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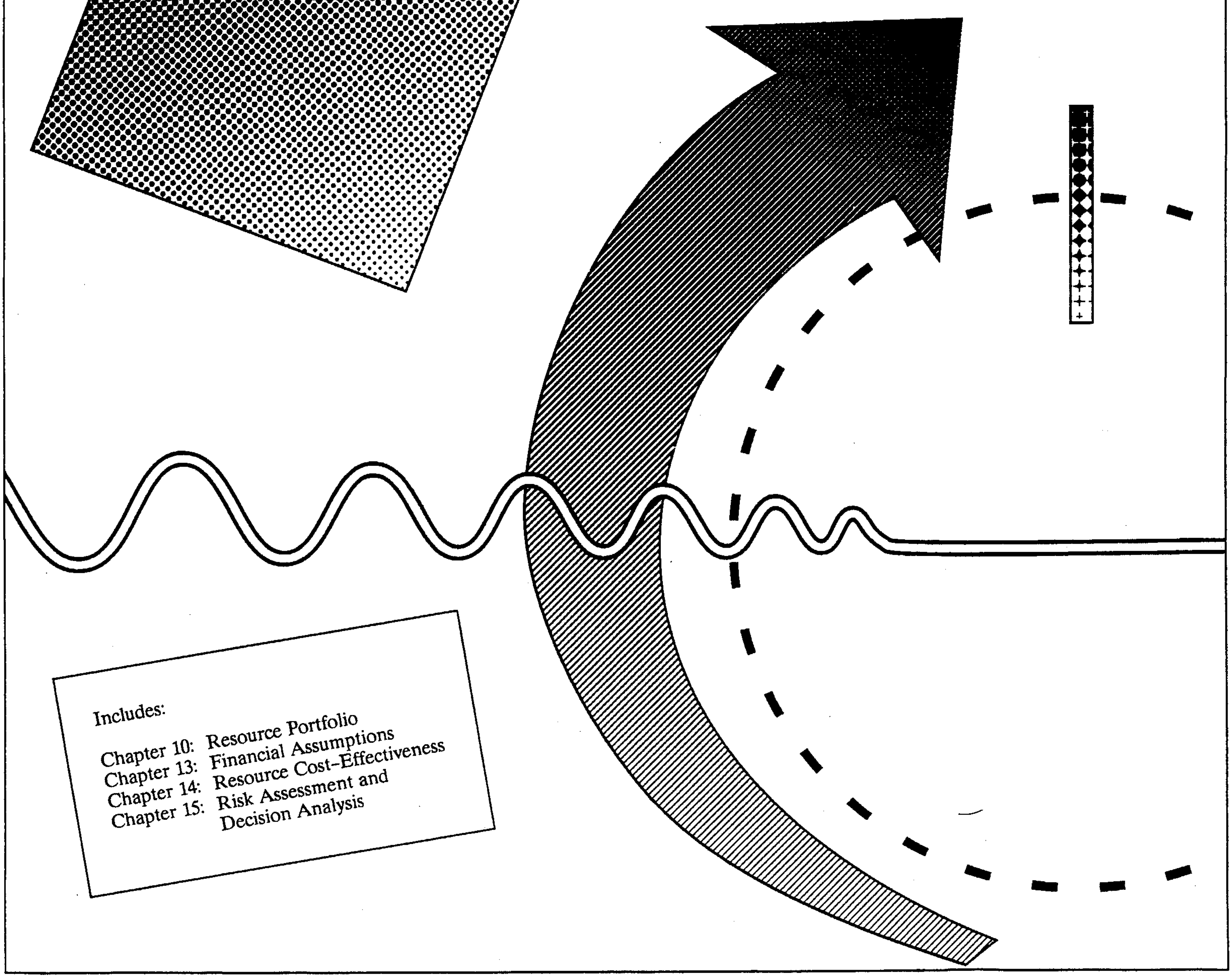
Draft

1991
NORTHWEST CONSERVATION
and
ELECTRIC POWER PLAN
VOLUME II
Group 6



Includes:

Chapter 10: Resource Portfolio
Chapter 13: Financial Assumptions
Chapter 14: Resource Cost-Effectiveness
Chapter 15: Risk Assessment and
Decision Analysis

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November 1990

To Interested Parties:

The attached document is a specific part of a larger document entitled, the "Draft 1991 Northwest Conservation and Electric Power Plan--Volume II." If you are interested in ordering any other parts of this plan, you may do so by writing or calling the Council's public involvement division (address and toll-free phone numbers are listed above). Volume I is the basic power plan. It contains all of the plan's major policies, directions and actions. Volume II is the technical, supporting documentation. A complete listing of Volume II is described below for your ordering convenience.

The Council is accepting public comment on this draft plan through 5 p.m., March 15, 1991. Please send comments to the Council's central office at the address above. Comments should be clearly marked. If you are commenting on Volume I, refer to document number 90-18. If you are commenting on Volume II, refer to document number 90-18A. Public hearings also are scheduled in each state. Please call your state at the following numbers for times, locations and to sign up to testify: Idaho: 208-334-2956, Montana: 406-444-3952, Oregon: phone numbers are listed above, and Washington: 509-359-7352.

- Volume I (40 pages)
- Volume II, Group 1 (60 pages)--Chapter 1: Recommended Activities for Implementation of the Power Plan; Chapter 11: Resource Acquisition Process
- Volume II, Group 2 (80 pages)--Chapter 2: Background and History of the Northwest Power System; Chapter 3: The Council's Planning Strategy; Chapter 4: The Existing Regional Electric Power System
- Volume II, Group 3 (210 pages)--Chapter 5: Economic Forecasts for the Pacific Northwest; Chapter 6: Forecast of Electricity Use in the Pacific Northwest
- Volume II, Group 4 (190 pages)--Chapter 7: Conservation Resources; Chapter 12: Model Conservation Standards and Surcharge Methodology
- Volume II, Group 5 (360 pages)--Chapter 8: Generating Resources: Chapter 9: Accounting for Environmental Effects in Resource Planning; Chapter 16: Confirmation Agendas for Geothermal, Ocean, Wind and Solar Resources
- Volume II, Group 6 (120 pages)--Chapter 10: Resource Portfolio; Chapter 13: Financial Assumptions; Chapter 14: Resource Cost-Effectiveness; Chapter 15: Risk Assessment and Decision Analysis

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CHAPTER 10

RESOURCE PORTFOLIO

Chapter 10
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Introduction

A resource portfolio can be thought of in the same terms as an investment portfolio. An investor seeks a mix of stocks that will produce a high return on investment with acceptable levels of risk. In the resource portfolio the Council's objective is to find the mix of resources that will minimize the region's power cost and also have the ability to adapt to an uncertain future. Both are trying to manage uncertainties by diversifying their investments to reduce risks. Additionally, both must use judgment to include in their decisions those attributes that cannot be quantified.

The resource portfolio is frequently thought of as simply four different resource schedules, one for each of the four deterministic load scenarios. While a set of specific resource schedules to specific load paths is one way of describing it, the resource portfolio is much more than that. It is more appropriate to think of the portfolio as a set of resource availabilities, resource development priorities, and rules for resource acquisition decisions. It represents a strategy for investment in the region's energy future. The information in the portfolio is intended to be used in conjunction with evolving load forecasts to guide the decision-making process toward the most economical resource decisions as the region's energy future unfolds.

The resource portfolio and the development process play several roles in the Council's planning process. First, they comprise the vehicle that integrates the conservation supply assessment, the generating resource assessment, the demand forecasts and associated uncertainty with the economics and physical characteristics of the existing hydro-thermal system in the Pacific Northwest. The process provides a framework for evaluation of alternative resource strategies, each of which will have its own economic costs and environmental consequences. This framework can be used to formalize some of the trade offs inherent in power planning. For the issues that are not quantifiable, the Council exercises its judgment in determination of the role of the various resources in the portfolio.

Perhaps the most significant use of the portfolio is in its contribution to the Action Plan. Once the strategy for the portfolio has been developed, the portfolio analysis can produce information about the likelihood and magnitude of decisions that will need to be made to maintain a reliable power system. This information flows into the development of the Action Plan and recommendations for near-term actions on conservation programs and generating resources. Both conservation and generating resources have lead times, and actions to secure resources frequently must be taken well in advance of need. While the development of the portfolio necessarily uses a long term view to capture all of the economic impacts of long-lived resources, it is the short term actions embodied in the portfolio that are the most important. The resource decisions made between the present and the next plan are the real commitments to the energy future of the region. Decisions that are required five or ten years into the future will have significant opportunity for review and debate. The Council realizes that it is extremely unlikely that the resources ultimately acquired over the next 20 years will be the same as those in the portfolio. However, the portfolio does provide the basis for resource decisions over the next few years. Once implemented, these decisions will be irreversible.

The portfolio also is used to develop marginal or avoided cost estimates for use as benchmarks in the resource acquisition process. These can be used to judge the cost-effectiveness of specific resources that may not have been treated directly in the resource portfolio analysis. See Volume II, Chapter 14, Cost-Effectiveness, and pages 10-41 through 10-45 of this chapter for a discussion of resources outside the portfolio.

In developing this resource portfolio, the Council's primary objective was to achieve the lowest present-value system cost[1] across the wide range of future uncertainty faced by the region. In addition, because future events are not likely to turn out as forecast, the Council's portfolio continues to exhibit a high degree of flexibility, allowing opportune responses to unforeseen changes. This helps to maintain a reliable, economic power system. The Council believes the concept of risk management should play an important role in the resource decision-making process. The flexible planning strategy that has characterized previous Council plans is emphasized again in the Draft 1991 Power Plan.

Generating resource characteristics that lead to enhanced flexibility and reduced risk are, primarily, short lead times and small unit size. Shorter lead times reduce the period over which the need for new resources must be forecast, and allow resource sponsors to move closer to the point of actual need before committing large amounts of capital for resource construction. Shorter lead times produce a greater likelihood that resources will be useful once they are ready for service. Resources with small plant sizes would allow the region to make many smaller decisions rather than a few large ones, and provide the ability to match resource development and load growth more closely.

The concept of resource options was developed and emphasized in the Council's first plan. An important objective of this concept is the reduction of resource lead times. The option concept permits the region to enter into the preliminary stages of resource development, siting, licensing and design based on a relatively high projection of future load growth. This strategy is expected to prove cost effective because the cost of acquiring options is low compared to the cost of actual resource construction.

The options concept leads to a second decision point regarding the appropriate time to begin constructing a resource. After option acquisition, load forecasts would continue to be updated, and the projected need for the resource re-evaluated. If loads have not grown sufficiently to justify entering construction, the option would be held until it was either appropriate to construct the resource or the option was lost. The options concept enhances the flexibility of the Council's resource portfolio and warrants additional analysis and policy development. Over

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1./ System cost is defined to be an estimate of all direct costs of a measure or resource over its effective life, including, if applicable, distribution and transmission costs, waste disposal costs, end-of-cycle costs, fuel costs and quantifiable environmental costs. System cost also takes into account projected resource operations based on appropriate historical experience with similar measures or resources.

the planning horizon, the ability to create resource options will improve the ability to match the rate of resource development with resource need and reduce the cost of the resource portfolio.

Most of the analysis for the draft resource portfolio was performed with a computer model referred to as ISAAC. (ISAAC is an acronym for Integrated System for Analysis of Acquisitions.) ISAAC was developed jointly by staff from the Council and Bonneville, with support from the Pacific Northwest Utilities Conference Committee and the Intercompany Pool. It is currently used by both the Council and Bonneville for resource planning studies. It is used in the portfolio development process because of its capability to treat several of the major uncertainties that affect Northwest power planning. The model is used in decision analysis studies to evaluate the risks associated with the resource portfolio or a particular set of decisions and is useful in developing risk management strategies. Volume II, Chapter 15 contains a description of the model.

Unless otherwise noted all costs mentioned in this chapter are expressed in January 1990 dollars. This applies to all resource levelized cost values, either real or nominal, and to any present value results for the portfolio studies.

Resource Portfolio Development

Process Overview

The Council's resource portfolio development process consists of a number of interrelated activities. These are shown graphically in Figure 10-1 and are summarized below.

Load Forecasts

The process began with development of electricity demand forecasts for the region. Five forecasts were developed, each representing a possible regional future. A probability distribution for future loads also was developed. In order to focus on the obligations of the Bonneville administrator, the forecasts also were broken down into demands of the public and investor-owned utilities. Volume II, Chapters 5 and 6 provide a detailed description of the forecasting process and its results.

Determination of Resource Availability

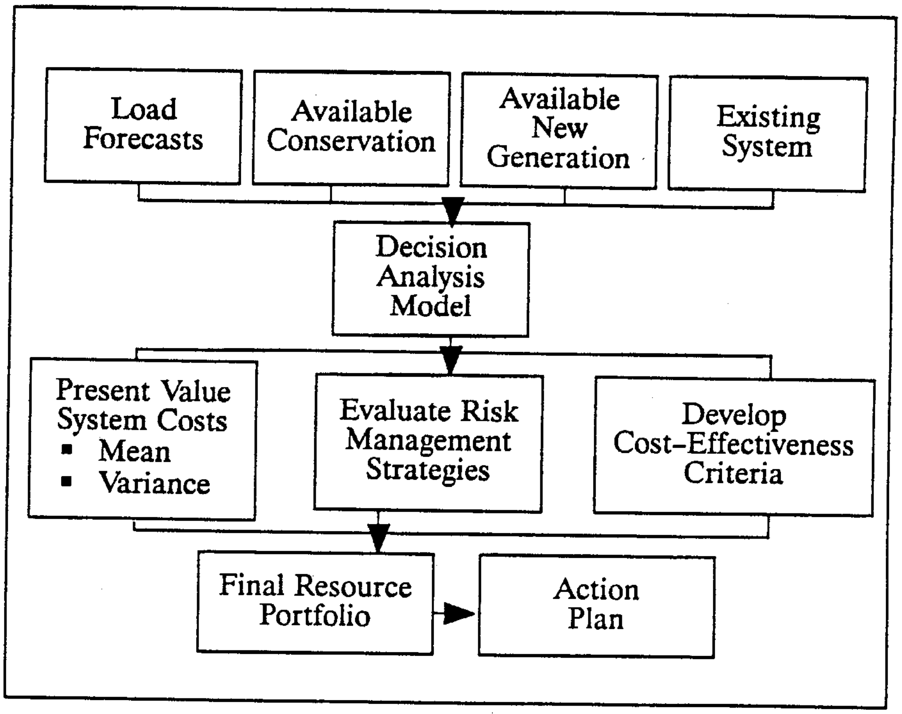
Information from the load forecasts and the avoided cost estimates were used to screen resources for the portfolio analysis. Initial estimates of the amounts of cost-effective resources were developed for generating resources and conservation programs. For many conservation programs, the amount of efficiency improvement available depends on the level of economic activity modeled for that sector in the load forecast. This correlation between conservation availability and load level is used in the portfolio analysis. For a full discussion of the conservation and generating resource potential see, respectively, Volume II, Chapters 7 and 8.

Portfolio Analysis

The load forecast range, its probability distribution, and the conservation and generating resource availabilities and costs were used with ISAAC to develop the Council's resource portfolio. ISAAC is used here because it incorporates the effects of long-term load uncertainty, resource option and construction lead time, conservation program ramp rates, seasonality and system operating impacts into the cost-effectiveness analysis. The process involved several repetitions of the forecasting and resource screening activities to ensure consistency among the portfolio, loads and electricity prices, and conservation energy potentials. Judgment is used to alter the portfolio in an attempt to balance cost and risk. After the resource portfolio had stabilized, it was used in development of the Action Plan, and avoided costs were calculated for the portfolio resources.

Analytical Flow

Figure 10-1
Portfolio Analysis Process



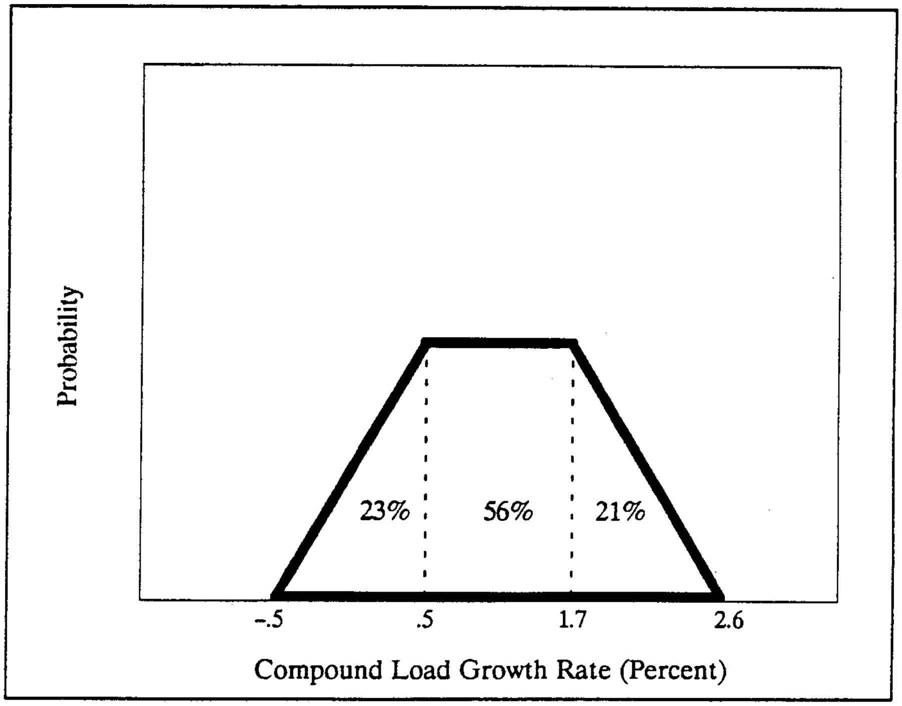
Load Treatment

Volume II, Chapter 6 describes the development of the four demand forecasts in detail. These forecasts provide the starting point for the portfolio analysis and obviously are a critical piece of information. However, these four specific forecasts are not used directly in the analytical process. Rather, they are incorporated into the analysis through definition of the probability distribution for regional loads.

As for any specific forecast, the likelihood is extremely small that future regional load will evolve exactly along any one of the four specific forecast paths. However, because of the philosophy underlying their development, the forecasts can be used to define a probability distribution for future electricity demand. The forecasts were developed in such a way that future load outcomes either below the low forecast or above the high were believed to have probabilities so low as to justify exclusion for planning purposes. In addition, the medium-low and the medium-high forecasts define the range of most likely load outcomes. These characteristics can be represented with the trapezoidal probability distribution shown in Figure 10-2. This distribution, expressed in terms of 20-year compound growth rates, has a uniform probability of occurrence for loads between the medium-low and medium-high, with probabilities dropping off linearly to zero at both the low and the high. This is a continuous distribution, implying that any load outcome across the entire range would be possible. The probability of a load occurrence between the low and medium-low is 23 percent; between the medium-low and medium-high, 56 percent; and between the medium-high and high, 21 percent. As described in Volume II, Chapter 6 the frozen efficiency forecasts are used in the portfolio analysis to avoid the double counting of conservation energy savings.

Trapezoidal Distribution

Figure 10–2
Load Growth Probability Distribution



Another component of load uncertainty included in the portfolio analysis is that associated with the direct service industries. In the detailed demand forecast range, firm direct service industry loads range from about 500 average megawatts in the low load scenario to about to 2,300 average megawatts in the high scenario (see Volume II, Chapter 6). The portfolio analysis uses approximately this same upper and lower limit for direct service industry load, but assumes no correlation with other loads. ISAAC contains an aluminum submodel that treats aluminum prices as a random variable. Aluminum prices are assumed to be driven by world markets and are determined independently from regional economic conditions.

