleton and Lake Tradition. As an area develops and demands for more power with higher reliability the need for switching and transmission substations increases. Switching stations can evolve into transmission substations because of their central location in the grid and their proximity to the load centers.

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[1] The maximum number of distribution stations that Puget Power allows on a networked line is four. This planning guideline reduces the number of customers affected from a single transmission line event.

1) The main substation 230-115 kV transformers, serving the study area, at Talbot Hill exceed their loading criteria for some single contingency events.

Loss of a 230-115 kV transformer at Talbot , during Puget Power system loading of 4600 MW, will load the adjacent transformer to approximately 127% of the nameplate. Some 230/115 kv transformers at the existing or future sites will need to be added.

2) The 230 kV transmission system needs to have improved capacity and diversity to support the existing and future loads.

Capacity is generally considered for the transmission system as the ampacity of a certain line due to its wire (conductor) size and temperature ratings. There are also other factors that can affect a transmission line design and ampacity. These are physical designs such as wood pole, steel pole or towers for transmission lines which have limits on weight and tension loading from the wire sizes. This limits the conductor size and ampacity of the line. Higher ampacity lines, when fully loaded, generally have higher EMF levels, therefore, choosing bigger and bigger wire sizes for higher ampacities may not be desirable or feasible.

Other capacity limiting factors associated with 230 kV transmission systems are bus, breaker and 500-230 kV and 230-115 kV transformer ratings. Bus work and breakers at 230 kV with ratings above 3000 amperes are expensive to build and maintain.

The reliance on, or to build a system on higher and higher single component ampacities, does not provide the transmission system with diversity. Diversity is required to meet reliability requirements of N-1, N-2, and N-1 with maintenance. Planning criteria, N-1 and N-2 are descriptions of a normal system with one or two components of the system out of service with no loss of customers or damage to equipment. This type of analysis is used to determine the system performance and reliability. If a high capacity piece of equipment fails, it generally has a high impact on the system. For example, if the system needs and uses a single 230 kV line rated at 3,000 amperes, loss of that line would require the alternate paths/sources to be rated at that ampacity. System diversity reduces the impact of single system component failures, and the dependency upon large components which may be approaching design limits. Diversity also allows the system to be operated at a higher efficiency level. For instance if you have two lines into a station, each rated at 75 MVA, the total installed capacity is 150 MVA. The effective use of that system using N-1 criteria is 75 MVA. The system is being reliably used at 50% capacity. If three lines at 50 MVA were installed the same station would have 150 MVA of installed capacity and 100 MVA of reliable capacity. The effective use of capacity is 66%. The point is diversity of components provides reliability and effective loading of parallel equipment.

Upgrading to larger transmission substation transformers and associated equipment is not always a solution to relieving the overloading of existing equipment. Three phase 230-115 kV transformers currently have design limits of approximately 500 MVA. Transformers larger than this may not be transportable over city or county roads to the substation sites. Higher capacity transformers, if desired, may have to be of single phase design. Higher capacity transformers would increase the number of components by approximately three, but they would also increase construction costs and the yard space required for a substation. In addition, increased components could decrease reliability. One advantage to using a single phase design transformer is that spare equipment requirements may be less.

Substation transformers and other station equipment failures have a generally lower probability than line outages, but have larger impacts. These impacts can sometimes be mitigated by design such as ringbus or double breaker-double bus designs. Building additional buses will create diversity and reduce the impact of station equipment failures.

230 kV CAPACITY PROBLEMS

- Loss of the 230 kV O'Brien-Christopher Tap during winter 1991 conditions, loads the 230 kV Talbot-O'Brien line to 100% of the continuous no wind winter rating and the 230-115 kV Bank #1 at Talbot to 106% of the nameplate rating.

- Loss of the Maple Valley-Talbot Hill 230 kV south bus during the winter conditions of 1991, loads the 230 kv Christopher-O'Brien tap to 118% of the continuous no wind winter rating.

230 kV DIVERSITY PROBLEMS

- Loss of the Talbot Hill 230 kV south bus overloads the north bus Bank 2 to 147% of nameplate and the Christopher-O'Brien tap to 102% of the continuous no wind winter rating.

3) There is a need for new distribution substations due to future and existing loads.

The existing distribution substations in this area, when considered as a group, are well utilized from a capacity point of view. They have a 80.3% utilization factor (load/capacity). Any additional load in the sub area should be accompanied by additional distribution and associated transmission system capacity.