Aluminum loads are developed in response to these aluminum prices in conjunction with electricity prices. ISAAC's aluminum submodel was calibrated to result in approximately the same range of loads for the direct service industry as contained in the detailed demand forecasts.

Resource Requirements

Comparing the Council's demand forecasts with the energy capability of existing system resources over time yields an estimate of surplus and deficits the region would face if no new resources were developed. The loads used in this calculation are the frozen efficiency forecasts described in Volume II, Chapter 6. The estimates for the capability of existing resources are based largely on the 1990 *Northwest Regional Forecast*, published by PNUCC in March 1990 (see Volume II, Chapter 4). The existing resource capability includes adjustments for firm imports and exports, expected retirement of existing thermal plants, and the scheduled return of Canadian Entitlement energy to British Columbia. The existing system capabilities are based on critical-water conditions. There are no adjustments made for either the potential early shutdown of the Trojan nuclear plant or reduced capability of the system hydropower facilities due to endangered species mitigation actions. Adjustments to the capability of the existing system will be incorporated into the plan if and when these events occur.

Figure 10-3 depicts the regional load/resource balance under the four deterministic load scenarios. Because there is some uncertainty about current levels of demand, the load/resource balance shows a range at the beginning of the planning horizon in 1991. On average it shows a small surplus, but ranges from a surplus of about 1,200 average megawatts in the low scenario to a deficit of about 500 average megawatts under high loads. Under low loads, the region is significantly surplus over the entire 20-year planning horizon with no new resource additions. If high loads occur, the region will need to develop over 13,000 average megawatts to maintain load/resource balance. One thing to note from this graph is how quickly the region is likely to need resources to maintain system reliability. In both the high and medium-high scenarios, resources are needed almost immediately. In the medium-low the point of need is about 1999.

Regional Need

Figure 10-3
Regional Resource Requirements

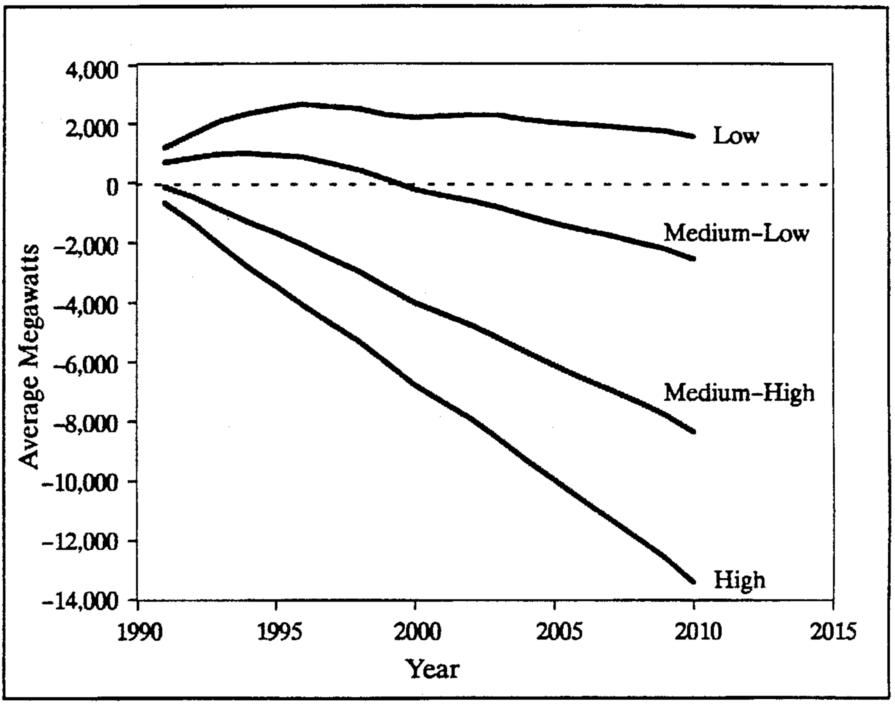


Figure 10-4 takes a closer look at the first ten years of the planning horizon using a probabilistic perspective. This is a scatter diagram where each dash represents a surplus or deficit point that occurs over the 100 separate load paths typically used in the portfolio analysis. The probability distributions for the loads underlying each point conform to those discussed earlier. Note that these are the surpluses or deficits that would occur if no new resources were added to the system. The solid line represents the average load/resource balance through time. This figure indicates that the expected point of need for new resources on a regional basis is about 1993.

Uncertain Need

Figure 10-4
Uncertainty in Regional Resource Requirements

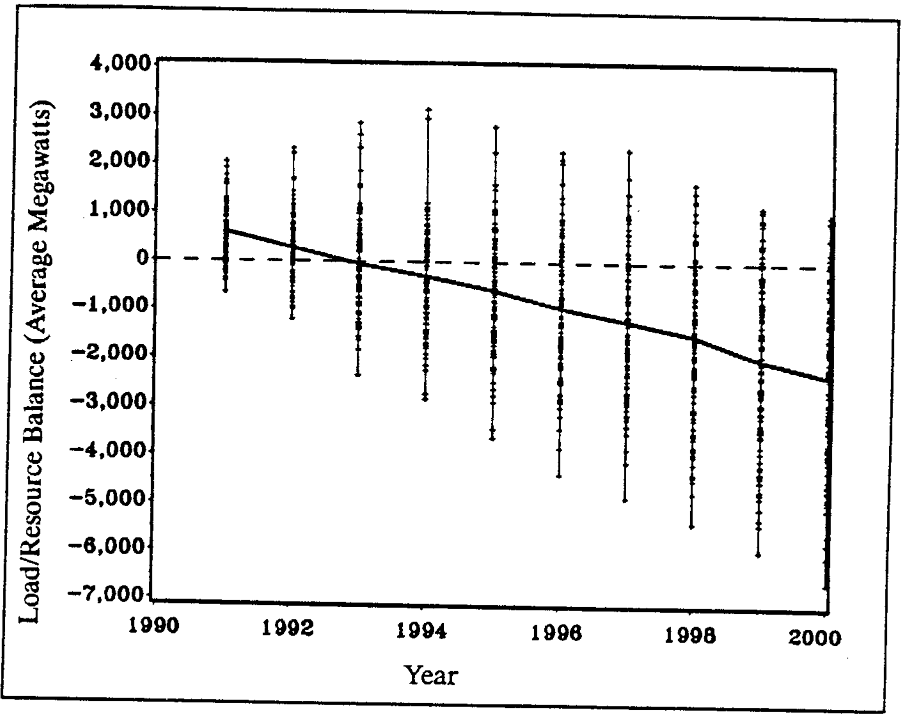
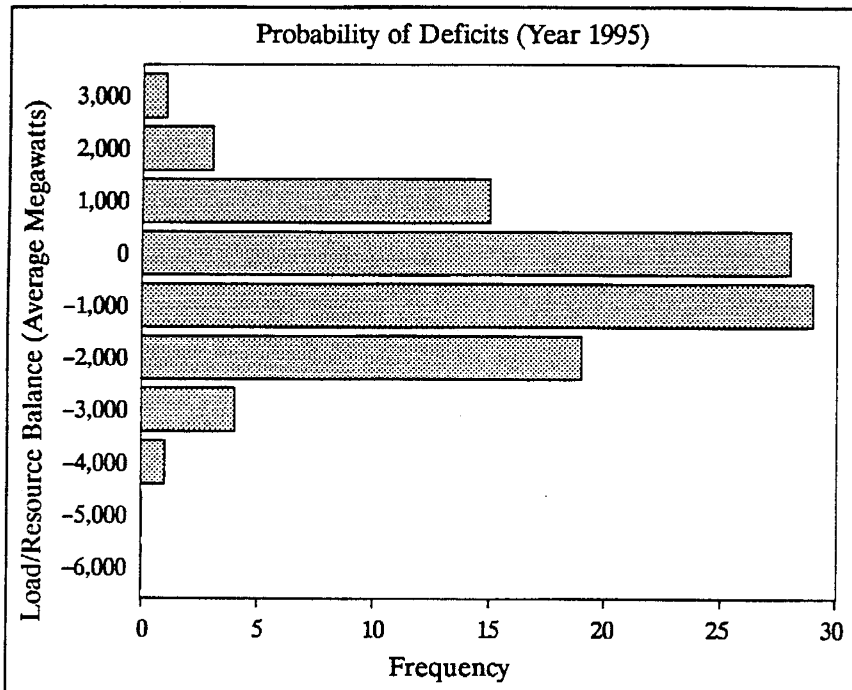


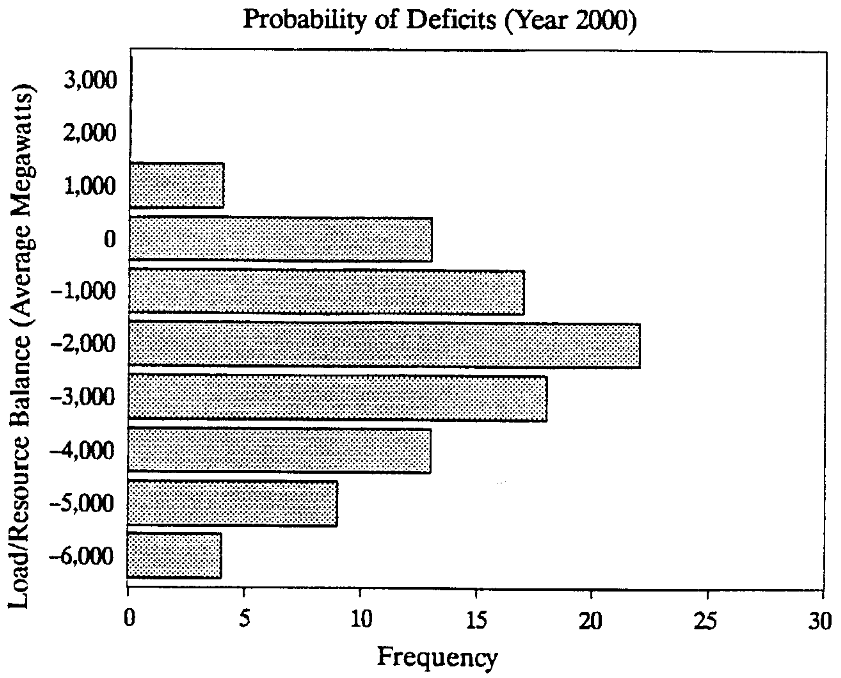
Figure 10-5 shows frequency distributions of the potential surpluses and deficits for 1995 and 2000. It provides information about the probabilities of seeing a surplus or deficit of a particular magnitude. The values on the vertical axis represent the midpoints of the range used for each bar. For instance, the estimate for the probability of a surplus in 1995 between 500 and 1,500 average megawatts is represented by the length of the 1,000 megawatt bar, or 15 percent. The cumulative probability is the probability of seeing a load/resource balance of less than the upper bound of the interval. For example, in 2000 the probability of seeing a deficit of 3,500 average megawatts or less is 74 percent. Another interpretation is that there is a 26 percent chance of needing more than 3,500 average megawatts of new resource to maintain load/resource balance. The mean value for the amount of new resource needed is 590 average megawatts in 1995 and 2,340 average megawatts in 2000.

Probability of Regional Need

Figure 10–5
Distributions of Regional Resource Requirements


Probability of Deficits (Year 1995)

Prob	Cum Prob
.01	.01
.03	.04
.15	.19
.28	.47
.29	.76
.19	.95
.04	.99
.01	1.00
0	1.00
0	1.00


Probability of Deficits (Year 2000)

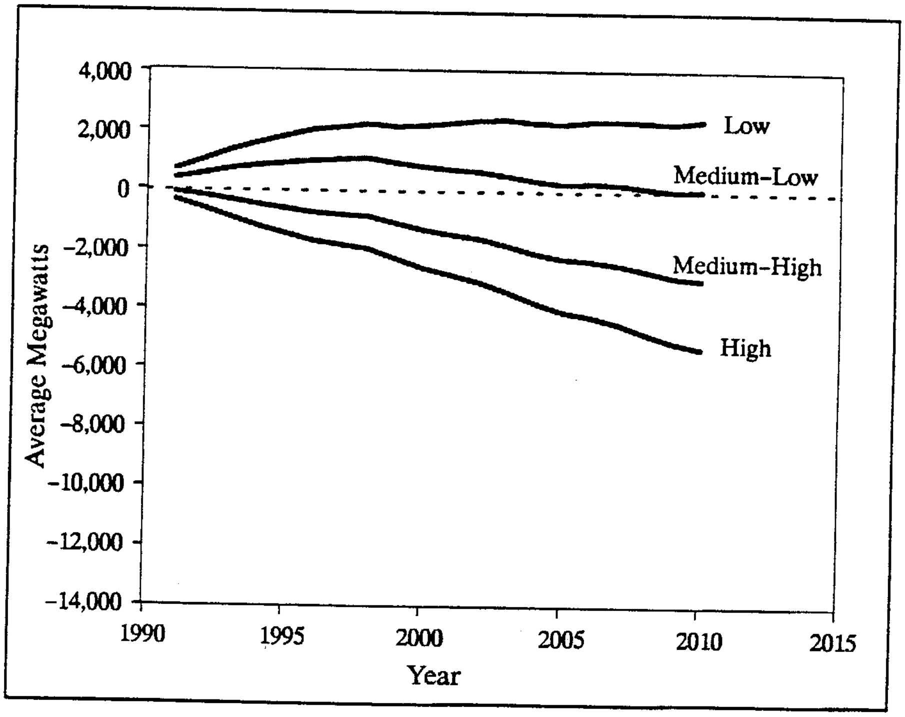
Prob	Cum Prob
0	0
0	0
.04	.04
.13	.17
.17	.34
.22	.56
.18	.74
.13	.87
.09	.96
.04	1.00

The Northwest Power Act requires the Council to forecast the electrical demand and plan for the resources to serve Bonneville's customers. The actions needed to meet the administrator's obligations are an important part of the plan. To date, only relatively small loads have been placed on Bonneville by the region's investor-owned utilities, and there currently are no long-term power sales contracts for significant amounts of energy. For most of the studies supporting the resource portfolio, the Council has assumed the investor-owned utilities place no additional load on Bonneville. The assumption used throughout the portfolio analysis is that Bonneville and the private utilities will plan for and acquire resources independently.

Figure 10-6 shows the range of energy requirements for Bonneville's public utility and direct service industry customers. These include the loads and resources of the region's generating public utilities. In the short term, Bonneville and the publics are about in load/resource balance. Depending on load growth, Bonneville can maintain balance for a period of time through exercising the recall provisions of current out-of-region contracts. Bonneville has about 300 average megawatts of energy that can be gained through contract recall provisions. In the portfolio analysis, this is one of the first actions taken by Bonneville, if needed. In aggregate, Bonneville and the publics need no new resources in either low loads or the higher probability medium-low scenario. Under high loads they could need as much as 5,300 average megawatts. Figure 10-7 shows the frequency distributions for resource requirements in 1995 and 2000.

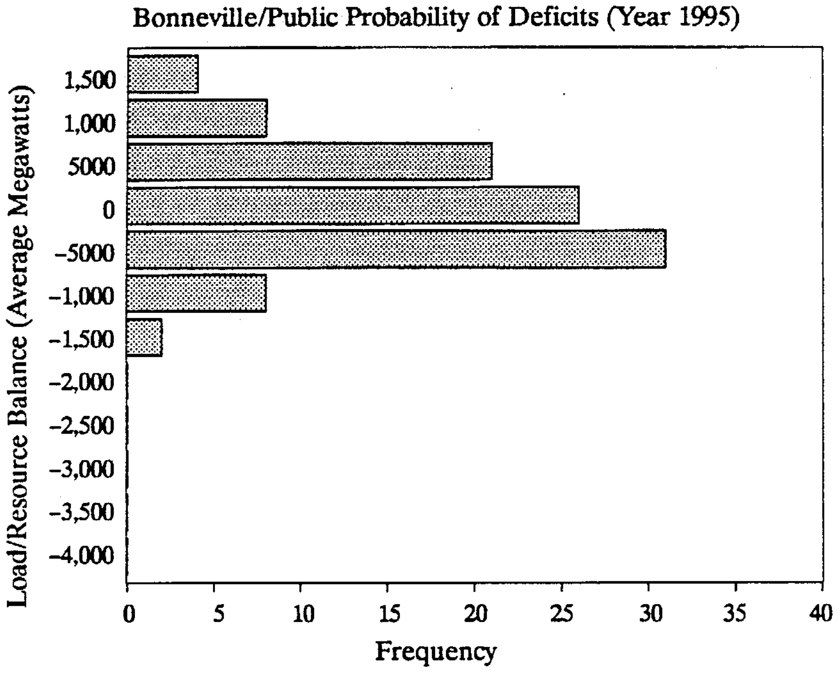
Public Utility Need

Figure 10-6
Bonneville/Public Utility Resource Requirements



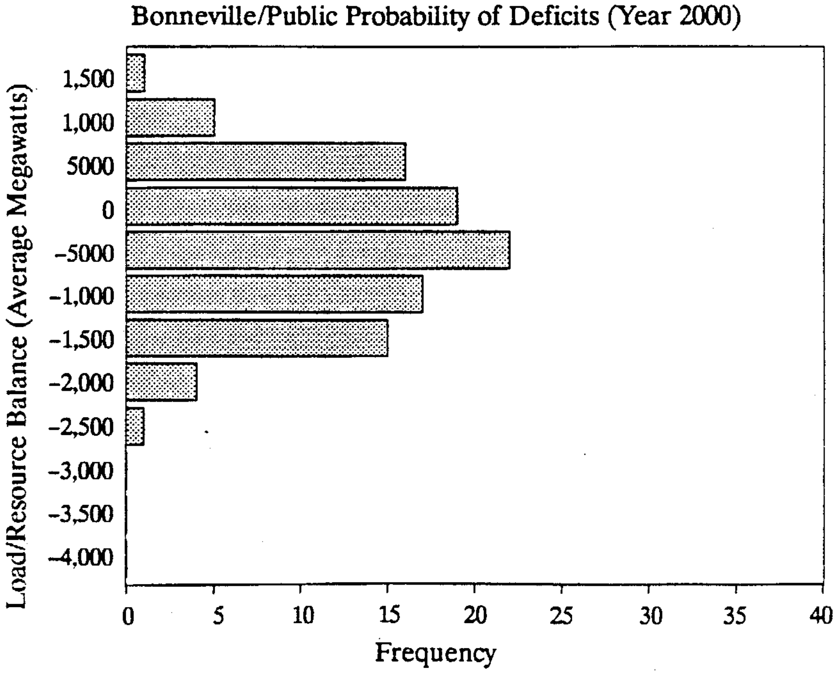
Probability of Public Utility Need

Figure 10–7
Distributions of Public Utility Resource Requirements



Bonneville/Public Probability of Deficits (Year 1995)

Prob	Cum Prob
.04	.04
.08	.12
.21	.33
.26	.59
.31	.90
.08	.98
.02	1.00
0	1.00
0	1.00
0	1.00
0	1.00
0	1.00



Bonneville/Public Probability of Deficits (Year 2000)

Prob	Cum Prob
.01	.01
.05	.06
.16	.22
.19	.41
.22	.63
.17	.80
.15	.95
.04	.99
.01	1.00
0	1.00
0	1.00
0	1.00

Finally, Figures 10-8 and 10-9 portray an estimate of the load/resource balance picture for the combined systems of the six investor-owned utilities in the Northwest. For planning purposes, the Council treats the private utilities as a pool. In fact, these are unique companies facing a diverse set of load growth and existing resource conditions, and it would be an error to infer much about the load/resource conditions of any individual company from this graph. However, the aggregate need for resources shown here is representative of expectations of the private utilities as a whole, and is appropriate for regional planning.

Comparison of Figures 10-6 and 10-8 shows that the Bonneville/public utility system and the investor-owned utilities are currently in about the same load/resource balance conditions. However the investor-owned utilities are forecast to have a higher proportion of regional load growth in their service territories. Much of the early resource development in the region is likely to be driven by investor-owned utility needs. Over the planning horizon, it is expected that over 60 percent of new resource additions will go to serve investor-owned utility needs.

Private Utility Need

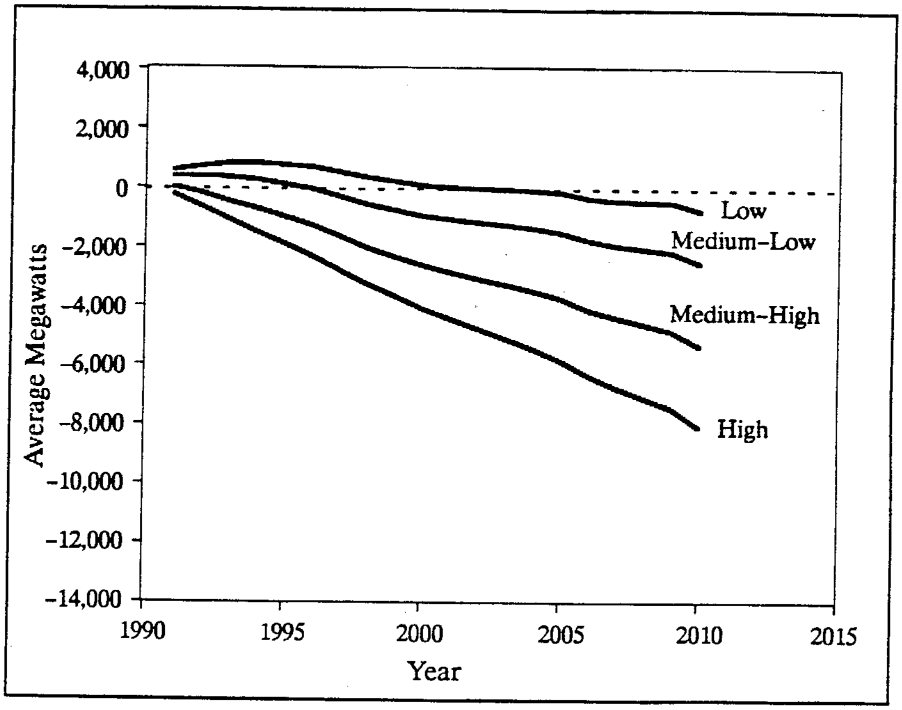
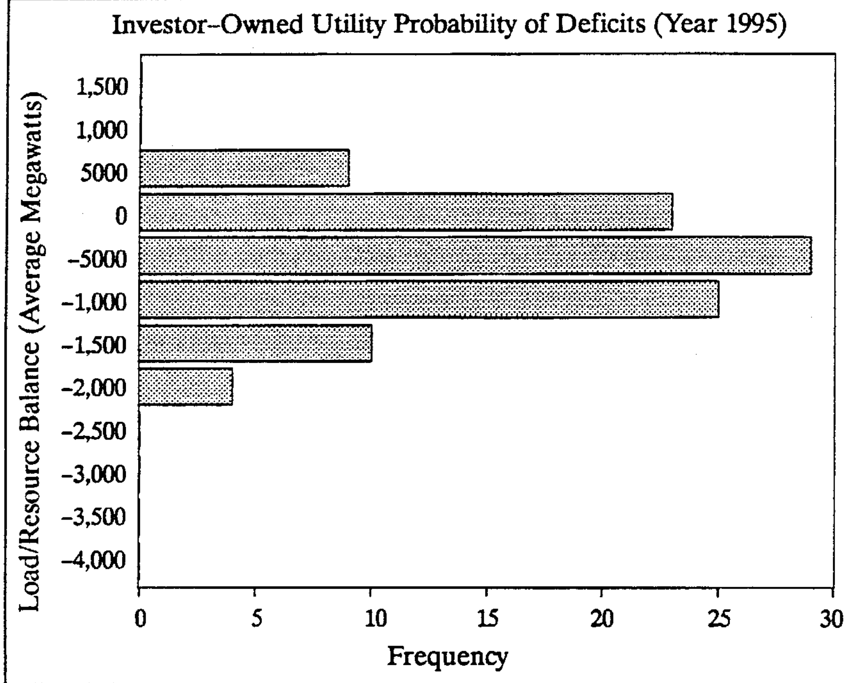


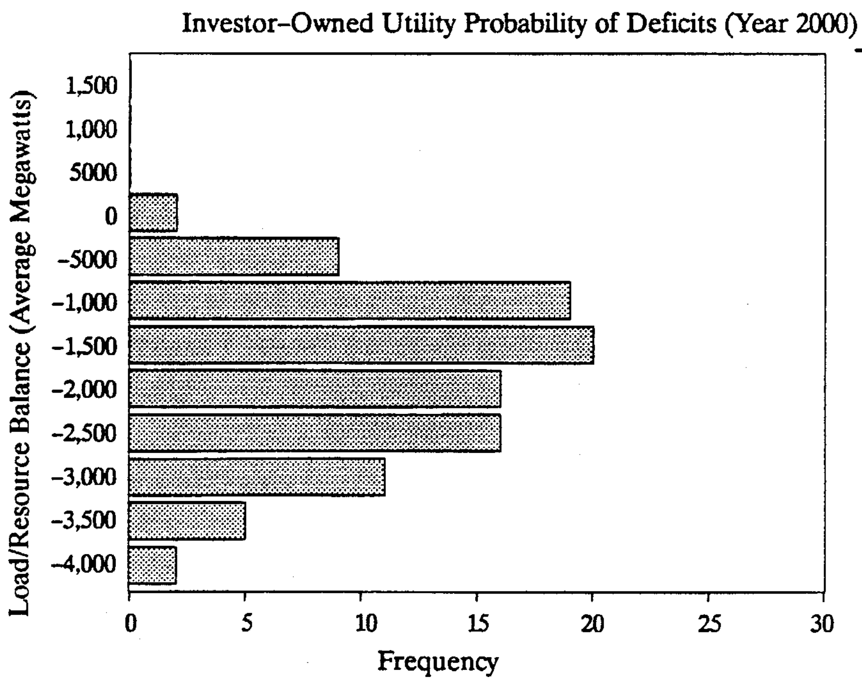
Figure 10-8
Investor-Owned Utility Resource Requirements

Probability of Private Utility Need

Figure 10-9
Distributions of Investor–Owned Utility Resource Requirements



Prob	Cum Prob
0	0
0	0
9	.09
.23	.32
.29	.61
.25	.86
.10	.96
.04	1.00
0	1.00
0	1.00
0	1.00
0	1.00



Prob	Cum Prob
0	0
0	0
0	0
.02	.02
.09	.11
.19	.30
.20	.50
.16	.66
.16	.82
.11	.93
.05	.98
.02	1.00

Resources Available

The Council has undertaken a detailed analysis of the conservation program measures and generating resource alternatives available to meet the region's energy needs over the planning horizon. These analyses were described in detail in Volume II, Chapters 7 and 8. A summary of the results is shown in Table 10-1. This table shows the amount of energy estimated to be available across the load forecast range, as well as the stand-alone levelized cost for each resource. For generating resources, the amount of energy available does not vary with the load forecast. However for conservation programs, the energy potential is frequently correlated with load growth. Many of the conservation program potentials are driven by the level of economic activity in their sectors; for example the rate of new building starts affects the energy available from the model conservation standards. As the economic activity driving the forecasts increases, more new buildings are constructed, affording more potential for conservation savings. The energy potential of the conservation programs has been adjusted for transmission and distribution line losses equal to 7.5 percent. Costs for the conservation program shown here include administrative costs, a 2.5 percent credit for the avoidance of transmission and distribution investment, and also have been adjusted for the 10 percent cost-effectiveness credit defined in the Act. For all conservation programs and generating resources the nominal levelized costs have been normalized to a 40-year physical life (see Volume II, Chapter 14). Note also that the resources in Table 10-1 are resource potentials. They are not the amount of resource actually acquired in the four deterministic forecasts. The data from Table 10-1 can be used to develop an aggregate supply curve for the portfolio resources. This supply curve is shown in Figure 10-10.[2]

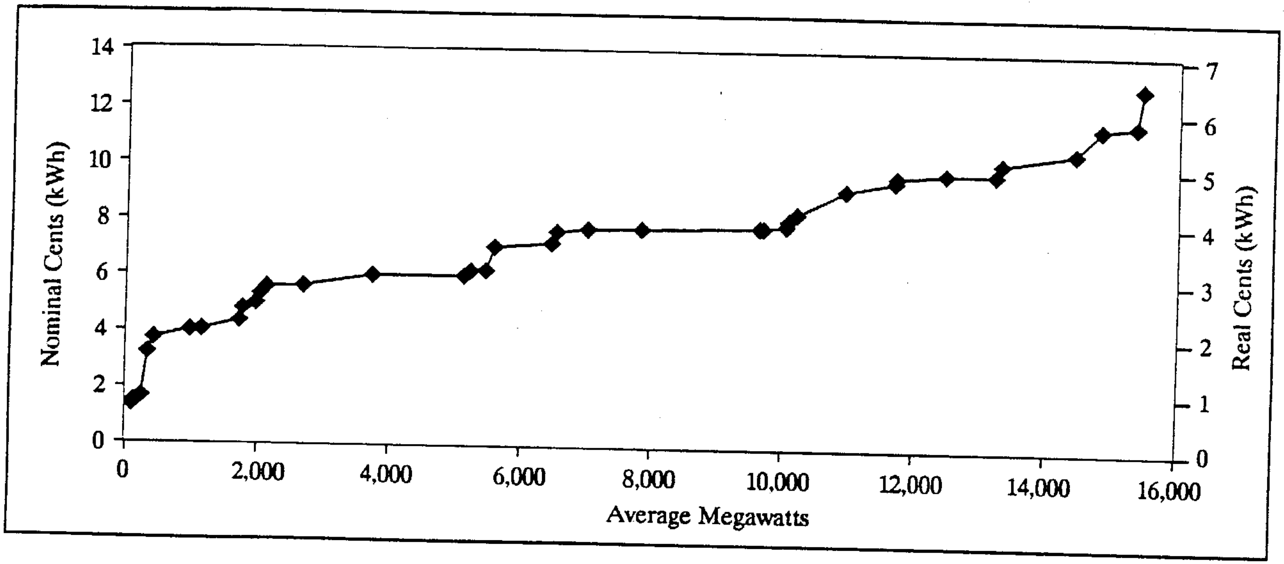
2./ During the final stages of compiling this draft plan, the Council discovered that the base cost data for cogeneration was in 1990 dollars. Reference costs for all other resources were expressed in 1988 dollars. The costs shown in the table are consistent with the costs used in the resource portfolio studies and have not been corrected for this discrepancy. This means that costs as shown for all cogeneration blocks are approximately 10 percent too high when compared to other resources. Given the time constraints, it was not possible to redo all of the portfolio studies with corrected cogeneration data. The Council will correct for this inconsistency before adoption of the final plan and will update all resource costs to 1990 dollars. The effect of this adjustment will be for cogeneration to move up in the priority order and to play a stronger role in the resource portfolio. This is likely to be especially true for cogeneration blocks 3 and 4.

Table 10-1
Resource Cost and Availability
(cents/kWh, average megawatts)

	Levelized Cost		Load Scenario			
	Real	Nominal	High	Medium-High	Medium-Low	Low
Non-Discretionary Conservation						
Freezers	.74	1.45	21	28	35	44
New Manufactured Housing	1.62	3.19	33	58	74	68
Commercial MCS	2.03	3.99	195	274	402	544
Water Heat	2.04	4.01	114	144	171	202
Multifamily Residential MCS	2.41	4.75	31	46	49	54
Refrigerators	2.81	5.54	56	70	84	100
Single-Family Residential MCS	3.13	6.17	33	82	160	268
Discretionary Conservation						
Conservation Voltage Regulation	.68	1.34	100	100	100	100
Industrial	2.20	4.33	285	357	442	575
Transmission and Distribution Efficiency Improvements	2.52	4.96	200	200	200	200
Multifamily Residential Weatherization	2.68	5.27	53	53	53	53
Existing Commercial	2.83	5.57	313	357	469	558
Single-Family Residential Weatherization	3.56	7.01	130	130	130	130
Irrigation	3.84	7.56	77	77	77	77
Generating Resources						
Hydro Efficiency Improvements	.84	1.65	110	110	110	110
Small Hydro 1	1.88	3.70	90	90	90	90
Hydrofirming (Combined Cycle 1)	3.03	5.97	1,050	1,050	1,050	1,050
Small Hydro 2	3.12	6.15	100	100	100	100
WNP-3	3.63	7.16	868	868	868	868
Cogeneration 1	3.89	7.67	480	480	480	480
WNP-1	3.91	7.69	818	818	818	818
Eastern Montana Coal	3.94	7.77	1,800	1,800	1,800	1,800
Hydrofirming (Combined Cycle 2)	3.03	5.97	1,400	1,400	1,400	1,400
Cogeneration 2	3.95	7.78	60	60	60	60
Geothermal	3.98	7.85	350	350	350	350
Municipal Solid Waste	4.08	8.03	30	30	30	30
Small Hydro 3	4.21	8.29	130	130	130	130
Eastern Washington Coal	4.63	9.13	750	750	750	750
Eastern Oregon Coal	4.81	9.47	750	750	750	750
Wind 1	4.89	9.63	20	20	20	20
Nevada Coal	4.96	9.76	750	750	750	750
Western Washington/Oregon Coal	4.96	9.76	750	750	750	750
Small Hydro 4	5.15	10.14	90	90	90	90
Cogeneration 3	5.36	10.56	1,130	1,130	1,130	1,130
Wind 2	5.80	11.43	380	380	380	380
Cogeneration 4	5.87	11.57	540	540	540	540
Biomass	6.54	12.88	90	90	90	90

Total Supply Curve

Figure 10-10
How Much at What Cost?



The conservation programs listed in Table 10-1 are classified as either "discretionary" or "non-discretionary." Non-discretionary programs are used in the portfolio analysis to model implementation of building and appliance codes, or the forced acquisition of cost-effective lost-opportunity resources. The development rates for the non-discretionary programs are not subject to program management in response to resource need. These programs produce energy savings regardless of need. For example, once fully incorporated into building codes, the level of savings from the model conservation standards would be driven primarily by the number of building starts. The standards automatically would produce energy savings across the entire load range. They would produce more energy in the high scenarios than in the low ones, but would produce a small amount of energy savings in the low scenarios even though no additional savings are required for the region in low-load conditions. This automatic correlation of savings produced to load level can add to the value of a resource and is detailed in the portfolio analysis. Additionally, all non-discretionary programs have equal and top priority in the resource development order in the portfolio analysis.

Discretionary programs are those programs whose development is managed in response to need. These programs are targeted primarily at the existing sectors (e.g., existing industrial or existing commercial) where a savings potential already exists and can be developed as needed. Delaying implementation of these programs is not likely to produce large lost-opportunity impacts. These are programs that are likely to be subject to direct program management and whose energy contributions can be managed in response to forecast need.

The acquisition of discretionary conservation in the portfolio modeling is controlled through a set of acceleration and velocity parameters defined for each program. These allow the programs to be modeled much as the movement of a car would be, with the activity level of a program analogous to the velocity of the car. Each program has an upper limit to its activity level (maximum velocity) and constraints on how quickly the activity level can change (acceleration and deceleration). High accelerations and velocities mean a program is quite flexible and energy could be acquired quickly. Low values indicate slow acquisition rates and difficulty in changing program activity levels. A minimum viable activity level to maintain the existence of a program after startup is also specified. The accelerations and velocities used for the discretionary programs are shown in Table 10-2.

Table 10-2
Conservation Program Assumptions

	Minimum Viable (%/year)	Maximum Acceleration (%/year/year)	Maximum Deceleration (%/year/year)	Maximum Rate (%/year)
Existing Residential Space Heat	2	7	7	15
Existing Commercial	2	2	2	8
Existing Industrial	0	2	3	8
Agriculture	0	2	3	8
Conservation Voltage Regulation	0	10	10	10
Transmission and Distribution	0	5	5	5

Cost-Effectiveness Studies

The estimates of resource availability in Table 10-1 can be thought of as individual investment opportunities to be used in developing the regional resource portfolio. A number of cost-effectiveness studies were performed using ISAAC to determine the best priority order for resource development. These studies were conducted by changing priority orders and comparing pairs of programs and generating resources until the order was found that led to lowest expected value system cost. This priority-order analysis involved only the discretionary conservation programs and generating resources. The non-discretionary programs were excluded from the priority order tests; however, they were included in the model runs to insure that their system effects and impact on the cost effectiveness of other resources would be included.

The initial priority order was based on levelized cost estimates for the programs and resources, and the process allowed the generating resources to compete with conservation programs for priority order. A limit of at least a $10 million present value improvement in system cost was imposed judgmentally as the minimum improvement to justify a switch in priority-order between two competing programs and/or resources. This is on a total system cost approaching $50 billion and is considered to be about the precision limit of a model like ISAAC.

Except for the amount of energy available for several of the resources, the conservation program assumptions for this analysis were consistent with the data described in Volume II, Chapter 7, and generating resource assumptions were consistent with Volume II, Chapter 8. For programs and generating resources in which the energy available was less than 300 average megawatts, the energy availability for these studies was raised to 300 average megawatts to ensure that the system effects of the resource would be captured in the present values. This increase in energy availability pertains only to these priority order studies. After the priority order was determined, the energy limits were again set back to those in Table 10-1 for further portfolio analysis. All sponsorship and financing assumptions were consistent with those described in Volume II, Chapter 13.

The results of this analysis are shown in Table 10-3. This is the priority order that was found to produce the lowest expected present value system cost across the entire load range, under the Council's base data assumptions and given the constraints mentioned above. This order was used as the basis for developing the resource portfolio, conducting sensitivity analysis, and development of Action Plan items. As stated earlier, the non-discretionary programs are all given equal and top priority in resource development.

The resource portfolio priority order shown in Table 10-3 represents a general order for development of resources during periods of acquisition. It does not mean that all of the potential of one type of conservation program or generating resource should be exhausted before moving to the next. Constraints on program and generating resource development rates and lead times will require parallel development paths for many of the resources in the portfolio.

Additionally, the methodology used in this analysis necessarily treats programs and resources as generic blocks. For instance, all of the potential cogeneration units within a block have the same physical characteristics, capital costs, operating costs, lead times, seasonal distributions, etc. In reality, there are likely to be significant differences between individual cogeneration installations competing for resource acquisition. In the actual acquisition decision, all projects should be evaluated on their own merits, taking into account their own unique characteristics (see Volume II, Chapter 14).