Utilization factor analysis assumes that the load is spread evenly around the subarea. Any spare capacity indicated in the utilization factor may not always be available for use. Specific geographic areas have higher load densities and utilization factors than others. Some distribution substations border natural or service territory barriers and these substations may not be able to provide or utilize neighboring substation capacity. Specific distribution substation siting looks at this and other criteria to evaluate the need for new capacity.

4) Substations on Radial lines

- Mercer Island, Mercerwood and Factoria Substations

These substations are fed radially from a 6.2 mile Lakeside-Mercer Island line. A transmission line failure on this line segment will take longer to restore until the alternate source from Shuffleton is available. The backup source from Shuffleton overloads during some outage conditions.

- South Mercer Substation

This substation is normally fed radially from the Lakeside-Shuffleton line.

5) Substation Bus Designs

Bus designs and layouts are important to system reliability and the ability to perform maintenance. Traditional single bus and single breaker bus designs have higher system impacts if the bus or equipment connected to the bus fails. This is because all lines connected to the bus must open to clear faults on the bus. Sometimes, during a maintenance period, system reliability is sacrificed because of the process for removing the bus or associated piece of equipment from service. System reliability could be improved during this maintenance period by:

- using bus designs such as ringbus, double breaker-double bus and bus sectionalizing, (Note: These designs generally have higher costs and require more yard space).
- reducing the number of circuit breakers that have to open for a bus fault

- providing an alternate, spare, backup or parallel breaker. During maintenance traditional single bus, single breaker bus designs have higher system impacts if the bus or equipment connected to the bus fails.

The 115 kV bus design at the Lakeside Substation needs to be modified to allow for bus sectionalizing and breaker maintenance.

- The existing bus design requires that the line section associated with that breaker is open at the Lakeside terminal during breaker and associated switch maintenance . This condition puts those substations being served from that line section on a radial tap. Note: Single contingency events will cause loss of load .
- A bus or breaker failure will cause all breakers at Lakeside to open. This can, under some loading conditions cause voltage problems.

The 115 kV bus design at Shuffleton needs to be modified to allow for breaker maintenance.

- The existing bus design requires that during breaker and associated switch maintenance that the line section associated with that breaker is open at the Shuffleton terminal. This condition puts those substations being served from that line section on a radial tap. Note: Single contingency events will cause loss of load .
- A bus or breaker failure will cause all breakers at Shuffleton to open. This can under some loading conditions cause voltage problems.

The 115 kV bus design at Lake Tradition may need to be modified to allow for breaker maintenance.

- The existing bus design requires that during breaker and associated switch maintenance that the line section associated with that breaker is open at the Lake Tradition terminal. This condition puts those substations being served from that line section on a radial tap. Note: Single contingency events will cause loss of load .
- A bus or breaker failure will cause all breakers at Lake Tradition to open. This may under some loading conditions cause voltage problems.

6) Loss of the Talbot Hill 115 kV North Bus overloads the Talbot Hill-Berrydale #2 line to 129% of the continuous no wind, winter rating.

Distribution Substations

There are 12 existing distribution substations in the Newcastle subarea which serve the distribution feeder lines commonly found in neighborhoods and commercial areas. A list of these distribution substations with their associated capacity and loading level follows, (see Table 2). The loading level shown on this table occurred on December 21, 1990 at 9:00 AM at a temperature of 16 degrees F. measured at the Sea-Tac Airport.

Table 2 Distribution Substations

Distribution Substations		Nameplate Rating MVA	1990 Winter Loads 12/21/90 MVA	
*College		12.5	13.1	
Eastgate		25	26.7	
•Factoria		12.5	10.9	
Somerset		25	17.2	
Highlands		25	22.8	
President Park		25	21.9	
Hazelwood		25	17.8	
West Issaquah		25	20.1	
Goodes Corner		25	16.1	Utilization
Mercer Island		20	20.1	Factor = 80.3%
Mercer Wood		20	11.2	
South Mercer		20	10.9	
	Totals	**260 MVA**	**208.82 MVA**	

*Border substation. Load and capacity is shared with adjacent subarea.

Note: The winter rating of a distribution transformer for continuous load is 132% of nameplate. In residential areas, the winter loading and equipment ratings determine when substation capacity improvements are needed. In predominantly commercial load areas, the summer transformer rating of 103% is used. The utilization factor, load versus nameplate capacity, indicates that the system was well loaded and the existing capacity well used. A high utilization factor may not leave much room for growth or equipment outages in the study area.

GROWTH PROJECTIONS

The total anticipated load demand from 1990 to 2020 is shown in Table 3. Table 3. also describes the FAZ contained within the Newcastle subarea. Population and employment forecasts for the next 30 years are converted to demand in MVA. These demand figures can then be used to determine the amount of new facilities which will be needed in this subarea.

Table 3 Newcastle Subarea, 2020 Peak Load Growth Forecast
Source: Population & Employment Data

PSCOG ZONE		1990	2020	1990-2020 GROWTH	GROWTH
Eastgate	Population	29593	35896	6303	40.77 MVA
4500	Employment	14403	25524	11121	
Mercer Island	Population	21157	21897	740	9.41 MVA
4400	Employment	5847	8640	3093	
Issaquah	Population	8058	10840	2782	24.82 MVA
4300	Employment	5605	13157	7552	
Newcastle	Population	16324	47778	31454	70.52 MVA
4220	Employment	1410	5486	4076	
Renton Highlands	Population	15169	19834	4665	22.09 MVA
4120	Employment	2872	7975	5103	--------
Total	Population	90301	136245	45944	167.61 MVA
	Employment	29837	60782	30945	

Notes:
New Residential Load = 1.63 KVA/person for January average peak.
New Commercial Load = 2.21 KVA/employee for January average peak.
Extreme Winter Peak = 1.17 time January average peak.
Population and Employment Forecasts form PSCOG[1] , 1988.

Note: The 167.61 MVA total load figure from Table 3. is the new load predicted to be added to the Puget Power Electrical system in the Newcastle area. Due to the effects of conservation and demand side management in the future, the existing load must be reduced by 6.94% and 10% respectively. Demand side management reductions do not apply to existing industrial loads. These loads are considered to practice this already. To calculate the total future load in this subarea, the total existing load from Table 2. must be

[1] The PSCOG name has been changed and is currently known as the Puget Sound Regional Council, PSRC.

reduced by the conservation and demand management factors and then added to the total new load from Table 3.

Table 4 30 Year Load Increase

Total Load Additions	Residential/Commercial
Existing Load Table 2.	208.82
Conservation - (6.94)	-14.49
Demand Mgmt. -(10%)	-20.88
Expected New Load, Table 3	167.61
Subtotal Area Load	341.06 MVA
2020 Forecasted Load Totals	**341.06 MVA**
1990 Peak Load	**-208.82 MVA**
30 Year Forecasted Load Increase	**132.24 MVA**

SYSTEM IMPROVEMENTS

System improvements required to serve forecasted load growth for the next 30 years are listed in Section 4 as construction projects that are in progress or plans for the future. A project is considered *in progress*, if specific site selection, preliminary engineering, permitting, or construction activities are currently underway. Schematic diagrams are included with the text to describe the transmission system as each improvement takes place. Drawing number two shows the new electrical facilities needed to serve the forecasted total study area load for the next 30 years.

CONSTRUCTION PROJECTS IN PROGRESS

LAKE TRADITION 230 kV DEVELOPMENT

Purpose The Lake Tradition 230 kV development is part of a larger project called the IP line Rebuild. The IP line rebuild, to be completed in 1996, is the rebuild of an existing line that originates near Kittitas in Eastern Washington. This 115 kV line will be upgraded to 230 kV and reconductored for higher ampacity. There are many benefits from this system improvement. There is improved service and reliability which comes with new line construction. The region benefits from additional transfer capability from Eastern Washington to Western Washington. There are lower overall system losses. The customers being served from lines in and around Lake Tradition will have improved service because of the new 230 kV-115 kV transformer provides a strong reliable source of power, (See Eastside subarea of King County Electrical Facilities Plans).

LAKESIDE 230 kV DEVELOPMENT

Purpose To provide a good 115 kV source to those customers served from the Lakeside Switching Station. The existing primary source of power is from Talbot Hill and the existing Talbot Hill-Lakeside 115 kV lines. The transformers at Talbot Hill are already heavily loaded. The initial phases of this development are to construct one 230 kV line north to Sammamish and one line south to Talbot Hill. The line to the south will be an upgrade of an existing 115 kV line.