Option and Build Decision Rules

In addition to the order of resource priorities, two other decision rules are required to define the resource portfolio. These are referred to as the option and build levels.

The option level governs the amount of resource for which options would be acquired and held in inventory. The build level governs the amount of resource moved out of inventory and into actual construction. The option and build levels represent levels within the range of load uncertainty to use as guides for making resource decisions.

Table 10-3
Resource Priority Order

Non-Discretionary Resources

- Freezers
- New Manufactured Housing
- Commercial Model Conservation Standards
- Water Heat
- Multifamily Residential Model Conservation Standards
- Refrigerators
- Single-Family Residential Model Conservation Standards

Discretionary Resources

- Conservation Voltage Regulation
- Hydro Efficiency Improvements
- Small Hydro 1
- Industrial
- Transmission and Distribution Efficiency Improvements
- Multifamily Residential Weatherization
- Existing Commercial
- Small Hydro 2
- Hydrofirming (Combined Cycle 1)
- Single-Family Residential Weatherization
- WNP-3
- Irrigation
- Hydrofirming (Combined Cycle 2)
- Cogeneration 1
- WNP-1
- Eastern Montana Coal
- Cogeneration 2
- Geothermal
- Municipal Solid Waste
- Small Hydro 3
- Eastern Washington Coal
- Eastern Oregon Coal
- Wind 1
- Nevada Coal
- Western Washington/Oregon Coal
- Small Hydro 4
- Cogeneration 3
- Wind 2
- Cogeneration 4
- Biomass

A hypothetical example is shown in Figure 10-11. In this example, the region has moved out along a somewhat random load path and finds itself at load level L in time period T. The future load path is still unknown, and decisions must be made in the face of this uncertainty. To do this, a range forecast is first made from period T and a probability distribution is applied to the forecast range. Within this range, further forecasts must be made to use as a guide in making option decisions and build decisions. The approach used here is to develop a median forecast and add or subtract constant energy amounts to develop the option and build forecasts. In this example, 1,500 average megawatts is added to the median forecast to generate the option forecast. The build level adjustment is zero, and the build forecast is identical to the median forecast. Once these forecasts have been made, the resource priorities, resource availabilities, and option and construction lead times are used to make resource decisions. Conservation acquisition and generating resource build decisions are guided by the build level forecast. Option decisions use the option level forecast as a target. The process repeats annually as the analysis moves through time.

Option and Build Level

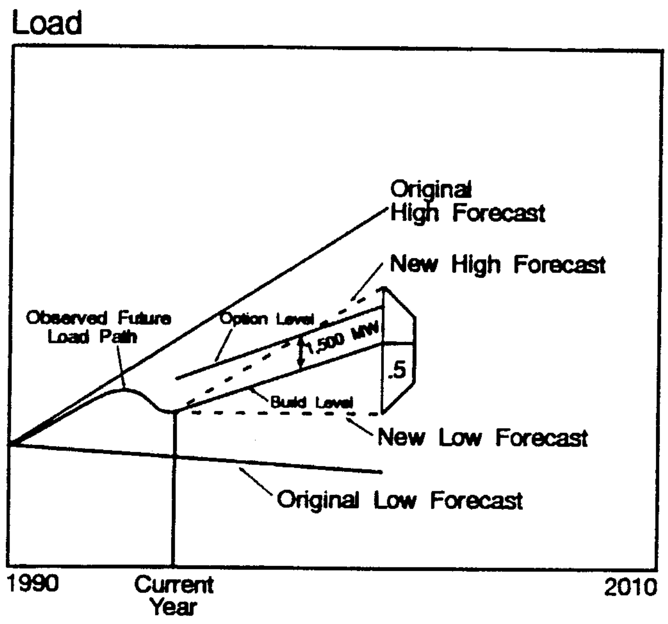


Figure 10-11
Example of Option and Build Levels

The Council conducted a number of studies at various combinations of build and option levels to determine which combination would result in the lowest present value cost on an expected value basis. The results are shown in Figure 10-12. The solid line shows the system cost impact of holding the option level constant at 1,500 average megawatts and changing the build level from -1,500 to +1,500 in 500 average-megawatt increments. The dashed line shows the cost impact of holding the build level constant at zero average megawatts and changing the option level in 500 average-megawatt increments. The graph illustrates that the strategy of making build decisions to a target of near load/resource balance, and at the same time carrying a sizable inventory of options produces the lowest system costs. This result makes intuitive sense because the option cost of the resources in the portfolio is much less than the cost of their actual construction.

Option and Build Level Studies

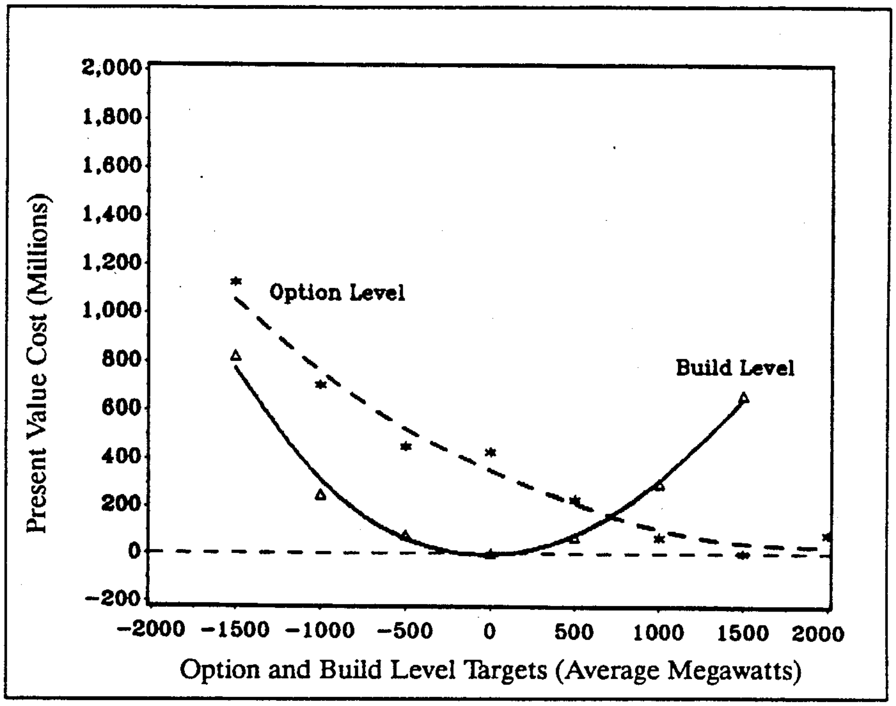


Figure 10-12
Cost of Option and Build Level Combinations

Options can be thought of as a relatively cheap form of insurance that reduce resource lead time and allow the region to guard against unanticipated periods of rapid load growth. It appears cost effective to build a significant inventory of options in order to assure flexibility in the resource acquisition process. However, because of the much higher costs associated with build decisions, they should be guided by using more conservative load-level targets, near the expected value of load, to produce the most cost-effective portfolio on an expected-value basis across the wide range of possible load outcomes.

Conservation Acquisition Studies

One of the important elements of the Action Plan is the call for action on conservation programs, with specific targets for acquisition over the next ten years. In the Council's early power plans, conservation was perceived to be a highly flexible resource that could be managed to easily adapt to load growth conditions. The experience of the last decade has shown, however, that conservation may not be flexible. It takes time to ramp programs up and to develop an infrastructure capable of reliable delivery of energy savings. Frequent changes in funding levels, program design, or acquisition targets can be disruptive to established utility programs and to the labor force involved in installation. Running a program as fast as possible until all savings have been exhausted and then a rapid program shutdown is likely to cause economic dislocations. Reasonable stability in funding levels and personnel have been identified as an important component in conservation program management and delivery mechanisms.

The Council conducted a set of studies to find the level of static conservation actions for the 1990s that would produce the lowest system cost. The first step in the study was to determine the conservation acquisition schedules needed to meet load in each of the low, medium-low, medium, medium-high, and high load conditions. The development schedules for each of the discretionary programs from 1991 to 2000 were then tested as a forced component of the resource strategy. In these runs, full load uncertainty with 100 load paths was used. The discretionary program energy was a constant pattern over the first ten years of each load path, regardless of need. If the forced schedule was one of the medium cases, and a load path turned out to be near the low, much more conservation than was needed would be acquired. In high load conditions, less energy than was needed would be achieved. After 2000, the program management logic in the model takes control of the program. Program scheduling then begins to respond to need under each load path. Only the discretionary programs were forced in these studies; the non-discretionary program energy varied with economic conditions as usual.

Figures 10-13 and 10-14 display the results of these studies. Figure 10-13 graphs the change in the mean present value system cost for each forced acquisition schedule tested. The base case here is one in which no discretionary program energy is allowed before 2000, and values graphed are changes in system costs from this no-action alternative. The graph shows that benefits increase rapidly as program energy approaches the medium target, and levels off and declines slowly as the higher conditions are approached. Expected value benefits are maximized near the medium schedule at slightly over $1 billion.

Forced Conservation Studies

Figure 10-13
Benefits of Fixed Conservation Targets

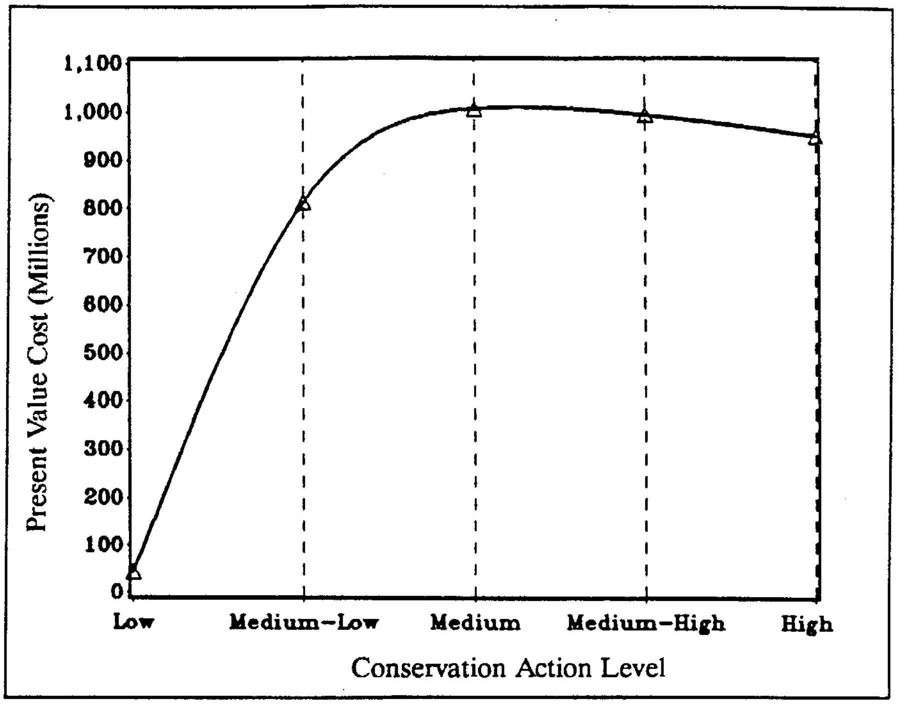
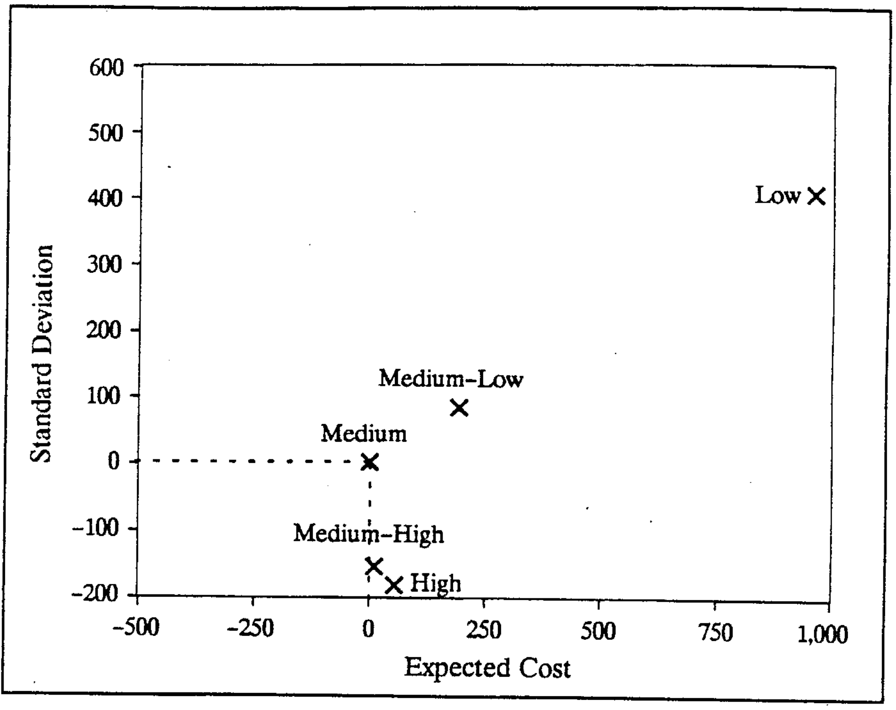


Figure 10-14 is a plot of the differences between the five alternative schedules against differences in their standard deviations. Changes in mean costs are plotted on the horizontal axis, changes in the standard deviation of cost are plotted on the vertical axis. The standard deviation is a measure of the dispersion of the values in the system cost distribution, and is frequently used to describe the risk associated with an action. The medium action schedule is used here as the base case, and occurs at 0,0. It represents the point of least cost. But it is not the point of least risk. Both the medium-high and high schedule have cost distributions with lower standard deviations than the medium. The medium-high schedule has a cost increase of about $10 million, with a reduction in standard deviation of about $150 million. The mean of the cost distribution is slightly higher, but the distribution of costs has less dispersion. This probably occurs because the higher conservation levels under the medium-high schedule limit the exposure to high cost resources in high load conditions more than the medium schedule does. In the judgment of the Council, the slight cost penalty of going to the medium-high acquisition schedule is more than offset by the reduction in risk.

Figure 10-15 shows the breakdown of the medium-high discretionary conservation energy by program for both Bonneville and the private utilities. These are the levels that are in the Action Plan; they are used in resource schedules discussed below.

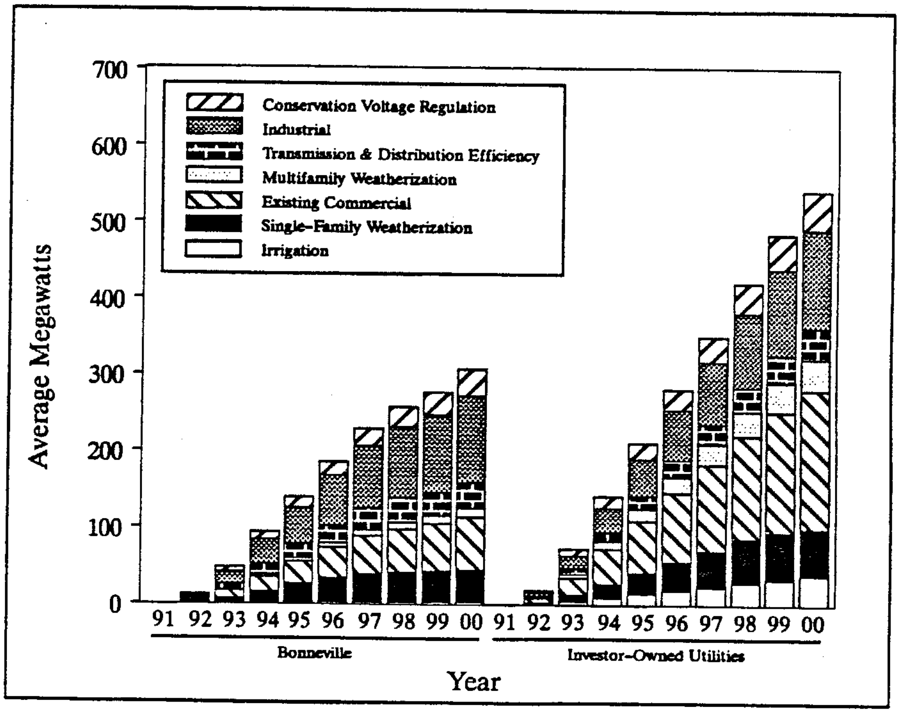
Forced Conservation Studies

Figure 10–14
Conservation Target Risk Analysis



Action Plan Targets

Figure 10–15
Discretionary Conservation Energy



Description of the Resource Portfolio

Resource activity contained in the portfolio can be described in a number of ways. That is because the resource portfolio is defined through the availability of resources, the priority order for resource development, the option and build decision rules, and a set of forced decisions independent of load path. One of the most straightforward ways is to show the resource acquisition schedules required to meet load under several different load scenarios. The resource schedules shown in Figure 10-16 illustrate the resource development schedule implied by the portfolio for Bonneville and the public utilities in each of the four deterministic load scenarios. These schedules are illustrative only. It is unlikely that any of these acquisition schedules will actually occur, because conditions inevitably will change in the future. In addition, these scenarios make the unrealistic assumption that planning can be done with perfect knowledge of future load conditions and that resources can be matched quite closely with loads.

Figure 10-16 shows that a wide range of resource activity is required across the load scenarios for Bonneville and its public utility customers. If low loads materialize, Bonneville implements the Action Plan's discretionary conservation program energy through 2000, then ramps the programs down to minimum levels, and is surplus through 2010. The same is true of the medium-low load conditions, although more conservation energy is developed because of the higher savings associated with the non-discretionary programs at this load level. In the medium-high condition, generating resources are needed to maintain load/resource balance. In the mid-1990s, Bonneville acquires small amounts of energy from hydroelectric efficiency improvements and new small hydroelectric plants. By 2001, Bonneville has firmed up 700 average megawatts of its nonfirm hydroelectricity, and has the output of WNP-3 available by 2003.[3] WNP-3 now is 76 percent complete and is being preserved in that condition.

Because of WNP-3's large size it is able to meet load growth to almost the end of the planning horizon. To meet long-term load under the improbable high-demand conditions, Bonneville would have to pull out all the stops. It firms up hydro in two blocks, having 700 average megawatts in place by 1997 and another 1,050 average megawatts by 2004. Completion of WNP-3 begins immediately and is online by 1999. WNP-1 comes online in 2005 and a coal plant is acquired near the end of the 20-year planning horizon.

The dotted line in these graphs represents a condition of load/resource balance. It indicates that in both the medium-high and the high conditions, Bonneville cannot maintain load/resource balance in the short term. The rate of load growth outstrips the ability to get resources in place because of conservation constraints and generating resource lead times. In the medium-high the deficit gets above 300 megawatts before resources begin to catch up to load. In the high the short-term deficit exceeds 1,000 average megawatts.

3./ WNP-3 now is 76 percent complete and is being preserved in that condition.