FUTURE TRANSMISSION IMPROVEMENTS

In addition to the planned 115 kV and 230 kV line and station projects, future transmission improvements will be required. Some of the plans for future improvement are regional, (They would provide system support within and outside of the subarea). The capacity, need, and timing may depend upon other facilities outside of the subarea. The timing, sizing, and routing will be performed on a narrower time frame of 5-10 years. Plans for future transmission improvements follow:

LAKE TRADITION 230 SUBSTATION ADDITIONS

Purpose The construction on the IP 230 kV line, by itself, does not solve reliability problems. Without additional 230 kV lines into Lake Tradition, the Lake Tradition IP line is considered a radial tap with a transformer at the end of it. Radial lines are subject to extended duration of outages. A radial system can be eliminated by routing additional 230 kV lines to Lake Tradition.

Scope Construct a new 230 kV line from Berrydale to Lake Tradition. Lake Tradition will become a 230 kV source of power when the IP line is upgraded and terminated at the Lake Tradition 230 kV bus. This source can provide the reliability needed at Berrydale for a bus fault at Talbot Hill. This line construction is an important part of the 230 kV reliability at Berrydale. This line section will also support Lake Tradition for transmission line faults on the new Wanapum-Lake Tradition.

FUTURE DISTRIBUTION SUBSTATIONS

There are seven new distribution substations that would be required to serve the 30 year forecasted load in the Newcastle study area. The siting, timing, and sizing, of these future distribution substations would be done on a narrower time frame of 3-7 years. Generally, the area served by a distribution substation can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon the growth patterns in a local area.

The specific site selection is an iteration process that examines:

- Growth in the area, (*The best electrical performance is to site the substation in the center of the load area*).
- The existing Distribution System. *If located properly, cost can be reduced and performance improved by selecting a site that improves support in a weak area or uses the strength of an existing system such as good wire size with sufficient switching capability.*
- Transmission line routing, (*The lowest impact would be a site which is on or near an existing highline*).
- Environmental impact of the site.
- Transportation access *during all weather conditions for routine and emergency switching or maintenance.*
- Existing zoning in an area.
- Security of the site.
- Physical arrangement of the site for station equipment arrangement.
- Site potential. (*The site should not exclude any future plans*).

Future Distribution Substations Listed by FAZ

- Eastgate FAZ
  - Eastgate 2, (Capacity increase at an existing substation).
  - Newport
  - Pickering
  - Tibbets
- Newcastle FAZ
  - Maycreek
  - Lake Boren
  - Ivy
- Issaquah FAZ
  - Lakemont
- Renton Highlands FAZ
  - Sierra

- **Eastgate FAZ**

There are four proposed substations and one substation capacity increase that would be necessary to serve forecasted load. They are:

1. Eastgate 2 is a capacity increase at an existing substation. It is proposed to serve customers in the area of Eastgate and Interstate 90. It will provide capacity to the area and provide a backup to the Sommerset, Hazelwood and Goodes Corner Substations.
2. Newport The Newport Substation is proposed to serve customers in the Newport area and along Interstate 405. It will provide capacity to the area and provide a backup to the Hazelwood and Factoria Substations.
3. Pickering The Pickering Substation is proposed to serve customers in the East Lake Sammamish. It will provide capacity to the area and provide a backup to the Goodes Corner and West Issaquah Substations.
4. Tibbets The Tibbets Substation is proposed to serve customers in south west Issaquah and Tibbets Creek area. It will capacity to the area and provide a backup to the West Issaquah and Lake McDonald Substations.

- **Newcastle FAZ**

The Newcastle FAZ has two proposed substations to serve the forecasted load. The proposed substations are:

1. Maycreek The Maycreek Substation is proposed to serve customers in the area of Maycreek and north Renton It will provide capacity to the area and provide a backup to the Hazelwood and Highlands Substations.
2. Lake Boren The Lake Boren Substation is proposed to serve customers in the area of Lake Boren and SE Bellevue. It will provide capacity in the area and provide backup to the Hazelwood, President Park and Highlands Substations.
3. Ivy The Ivy substation will serve the area beteween Eastgate and Issaquah along the southern shore of Lake Washington. A 115kV line will extend from Pickering to Ivy and then to Boeing Computer Services. Ivy and this line will also provide backup capacity to Goodes Corner, Lakemont, Tibbetts and Eastgate substations.