Four Resource Futures

Figure 10-16
Bonneville/Public Utility Resource Schedules

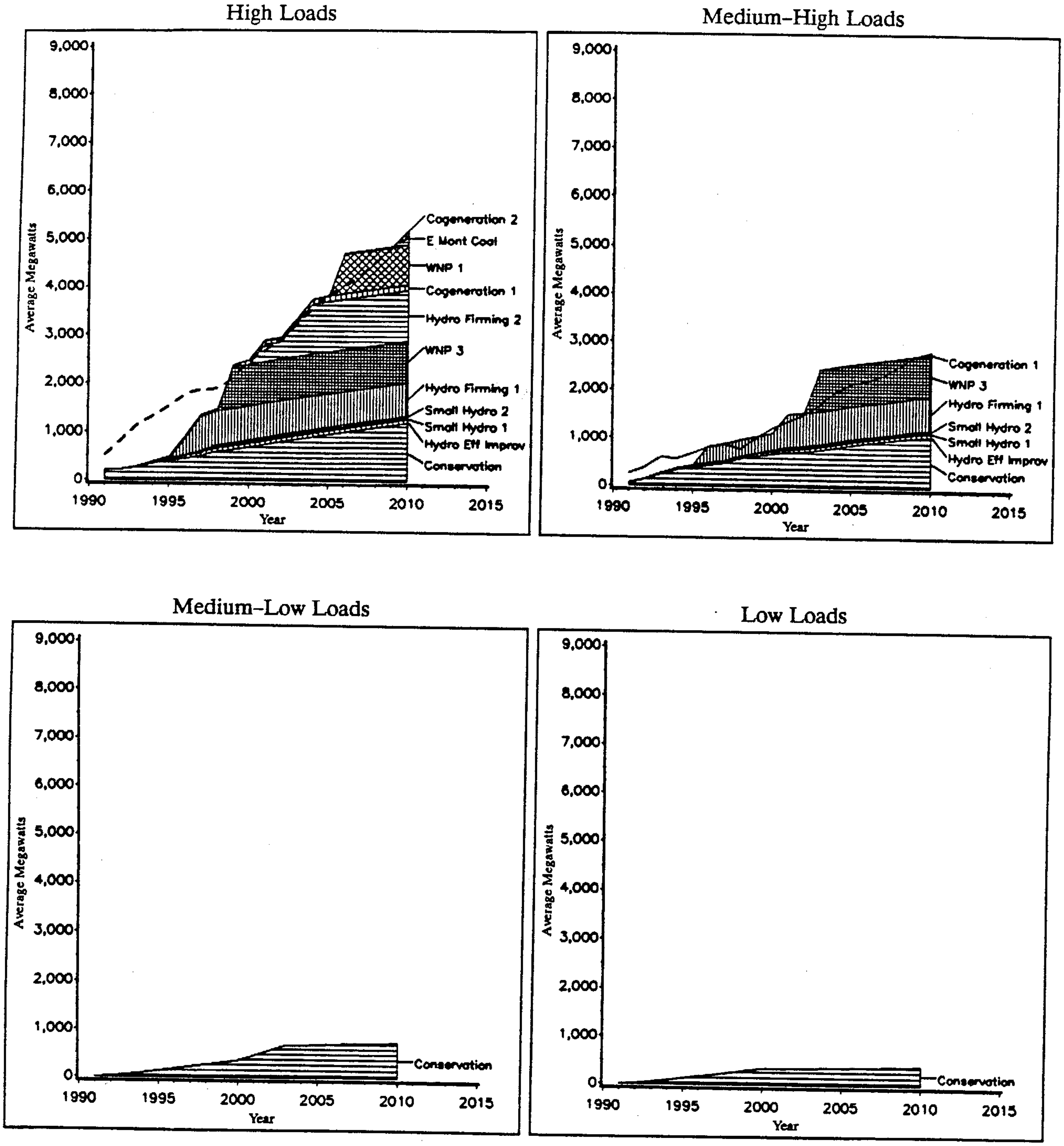

High Loads
Medium-High Loads
Medium-Low Loads
Low Loads

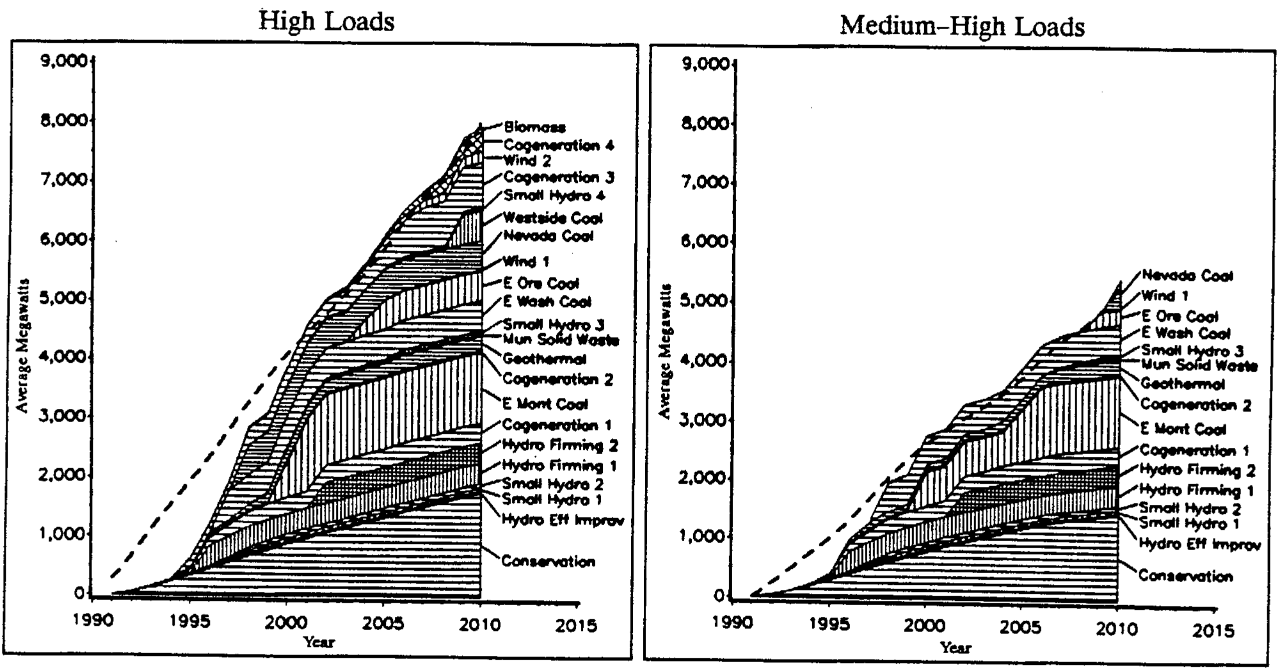
Figure 10-17 displays the resource schedule information for the investor-owned utilities. As mentioned previously, for planning purposes these utilities are treated as a group and are assumed to coordinate their resource development activities.

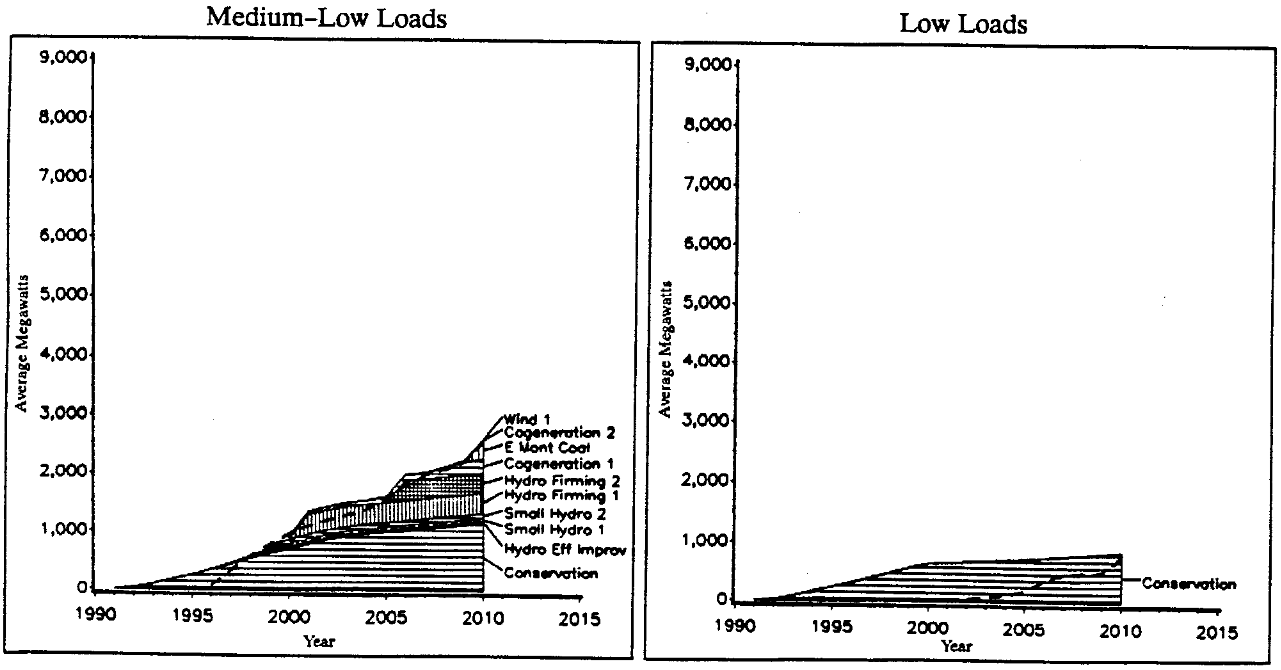
As the figure indicates, the private utilities need new resources in all load cases. Conservation is sufficient only in the low, where the Action Plan conservation energy in conjunction with the non-discretionary programs combine to end the planning horizon in load/resource balance. In all other scenarios, significant amounts of generating resources are required. By the year 2000 the medium-low requires about 160 average megawatts of hydroelectric efficiency improvements and small hydroelectric plants, 350 average megawatts of firmed hydroelectricity, and 60 average megawatts of cogeneration. To meet the medium-high in 2000 would require having in place an additional 230 average megawatts of cogeneration, 100 average megawatts of geothermal, and over 1,000 average megawatts of new coal-fired resources. If an attempt were made to develop enough resources to meet high load growth in 2000 it would require an additional 420 average megawatts of cogeneration, 100 average megawatts of small hydroelectric projects, and another 500 average megawatts of coal. That's 2,100 average megawatts of coal online by the year 2000. Like Bonneville, the private utilities cannot maintain load/resource balance in the mid 1990s in either the medium-high or high load conditions. Deficits reach 600 and 1,300 average megawatts in the medium-high and high respectively, before resource development can begin to catch up. It's not shown here, but studies have shown that even in medium-load conditions, the private utilities as a group may have difficulty in maintaining load/resource balance in the early to mid-1990s.

The data used to develop Figures 10-16 and 10-17 is available in Appendix 10-A. It has detailed information on the schedules for each conservation program and generating resource over the planning horizon, for each of the deterministic load forecasts. The appendix also has information on the timing of the decisions necessary to support these resource schedules.

The specific scenarios just presented are illustrations of the resources needed to meet load should a particular demand scenario occur. In fact, the likelihood is extremely small that any of these specific load paths, and the associated resource actions, will materialize. The actual portfolio analysis is conducted across a large number of load paths, and the resource schedules and decision making activity vary dynamically across the entire load range. One of the most important pieces of information about the portfolio is the timing of resource decisions required to maintain a reliable and low cost power system. Because portfolio studies are conducted across many load paths, it is possible to answer questions about the timing of decisions in probabilistic terms. For example, a resource developer might be interested in the likelihood of making acquisition decisions on geothermal energy by the year 1995. Results from the portfolio studies can be used to answer this type of question.

Figure 10-17
Private Utility
Resource Schedules





The timing and probability of decisions for the various types of generating resources were evaluated for the base case resource portfolio. Probabilities for making both option decisions and build or acquisition decisions were investigated. The results are shown in the three-dimensional surfaces of Figures 10-18 through 10-27. On these graphs, the horizontal axis represents time, the vertical axis is probability, and the axis going into the page represents energy. Both the probability and the energy are cumulative. These graphs can be used to answer questions about the probability that resource decisions will need to be made as a function of time and energy amount.

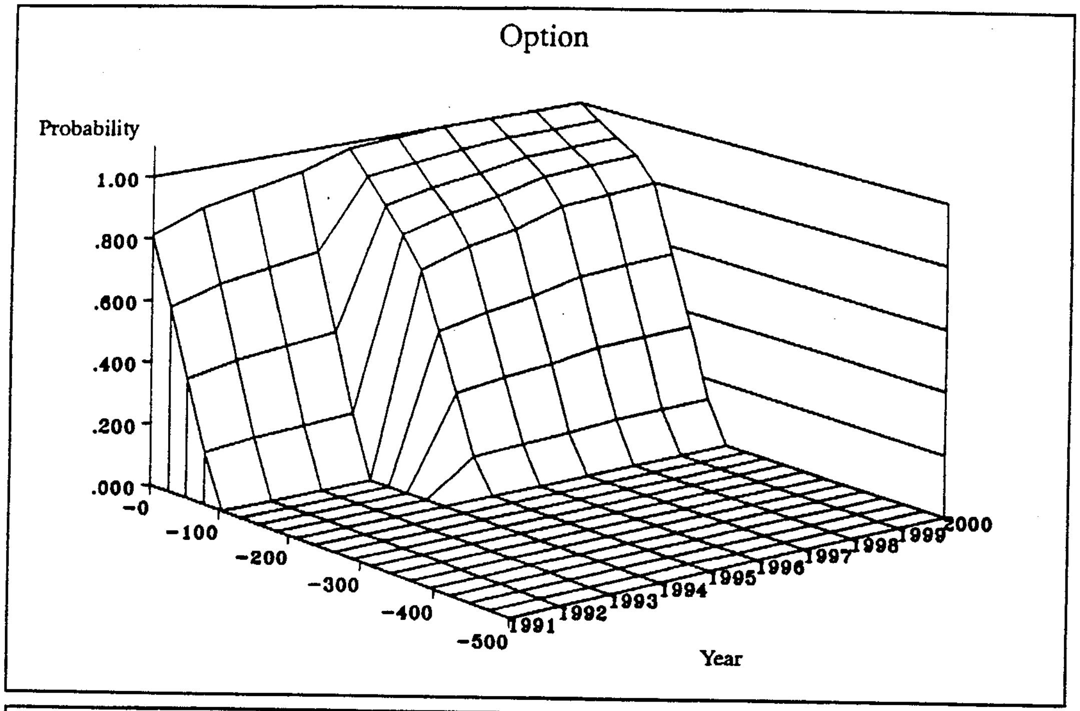
For example, Figure 10-19 describes the probability of option and acquisition decisions for combined-cycle combustion turbines, which are used as a surrogate for firming nonfirm hydroelectricity. From the graph, the probability that by 1991 at least 300 average megawatts from combined-cycle turbines needs to be optioned is over 80 percent, and the probability that at least 600 average megawatts is optioned is about 30 percent. The probability that by 1995 at least 1,200 average megawatts has been optioned is approximately 50 percent. The probability is zero that more than 1,800 average megawatts will be optioned until 1997. Figure 10-19 also shows the related build or acquisition decision probabilities for combined cycle. Because the turbines are modeled as having a two-year option lead time, no build decisions can take place before 1993. But in 1993 the probability of making build decisions on at least 300 average megawatts jumps to close to 40 percent. Comparing the combined-cycle option probabilities for 1991 and the build probabilities for 1993 reveals that in 80 percent of the load cases studied, at least 300 average megawatts was optioned in 1991 and in 40 percent of the cases all this energy was moved into construction in 1993.

The probabilities and energies represented in these surfaces are regional aggregates. The information is based on split-region studies, however in aggregating the data, decisions are not differentiated between Bonneville and the investor-owned utilities. The results reflect the combined decisions for both Bonneville and the investor-owned utilities. Many of the acquisition targets for generating resources in the Action Plan are based on this data. Typically the 50 percent probability level in 1995 was used to set the Action Plan target. For instance, the probability of having made acquisition decisions on at least 150 average megawatts is about 50 percent, and this is the Action Plan target for small hydro.

In reviewing the activities that the region is likely to be engaged in during the 1990s, the Council sees in the base resource portfolio that a large portion of the conservation resource is likely to be needed during the next 10 years. If loads grow above 1.0 percent per year, the region is likely to experience energy deficits during the mid 1990s. To deal with this, a wide variety of conservation and generating resources will be needed to get the region back in load resource balance by about the year 2000.

For this reason, the Council recommends beginning the process of identifying sites and obtaining necessary licenses and approvals for the resources that could be needed during the 1990s. On the other hand, to avoid overcommitting to these resources and creating another large surplus, the Council recommends that only conservation, system efficiency improvements, lowest cost hydropower and cogeneration facilities actually be acquired.

Figure 10–18
Option and Construction Decision Probability for Hydro Efficiency Improvements



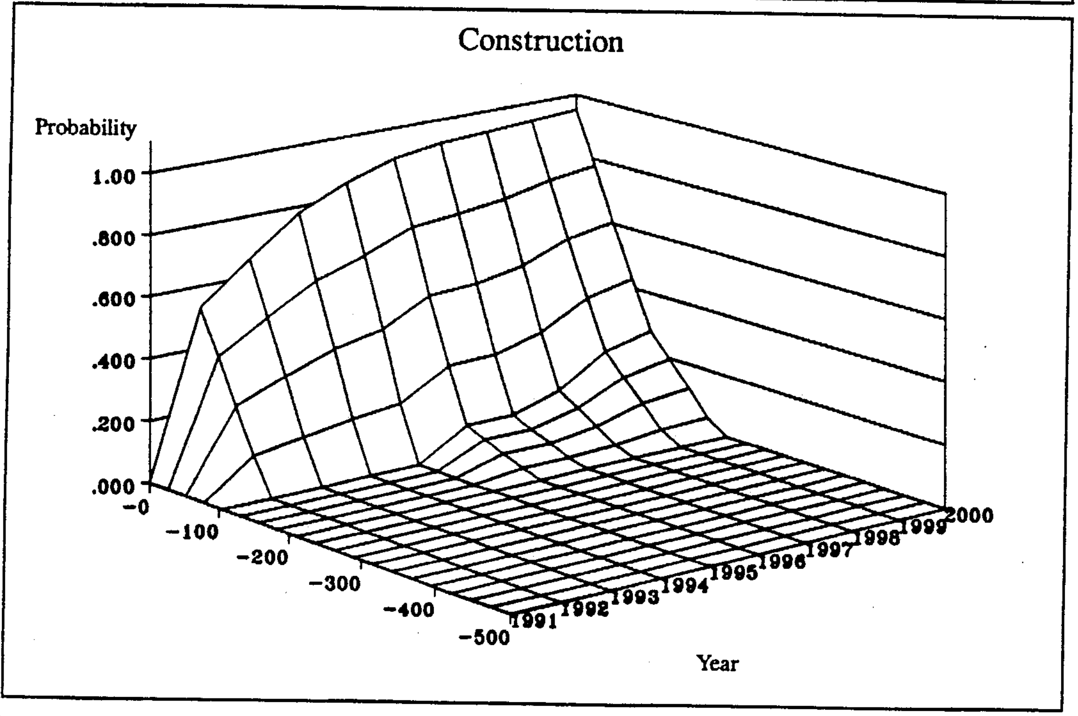
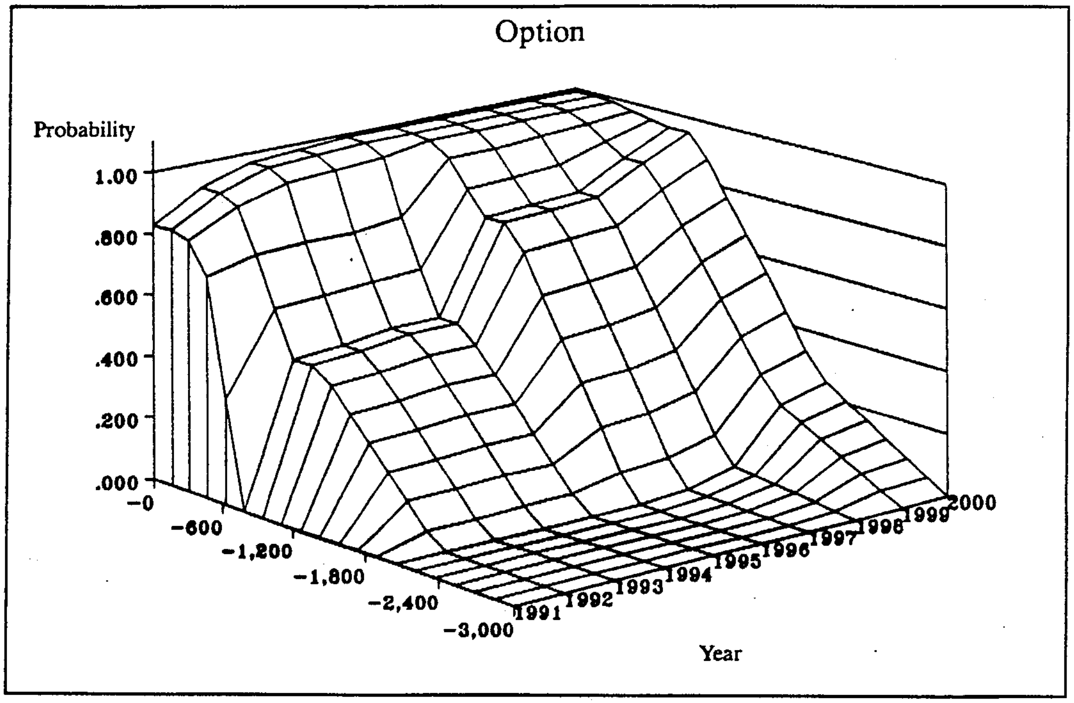


Figure 10-19
Option and Construction Decision Probability for Hydrofirming

Option



Construction

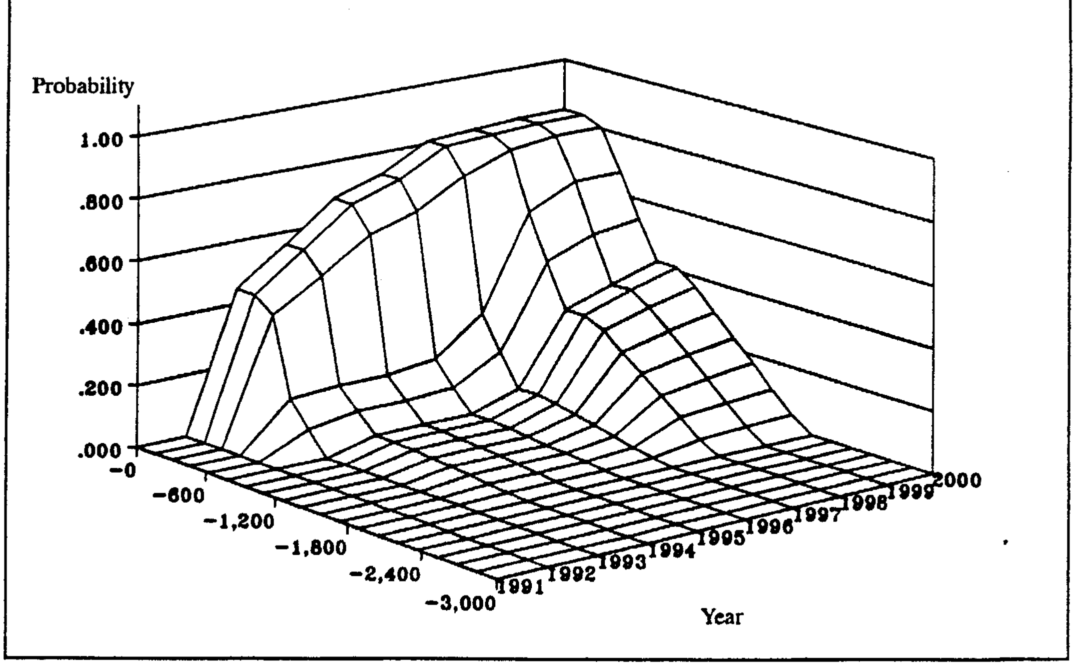


Figure 10–20
Option and Construction Decision Probability for Cogeneration

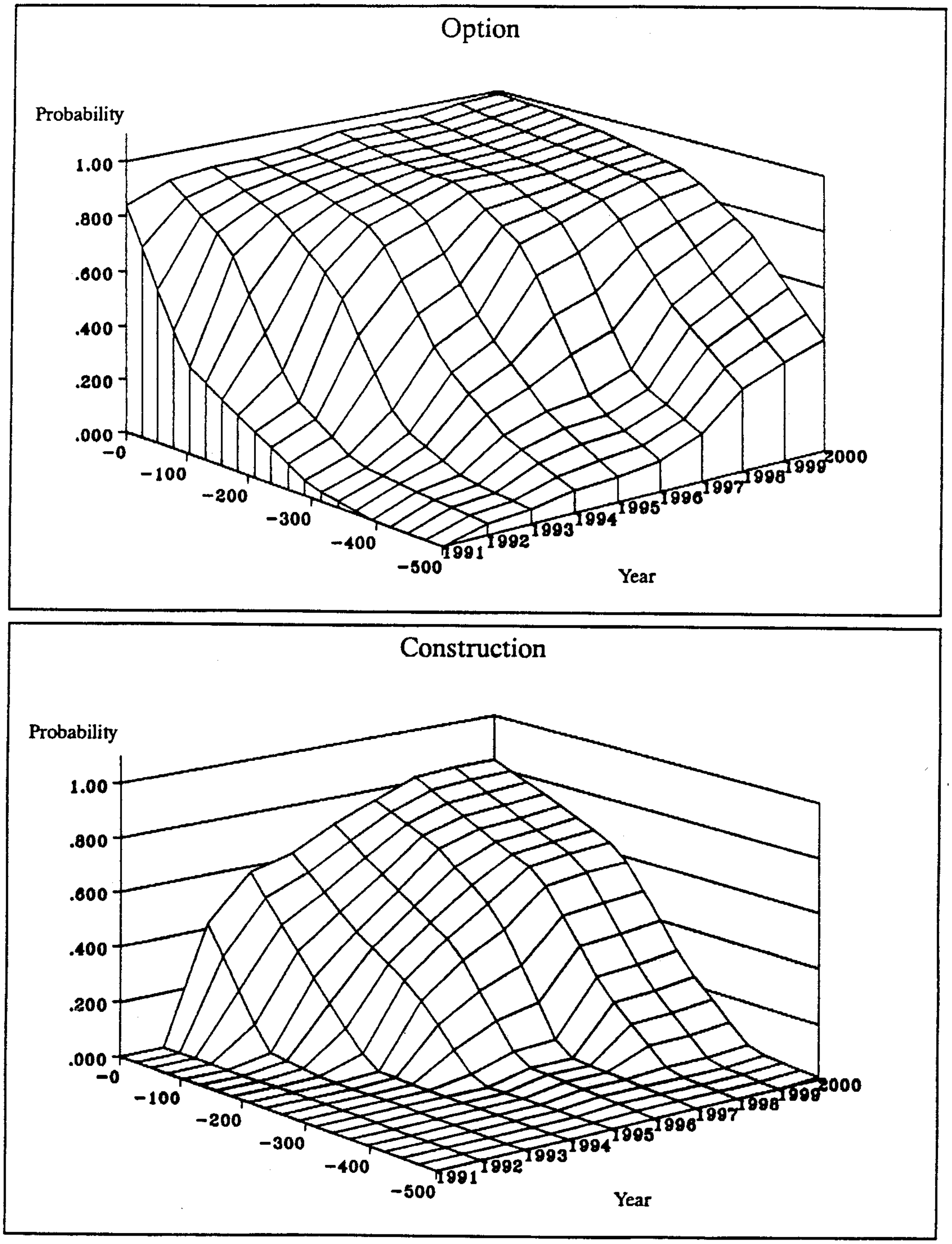
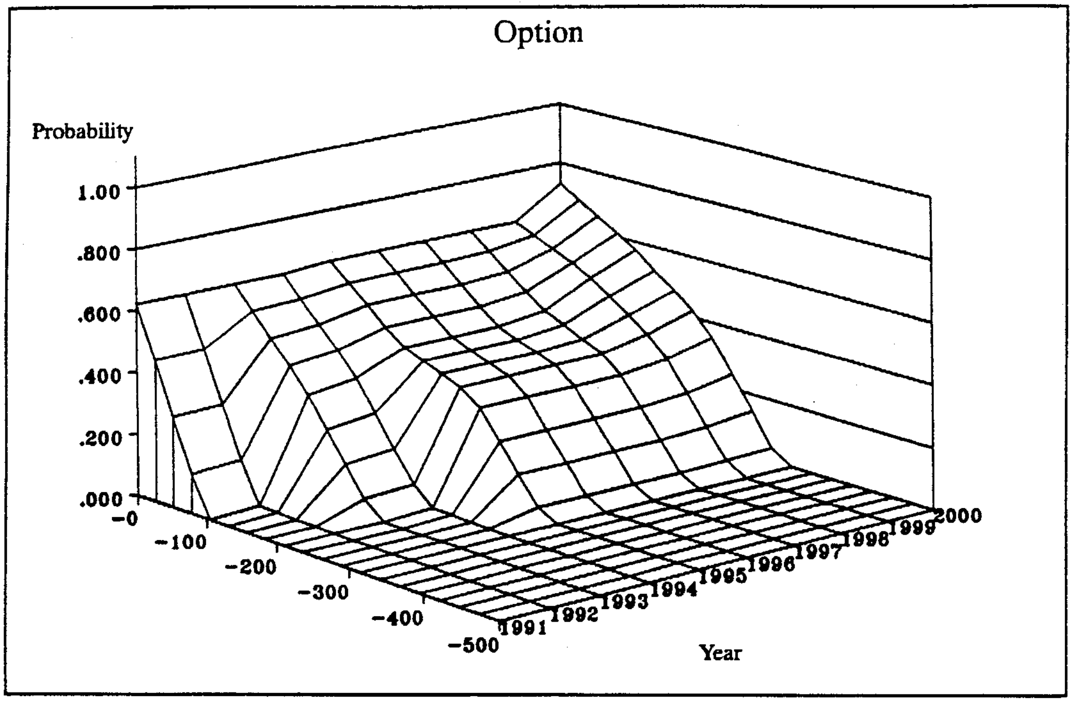


Figure 10-21
Option and Construction Decision Probability for Geothermal


Option

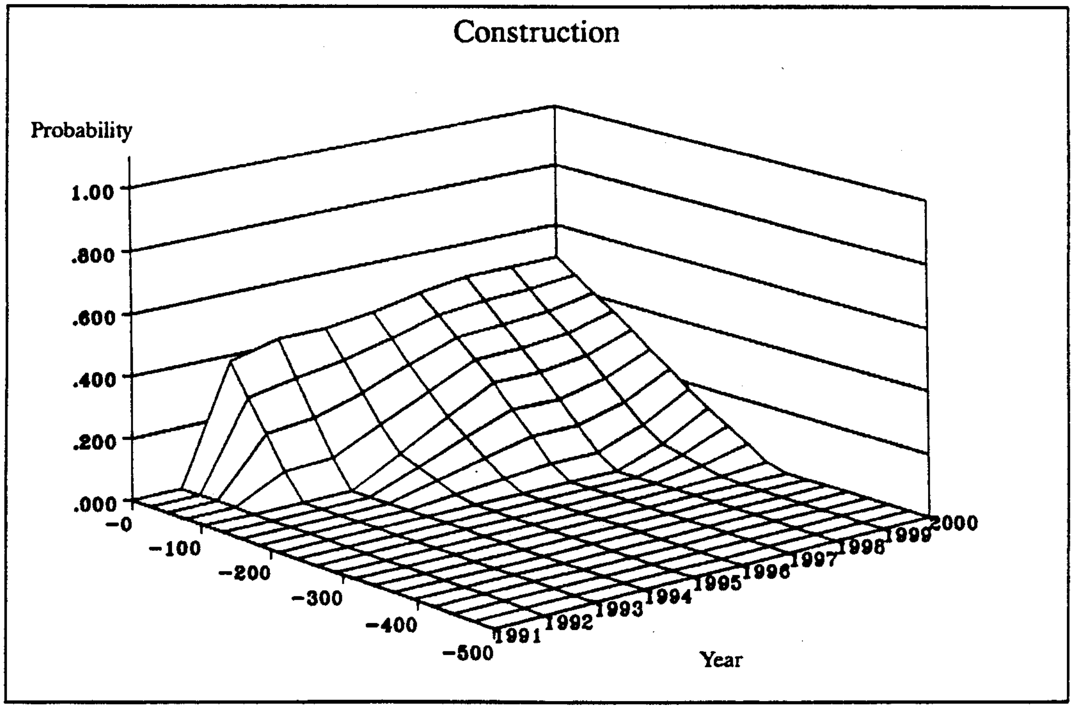
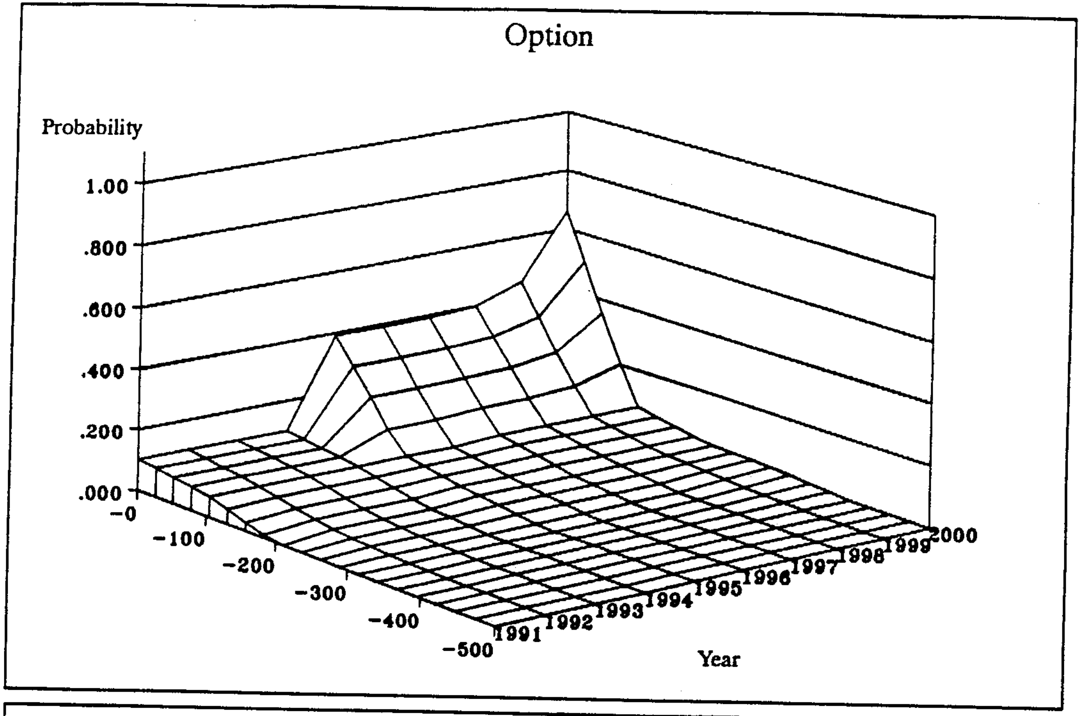
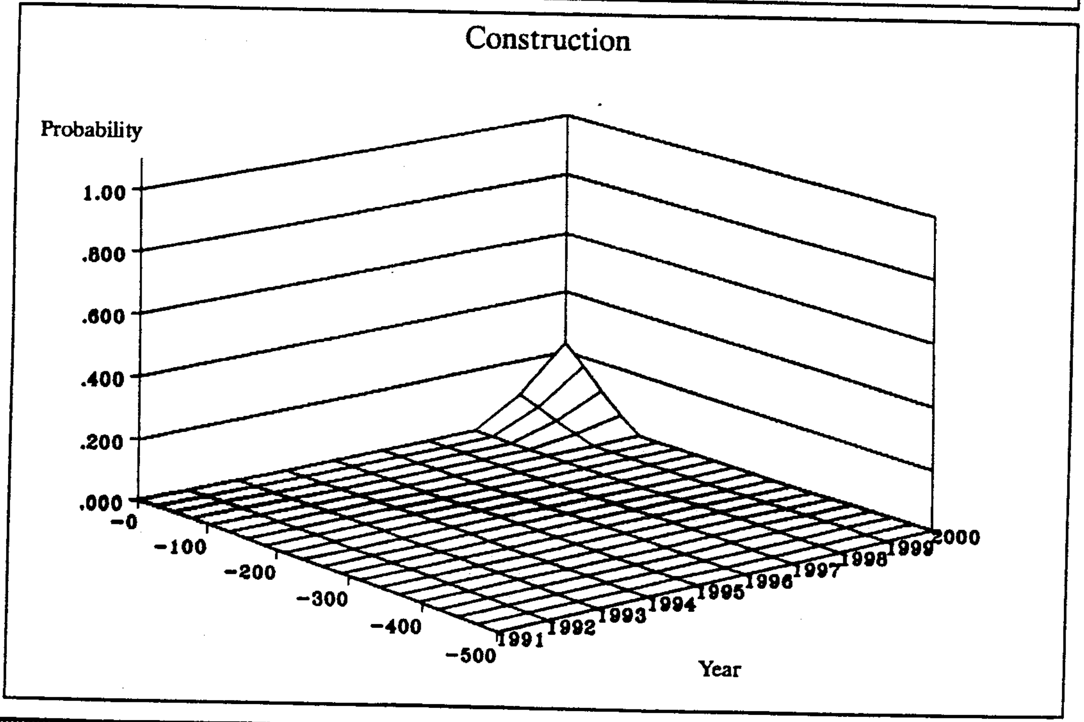

Construction

Figure 10-22
Option and Construction Decision Probability for Biomass and Municipal Solid Waste