- **Issaquah FAZ**

The Issaquah FAZ has one proposed substation to serve the forecasted load. The proposed substations is:
Lakemont The Lakemont Substation is proposed to serve customers in southeast Bellevue and Coal Creek area. It will increase capacity to the area and provide a backup to the Goodes Corner and the Eastgate Substations.

- **Renton Highlands FAZ**

The Renton Highlands FAZ has one proposed substation to serve the forecasted load. The proposed substation is:

Sierra The Sierra Substation is proposed to serve customers in the area of May Creek and northeast Renton it will provide capacity in the area and provide backup to the Highland, Hazelwood and Somerset Substations.

Note: *The area served by a distribution substation can range from one square mile in a commercial area to four square miles in a fully developed single family residence area. Planning and siting would depend upon growth patterns in a local area. It is expected that a utilization factor, load versus capacity, will be maintained in the 75-85% range. This percentage allows for the need that capacity must always be greater that the total load. This is due to: 1)Backup capacity that must be available in every local area for equipment failures and equipment maintenance, 2)Capacity must be available to serve higher loads caused by extreme weather conditions, 3)Capacity must be added in fixed and large amounts, whereas the load grows evenly.*

The substations are described in Table 5.

Table 5 Future Distribution Substations

FAZ	Name	Substation	Capacity
4500	Eastgate	Eastgate 2	25 MVA
		Newport	25
		*Pickering	12.5
		Tibbets	25
4220	Newcastle	Maycreek	25
		Lake Boren	25
4300	Issaquah	Lakemont	25
4120	Renton Highlands	Sierra	25
		Future Total	**187.5 MVA**

*Border substation with other subarea. The load and capacity is shared with other subarea.

Note: The future distribution substations will add approximately 187.5 MVA of capacity to serve an estimated 132.24 MVA increase in load. The total distribution capacity in the study area will increase from a 1990, 260 MVA to a 2020 capacity of 447.5 MVA. This corresponds from an existing residential and commercial customer 209 MVA load to a forecasted 341 MVA load. The distribution equipment utilization factor, load versus capacity, will change from 80.3% to 76.2%.

FUTURE CONSIDERATIONS

This section of the Newcastle Electrical Facilities Plan contains a discussion of system and facilities development that could be expected in the Newcastle study area over the future, 20-30 years, or beyond.

Talbot-Lakeside #3 115kV Line

Purpose To provide 115kV line capacity to new distribution substations in the area. This line becomes necessary when Maycreek and Newport distribution substations are constructed. The need for this line may be accelerated to strengthen 115kV transmission line ties between Talbot and Lakeside, when Talbot-Lakeside #1 & #2 are converted to 230kV.

Scope The project would require approximately 2.25 miles of 115kV transmission and utilize some of the existing right of way of the 55 kV. See the Highline/Green River Subarea, System Improvements In Progress, Renton Reliability 115kV Improvements.

Discussion:

The Newcastle subarea is bordered by three major transmission substations, Talbot Hill, Lakeside and Lake Tradition. Additional future considerations for these substations impacting this subarea are discussed in the Highline/Green River, Benson/Tahoma/Raven Heights and the Eastside subarea reports.

XIV. GLOSSARY OF ELECTRICAL TERMS

CAPABILITY	The maximum load that a generator, turbine, power plant, transmission circuit, or power system can supply under specified conditions for a given period of time without exceeding approved limits of temperature and stress. Used synonymously with Capacity.
CAPACITY	Used synonymously with Capability.
CIRCUIT	A set of conductors through which an electric current is intended to flow. For alternating current transmission, a circuit will have three conductors. Also called a "line."
CIRCUIT BREAKER	An electrical switch capable of interrupting the large currents which flow during system faults, or failures.
COGENERATION	The production of both electricity and any other form of useful energy (such as steam or heat).
COINCIDENCE FACTOR	The ratio of the sum of the coincidental demands of two or more customers, or classes of service, to their noncoincidental peak demands. The percent of customer or class peak demand that is required at the time of the system peak.
COMPONENT CAPACITY	The amount of electric power which an individual system component, such as a transmission line, a circuit breaker, or a transformer, is rated to carry.