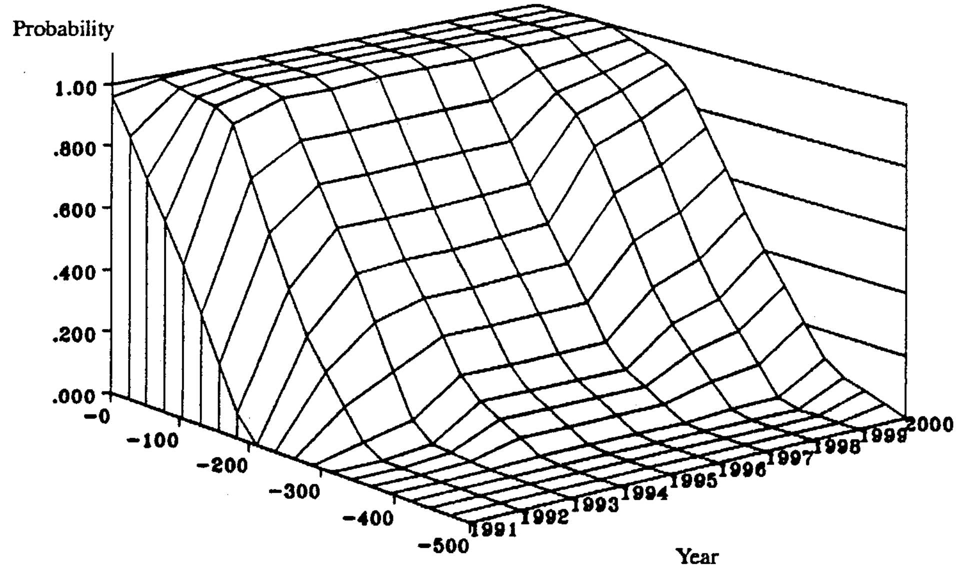




Need for Decisions

Figure 10-23
Option and Construction Decision Probability for Small Hydropower

Option



Construction

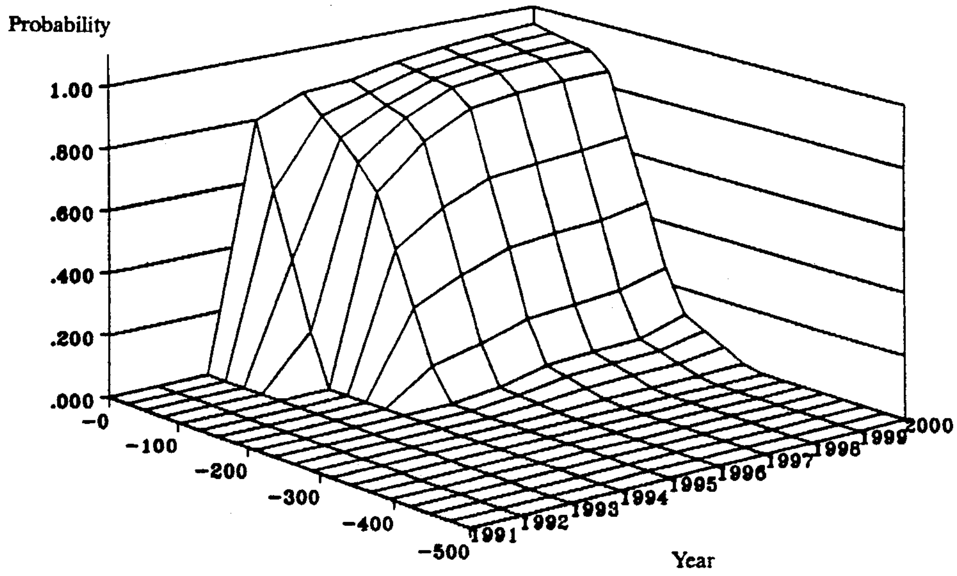
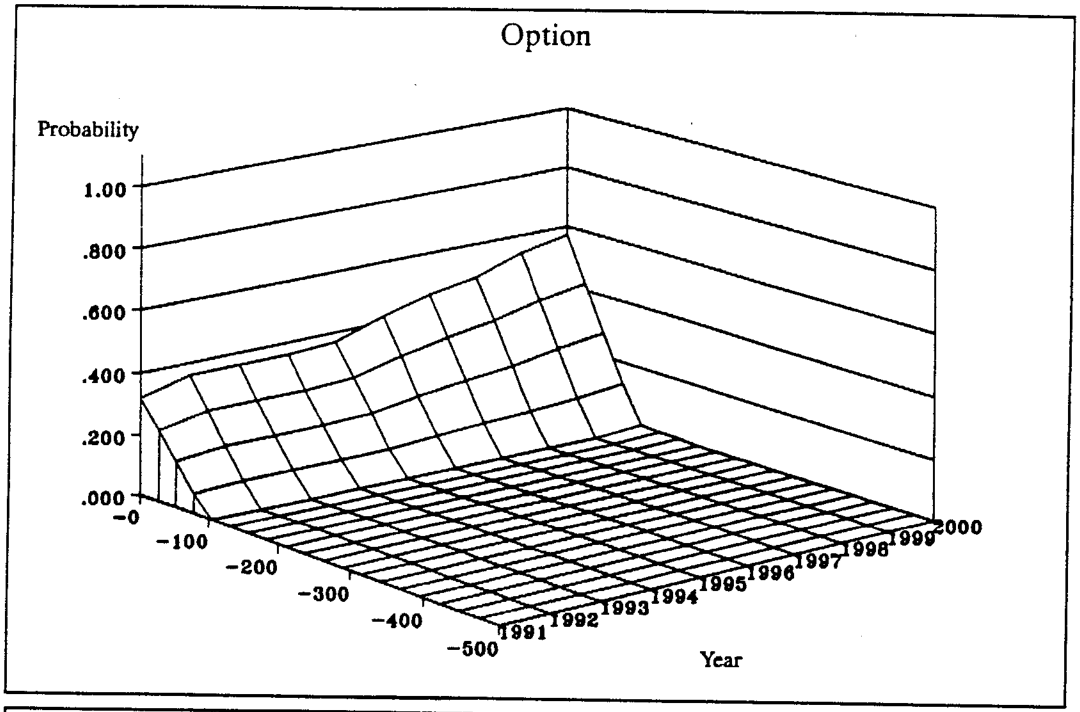
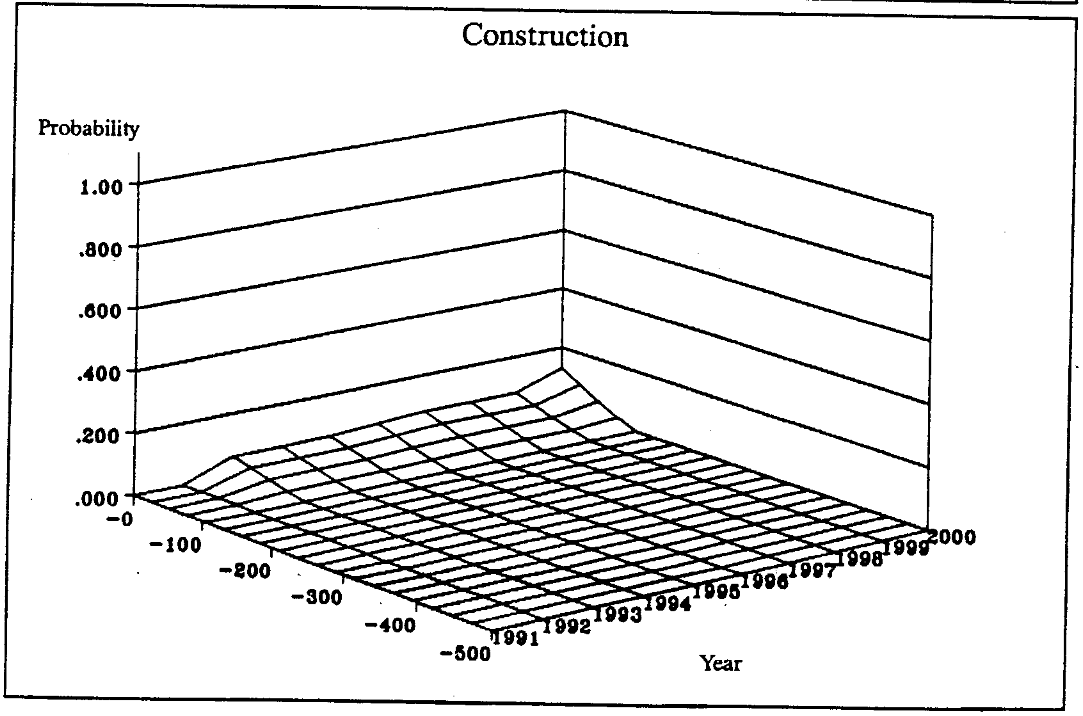


Figure 10-24
Option and Construction Decision Probability for Wind

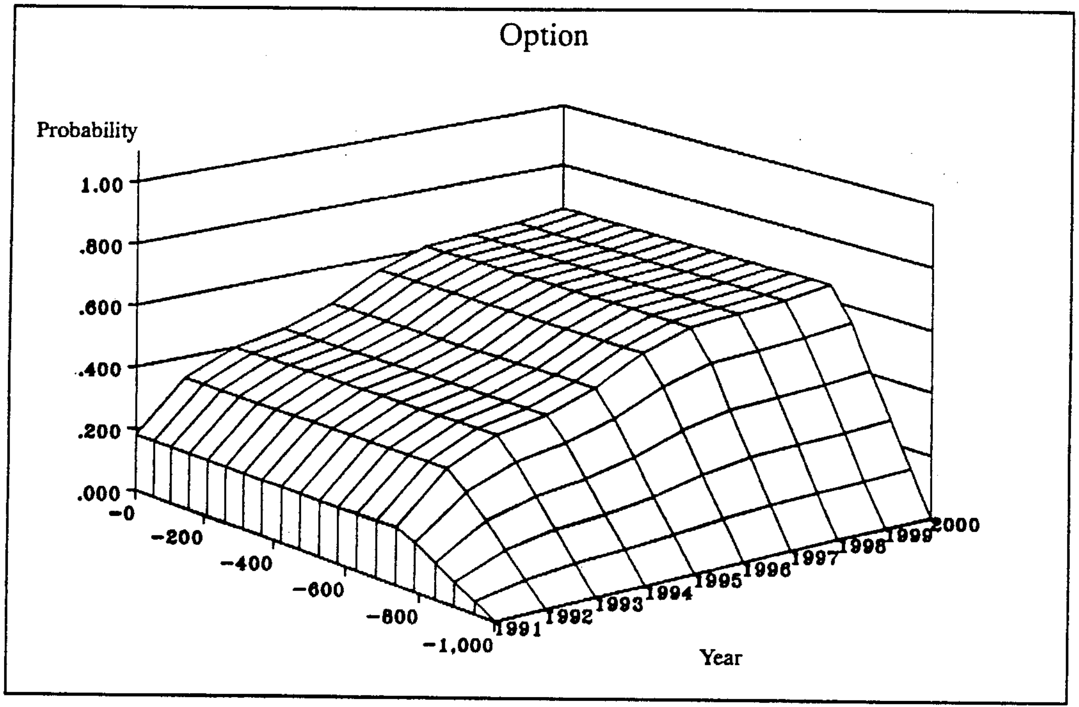




Need for Decisions

Figure 10–25
Option and Construction Decision Probability for WNP–3

Option



Construction

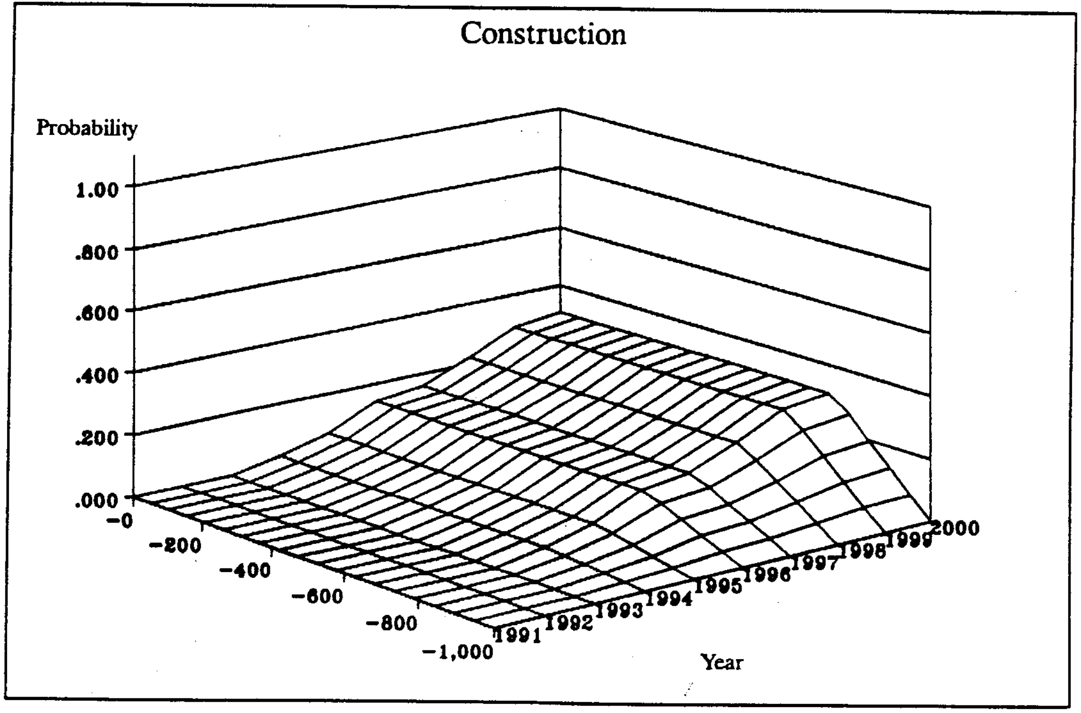
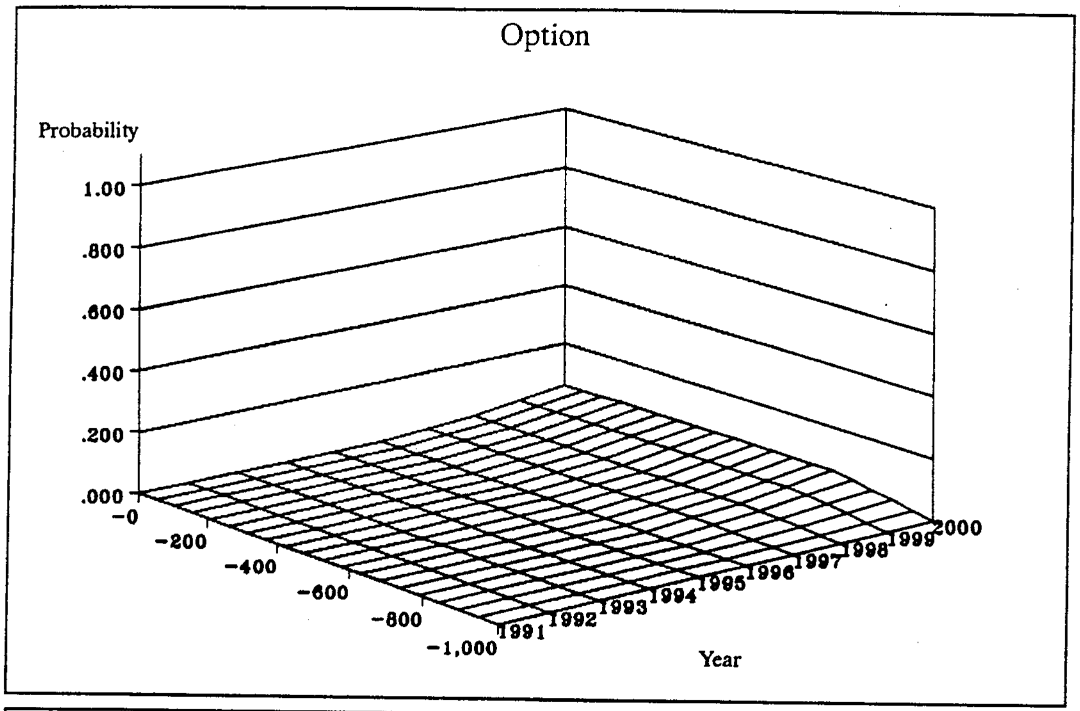
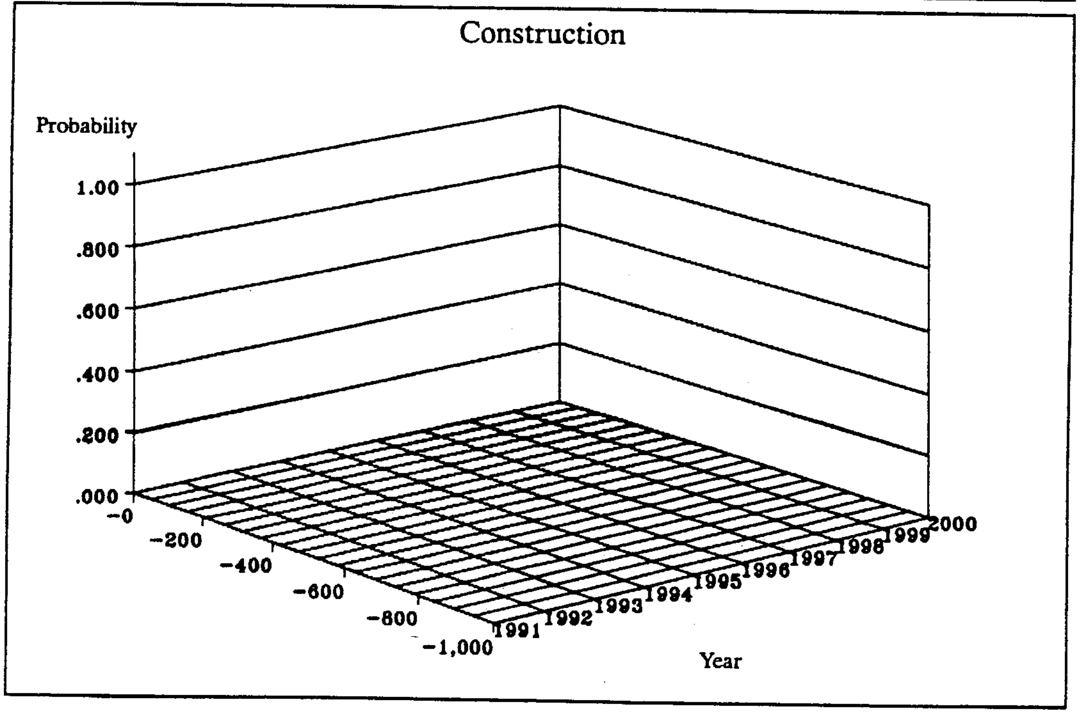


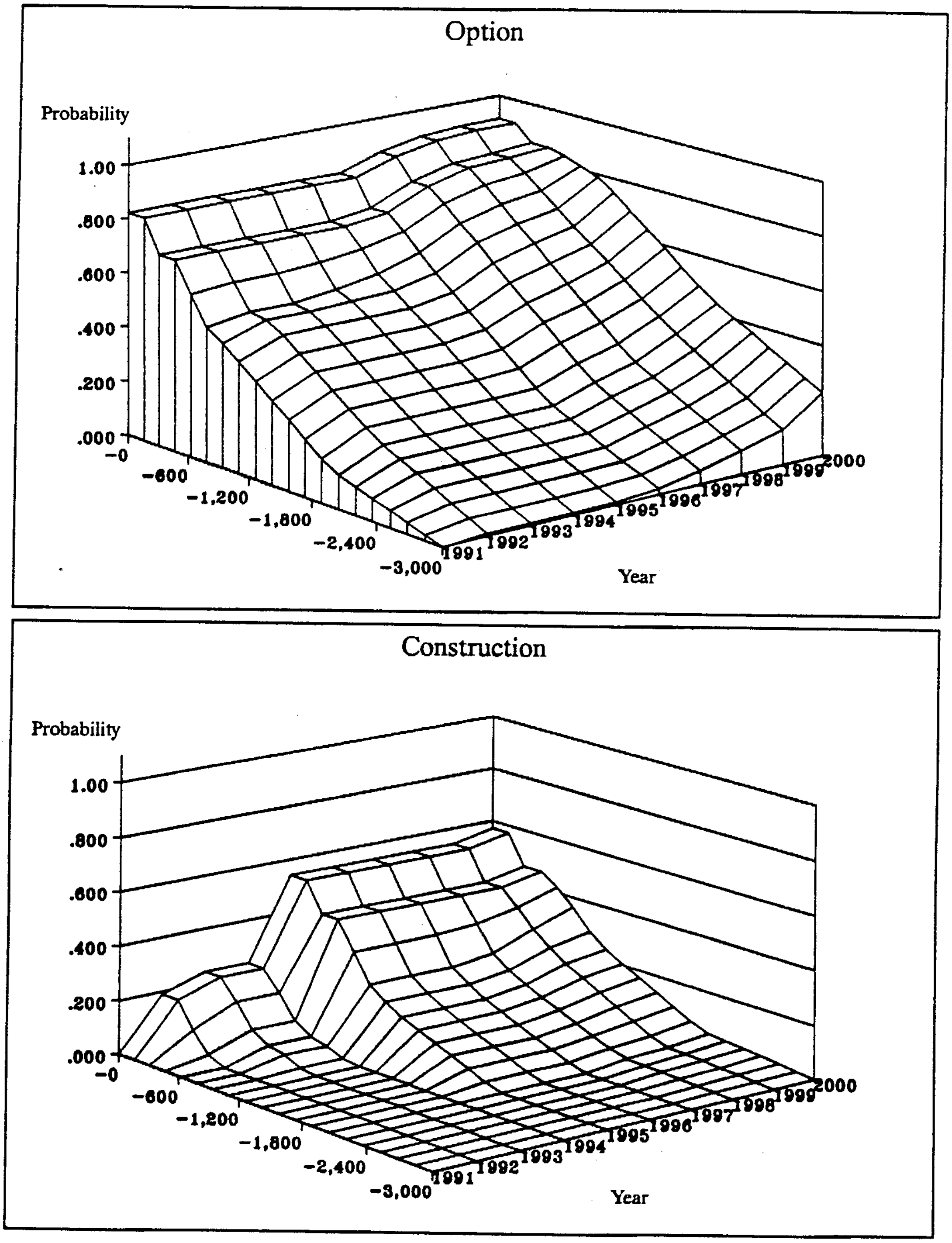
Figure 10-26
Option and Construction Decision Probability for WNP-1





Need for Decisions

Figure 10–27
Option and Construction Decision Probability for Coal



Resources Outside the Portfolio

The purpose of this section is to describe what it means for a resource to be included in the resource portfolio of the Council's 20-year power plan and, also, what it means for resources that are not in the portfolio. Since the Council's first power plan in 1983, there has been confusion about what the 20-year resource portfolio represents. The resource portfolio gets a lot of attention in the Council's planning, because it is the end result of months of issue papers and public comments on the building blocks of the plan. The issue papers lay out economic and demographic assumptions, financial assumptions for prospective resource developers, costs and availability and environmental values for all identified new resources, assumptions regarding existing resources, and so forth.