CONDUCTOR	A wire or cable intended to carry electric power, supported by poles, towers or other structures.
CONSERVATION	To improve the efficiencies of energy use through implementation of cost effective measures.
CONVERSION STANDARDS	Minimum standards for building thermal efficiency for buildings being converted to electric space conditioning.
CURRENT	The rate of electrical "flow", measured in amps.
DOUBLE CONTINGENCY	A situation in which two system components are simultaneously removed from service.
DEMAND	The rate at which electricity is delivered. Demand is expressed in watts, kilowatts (kW), megawatts (MW), kilovoltamperes (KVA), or megavoltamperes (MVA). (See LOAD)
DEMAND SIDE MANAGEMENT	Influencing the demand for electricity so that demand conforms to supply conditions. Generally this involves shifting peak load to off-peak times. Total energy is not reduced.
DISTRIBUTION	The transport of electricity from distribution substations to ultimate usage points such as individual homes and businesses at a voltage level of 12 or 34 kV.
DISTRIBUTION SUBSTATION	A substation which transforms voltages of 115 kV or greater to lower voltages of 12 or 34 kV.

DOUBLE CIRCUIT	A configuration of transmission lines whereby two separate circuits are supported by a single structure.
ELECTRIC SYSTEM	The combination of all of the electric utility facilities in an area, including distribution and transmission lines, substations and generating stations used for delivering electricity.
ENERGY, AVERAGE ANNUAL	Average annual energy generated by a hydro project or system over a calendar year.
ENERGY, ELECTRIC	The total amount of power consumed over a given amount of time. Energy is often expressed in kilowatt-hours (kWH).
FEDERAL ENERGY REGULATORY COMMISSION (FERC)	The division of the U.S. Department of Energy that is responsible for regulating power generation.
FEEDER	A circuit from a distribution substation to the customer, usually energized at 12 or 34 kV.
GENERATOR	A device that converts mechanical energy into electrical energy.
GENERATION	The act or process of producing electric energy from other forms of energy.
GRID	An interconnected system of electric lines and associated equipment.
KILO (k)	A prefix indicating a 1000; thus, a kilovolt (kV) equals 1000 volts.

LOAD	The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the power consuming equipment of the customers.
LOAD FACTOR	The ratio of the average load to the peak load during a specified period of time.
LOOP	To connect a transmission line into a new substation so that there is both an incoming and an outgoing line.
MEGA (M)	A prefix indicating a million; thus one megawatt (MW) equals 1,000,000 WATTS, or 1,000 kilowatts.
MEGAVOLT-AMPERE (MVA)	1,000,000 volt-amperes.
MEGAWATT (mW)	1,000 kilowatts, or 1,000,000 watts
OFF-PEAK	Any time when the demand for electrical energy is less than 90% of the peak load.
OUTAGE	The loss of service of a component of the electric system. The outage may or may not result in a loss of electric service to customers.
OVERLOAD	A situation where the load on a system component is above the component capacity.
PEAK LOAD	The highest electrical load demanded by the customers.
POLE	A column of tapered wood, steel, or concrete, supporting overhead conductors.

RADIAL LINE	A power transmission circuit with only one source of power.
RADIAL SYSTEM	A system in which independent lines branch out radially from a common source of supply.
RELIABILITY	An assessment of the duration and the frequency of electric service interruptions.
SCHEMATIC DIAGRAM	A diagram of the power system, with graphical symbols representing components.
SERVICE DROP	The set of conductors that supply energy to the customer's premises.
SINGLE CONTINGENCY	A situation in which one system component is removed from service.
SUBSTATION	Any electric power station. Common functions include controlling and monitoring the electrical system, and transforming voltages to higher or lower voltages. See distribution substation, switching station and transmission substation.
SYSTEM CAPACITY	The amount of electric power which the electric system under normal operating conditions is capable of supplying.
SWITCHING STATION	A substation consisting of equipment for controlling and monitoring power flow. It does not include equipment for transforming voltage levels.

TAP	To extend a transmission line into a new substation by simply running a new single circuit line from the existing line to the substation. Compare to loop.
TRANSFORMER	A device for changing the voltage of electrical energy.
TRANSMISSION	The transport of electricity from generation to transmission substations and from transmission substations and switching stations to distribution substations.
TRANSMISSION LINE	A power line or circuit usually carrying voltages of 115 kV or higher.
TRANSMISSION SUBSTATION	A substation which transforms power from 500 or 230 kV to 230 or 115 kV. The lower voltage lines primarily deliver power to distribution substations.
VOLTAGE	The electrical "pressure", measured in volts.