Because the resource portfolio is an important step in the Council's work and evolves over the entire planning process, it is natural to focus on the results. Resource developers look to the portfolio to find out what the plan recommends for their particular resource. However, as important as the resource portfolio is to the Council's plan, it is impossible for the plan to identify and anticipate all future resource alternatives. The resource portfolio in this light is a benchmark set of resources against which the Council can evaluate all future resources. No irreversible commitments are implied by the selection of a given resource portfolio. The Action Plan is the only place where the Council documents its preferred activities, many of which may involve irreversible commitments.

What Does the Resource Portfolio Represent?

The previous section discussed the information and models that go into the development of the 20-year resource portfolio. Resources with relatively well known characteristics are selected in the best chronological order to deliver power at the lowest cost over a range of future loads. The Council understands that resources in the portfolio may be different from those actually acquired over the next 20 years. The resources in the portfolio are those that are considered to be available and reliable today, and if a decision had to be made today for the next 20-years of resource acquisition, this portfolio probably would be the lowest cost, and least risky.

However, the only decisions that have to be made in the Power Plan are those near-term decisions necessary to acquire resources or decisions to build the capability to acquire a resource in the future. Capability can be developed through pilot programs, research and development, and options. The Council fully expects that other resources, through technological breakthroughs or better financing terms, for example, ultimately could be more desirable and, to the extent they are consistent with the plan, should be acquired in the future.[4]

4./ Resources appear in the portfolio because they are cost-effective, which includes an assessment of their reliability, availability, and compatibility with the region's power system. If other resources, not identified in the portfolio, but with similar characteristics, are brought forth, the Council will be prepared to determine their consistency with the plan.

Resources that are first in the portfolio clearly have a higher probability of being acquired than resources that are not needed until after the turn of the century, but even those first resources are not guaranteed to be acquired. What is true is that resources with the same or similar characteristics and with the same or lower costs should be acquired, assuming that need arises. The Council's resource portfolio is composed of known resources. For example, combustion turbines, single or combined cycle, are a well known source of power that fit well within the region's power system. If a different resource with similar characteristics and lower costs were offered in response to a bid to supply power, that resource would be selected, as it should be. We cannot identify such a resource at the present time; however, in the future there may be resources developed that may have all of the characteristics of combustion turbines at lower or similar costs.

Categories of Resources Not in the Resource Portfolio

Any resource not in the portfolio can compete with any resource in the portfolio on the grounds of cost, power characteristics, and environmental suitability. There are a number of reasons why resources are not included in the portfolio:

1. First and foremost are resources that are not cost-effective. The definition of cost-effective includes a finding that the resources are, or will be, reliable and available when they are needed.

2. Specific resources that can not be identified.

3. Out-of-region resources beyond what is currently under contract. This category is a special subset of category two.

Each of these categories of resources is discussed in somewhat more detail below.

Resources that are Not Cost-Effective

In order to be included in the resource portfolio, resources must be more effective at reducing the present-value cost of serving regional loads than competing resources. If a resource fails this test, it is deemed to be out of the portfolio on grounds of cost-effectiveness. In addition, there are some resources deemed by the Council to be too risky or environmentally sensitive. An example of the latter case is hydropower development on the many miles of streams the Council has included in protected areas.

However, in its analysis, the Council uses financial assumptions typical of public utilities, investor-owned utilities, and independent power producers. Clearly, not all developers within each category have access to capital at the same costs. To the extent that individual developers have access to low-cost capital, they may be better equipped to respond to a request for proposal.[5] Given that the resource being proposed satisfies all parts of the definition of cost-effectiveness and is compatible with the goals and objectives of the plan, that resource should be acquired, again regardless of whether it is contained in the resource portfolio.

Specific Resources that Cannot Currently be Identified

Some resources, such as cogeneration and small hydropower, are included in the plan based on rough estimates of how much is available and will be developed within certain estimated costs. There may be more, or less, than is assumed. In fact, we will not know how much will be developed until it happens. If our initial estimates were too low and there are more cost-effective resources in these categories, they should be acquired as needed.

Other resources in this category might include some portion of the renewable resources. Because all renewables are site specific and many await better characterization of the resource (wind, solar insolation, geothermal heat, etc.) that will drive electric generators, it is virtually impossible at this time to determine all of the possible resources that can and will be developed. The development of many of these resources awaits entrepreneurs willing to invest in spite of limited information about the driving renewable resources.

Resources from Out-of-Region Suppliers

Out-of-region resources play two roles in the Council's plan. First, they provide alternatives to the regional resources identified in the plan's supply curves and resource portfolio analysis. Second, they provide a source of emergency purchases in the case of firm deficits in the Council's portfolio analysis. These two roles are quite different and have different implications for the analysis underlying the plan. Each will be described in turn.

The role of regional resource alternative has been discussed in general terms above. New resources acquired over the next 20 years could include exchanges with and resource purchases from British Columbia, Alberta, California, the desert Southwest, Utah, and any other interconnected systems. Out-of-region resources, beyond those currently under contract, have not been specifically included in the resource portfolio. Out-of-region resources have not been included because 1) they cannot be identified at this time, and 2) if they could, there would be no good way of estimating the acquisition price and other terms and conditions of the agreements. However, based on past experience, there will be ample opportunity to negotiate cost-effective exchanges with connected systems. The Council is aware of the many opportunities that exist for utilities. Out-of-region resources should be secured if they cost less than those in the resource portfolio and are operationally and environmentally compatible.

5./ Developers typically can finance plants with a high percentage of debt capital. This can result in a private developer being able to build a resource at lower costs than, for example, an investor-owned utility, which is constrained to use no more than a certain fraction of debt capital.

Finally, there are about 15,000 megawatts of gas-fired generation in California, much of which is slated for retirement. The Council is including in its plan actions to begin the development of hydro-firming resources. California's gas-fired generation might be an alternative to construction of new plants in the Northwest. Negotiating with California to keep those resources in a ready state could result in lower costs than building new resources in the Northwest. Environmental considerations in southern California might interfere, however with the Northwest using California's gas-fired generation.

The second role, that of a source of emergency purchases, is more complex to describe. In the computer modeling for the Council's portfolio analysis there are occasions on which lead-time constraints do not allow sufficient resources to be acquired to meet firm loads. In those cases, either or both of a supply of emergency purchases and an imputed cost of load curtailment are necessary in order to calculate a cost to that event. The cost is necessary because a resource strategy that consistently undershoots load because of, for example, long lead times should be penalized in terms comparable to the other costs that it incurs, such as capital and fuel costs.

The magnitude of these costs, emergency supply and cost of failure to meet load, affect the option and build levels that are appropriate for the Northwest power system. (The role of option and build levels is described further in the discussion about the Council's decision model.) High costs imply that higher option inventories and building ahead of perceived need are best; low costs imply that it is economic to take chances with underbuilding because the consequences are slight.

The Council conducted a preliminary investigation of sources of emergency purchases and concluded that approximately 1,500 megawatts, broken up into three 500 megawatt blocks (at 3.0, 3.5 and 4.0 cents per kilowatt hour in real terms) was reasonable for the limited purposes of modeling the resource portfolio. If further investigation indicates that a reliable emergency supply exists, the Council may wish to include short-term purchases in the future as a regular component of the resource portfolio, on which the region could rely to substitute for firm resources.

Summary

This section is intended to clarify some of the misunderstanding about the role of the resource portfolio in the Council's plan. Readers should not go away with the idea that the resource portfolio is unimportant. The process of developing the resource portfolio forms the basis for the Council's Action Plan and for the Council's future determinations of whether alternative resources are consistent with its plan. Resources in the portfolio and those categories of resources not included are all addressed in the Action Plan. For example, the Action Plan may include guidance to take actions to ensure that promising resources ultimately can be competitive with resources in the portfolio. These actions are influenced by what is learned about resource compatibility and costs in the system analyses.

All planning proceeds from what we currently know. The goal of good planning is to be able to react to unforeseen events, both good and bad.

Reliable, compatible, environmentally sound, and lowest-cost resources always should be chosen, wherever they are found.

Analysis of Alternative Scenarios

The Council realizes that many of the assumptions that underlie the draft plan will turn out to be different than we forecast them today. Some of these uncertainties, such as load growth and hydro conditions, are treated explicitly in the portfolio modeling. Other uncertainties, such as future fuel prices, environmental effects, and ultimate resource supply, are not incorporated directly into the analysis, but can have a large impact on resource decisions. While the Council believes that the data development process has produced reasonable and balanced estimates for input into the modeling process, there is little question that a large range of uncertainty exists around many of the important parameters in power planning.

To gain insight into the effect of some of these uncertainties, the Council examined the consequences of a variety of alternative future scenarios and their potential impact on the portfolio. The ramifications of each alternative scenario were analyzed, discussed and debated. The purpose of the exercise is to explore the limits of the region's energy future. These exploratory studies can help to identify the more significant risks facing the region and identify actions that help manage this risk. Some actions are robust. That is, they can work over a wide range of uncertainty to mitigate risk. It's important to identify these actions and incorporate them into the Action Plan.

Alternative Scenarios

In developing the following scenarios, the Council modified two types of assumptions. The first dealt with the level of constraint to development of thermal resources that might be encountered in the region. In order to meet load under the medium-high and high demand scenarios, the Council projects that significant amounts of new large thermal resources would be required. There are significant questions concerning the feasibility of developing this amount of new thermal resource. To address this question, the Council evaluated the impact of increasing delays or constraints to construction above and beyond that embodied in the base portfolio. The response to these constraints typically was expressed through a change in the resource development order from the base case portfolio.

The other type of assumption change dealt with an attribute or outcome of some aspect of the future over which we have little control. It is simply an outcome of an uncertain event. An example would be a large unexpected change in fuel prices. The following scenarios and portfolio attributes generally change one type of assumption or the other. However, the fuel price sensitivities discussed below change both types of assumption. Instead of attempting to predict the likelihood of these scenarios, the Council focused primarily on plausible conditions under which our energy future could be changed. Table 10-4 summarizes the alternative future scenarios examined in this process, and they are discussed below.

Base Case

The base case portfolio for these studies is very similar to the resource portfolio described earlier in this chapter. It was an earlier repetition of the least-cost resource portfolio, before adjustments were made for forcing conservation to the medium-high schedule, and other adjustments to the costs of some resources. It exhibits a wide variety of resource development depending on the particular needs of the region over the next 20 years.

While this portfolio is commonly referred to as least cost, this is an oversimplification of the process through which the Council develops the base case resource portfolio. Throughout the process, the Council reviews and evaluates the recommended assumptions for each resource and modifies the resource planning assumptions appropriately. These modifications may incorporate significant siting or design changes that are more likely to make the resource acceptable, reliable and available. The Council frequently incorporates technological improvements that reduce the environmental impact of a resource. The base case resource portfolio also includes judgments of the amount of each resource that is likely to be available. In specific cases, such as protected areas for hydropower and in the case of the number of coal-fired power plants, the Council has limited the resources available.

Sixty-Percent Penetration for Conservation

One of the sensitivities addressed the question, "What if conservation programs are not as effective as the Council assumes?" Obviously, if conservation is not as effective, other resources are needed sooner. In looking at this sensitivity, it was apparent that if conservation programs achieve only 60-percent penetration of each market sector, instead of the 85 percent assumed in the base case, significant amounts of additional generating resources will be needed on an accelerated schedule. The cost impacts of a failure of conservation acquisitions to deliver 85 percent were estimated to be $1.6 billion in present value greater than in the base case resource portfolio. This value is the expected value of a distribution of cost impacts that ranges from $900 million to $2.7 billion (see Figure 10-28). Failure for the region to achieve a high penetration rate of cost-effective conservation measures throughout the Northwest economy will be very costly. At the same time, if the Council's estimates of conservation savings cannot be achieved, alternative resources need to be available to maintain a reliable power system.

Existing Resource Loss

Questions have been asked about the effect of the potential loss of an existing system resource. To evaluate this event, the Council assumed that a 730 average megawatt thermal resource in the region suddenly was shut down. The cost impact of losing this amount of energy from the existing power system was estimated to be $1.6 billion. The distribution of cost impacts is shown in Figure 10-29. Loss of significant amounts of energy from the existing power system is likely to be very expensive to replace, and a significant amount of lead time will be needed in order to develop the resources that would replace the loss. The ultimate requirements for additional resource acquisition depend on the load scenario encountered, but the probability of need for high cost renewables and large thermal resources increases significantly over the base case.

Twenty-five Percent Coal Tax

The Council also looked at the cost impacts on the resource portfolio of a 25-percent increase in the cost of coal due to a carbon tax. This tax would impact on all coal-fired resources and would, therefore, increase the fuel component of the energy production from these facilities. The draft resource portfolio incorporates almost 5,000 megawatts of available coal, and these are needed in high-load cases. In these cases, the cost of fuel for most of these plants would be increased. This sensitivity study showed that the expected cost of the region's portfolio would increase by $350 million, if there were a 25 percent coal tax (see Figure 10-30).

1,000 Megawatts of Geothermal

The Council incorporated 300 megawatts of geothermal resources in the base case resource portfolio. Many people have argued that the geothermal resource in the Cascade mountains is significantly larger. The Council evaluated the impact of confirmation of an additional 1,000 megawatts of geothermal energy through the demonstration projects. Cost estimates used for this additional energy were the same as that used for the commercial projects in the base portfolio. This sensitivity study reduced the costs of the base portfolio by $163 million (see Figure 10-31). It also produces a moderate reduction in the probability of need for the higher cost coal plants.

Slight Thermal Delay

This scenario assumes that problems continue with resolving the barriers to completing WNP-1 and WNP-3. Because of delays in the availability of WNP-1 and WNP-3, higher cost gas-fired cogeneration and hydrofirming resources need to be moved up to displace the need for WNP-1 and WNP-3. The acceleration of these resources and the displacement of the plants to a later location in the resource portfolio increases the expected costs for the region of this resource portfolio by about $100 million. The distribution of the cost differences is shown in Figure 10-32. As a fallout of this scenario, the region becomes more dependent on gas-fired technologies. This increased dependence on gas exposes the region to higher levels of economic risk if gas prices escalate quickly or if natural gas availability becomes a problem. A further variation of this portfolio examined the impact of rapidly escalating natural gas prices at rates comparable to the Council's highest gas price escalation rate. If this occurred, the cost to the region is expected to be significantly higher, about $1.66 billion over the base case. Alternatively, if this strategy were pursued and gas prices escalated at rates near the Council's low natural gas price forecast, the region would be better off by about $380 million over the base resource portfolio strategy.

Moderate Thermal Delay

If the difficulties with removing the barriers to completing WNP-1 and WNP-3 continue, then additional resources need to be moved up in order to meet regional energy needs. These resources include the moderately expensive hydropower blocks, geothermal and wind, in addition to the turbines and cogeneration moved up in the previous scenario. Moving up these resources in the resource portfolio increases the expected costs of the resource portfolio by about $300 million. While the cost increase is moderate, the Council was concerned with the availability and predictability of these resources. If these resources are not available to displace the need for WNP-1 and WNP-3, regional costs could be significantly higher. Figure 10-33 shows the cost distribution for this scenario.

Extended Thermal Delay

If in addition to the delays surrounding the WNP-1 and WNP-3 plants, the region also has significant difficulty in siting, licensing and constructing new coal-fired resources, there is a need for moving even higher-cost resources forward in the region's resource portfolio. In addition, the region would need to accelerate the most expensive blocks of cogeneration, small hydro, and wind. As shown by Figure 10-34, this scenario is expected to cost about $500 million more than the base resource portfolio. Even with all of these changes, there is still a significant probability of need for actions on large thermal before 2000.

Maximum Thermal Delay

The Council looked at a scenario that ignored the cost-effectiveness of portfolio resources and focused efforts on delaying thermal resource decisions as long as possible. To do this, the Council assumed that hydropower, geothermal and wind resources are developed as needed to meet the region's load growth. Following these resources, the gas-fired technologies are acquired, primarily cogeneration and the use of combustion turbines to backup nonfirm. These resources have shorter lead times and are smaller than the larger thermal power stations that follow. Finally, if loads continue to grow, WNP-1 and WNP-3 and the 5,000 megawatts of available coal are developed. This resource scenario has an expected cost increase over the base portfolio of about $1.8 billion (see Figure 10-35). Most of this impact is due to the fact that higher-cost resources are acquired much earlier. While thermal resources could be delayed if loads grow at above the medium scenario, thermal resources still are likely to be needed before 2010.

Loss of WNP-1 and WNP-3

The question frequently is asked, "What is the impact if WNP-1 and WNP-3 are not available?" In evaluating this sensitivity study, WNP-1 and WNP-3 were removed from the Council's resource portfolio. If these resources are lost to the region, the cost of the resource portfolio increased by about $300 million (see Figure 10-36). Other thermal resources need to move forward in time, in order to displace the 1,600 megawatts that could be available from WNP-1 and WNP-3.

Coal and Nuclear are Banned

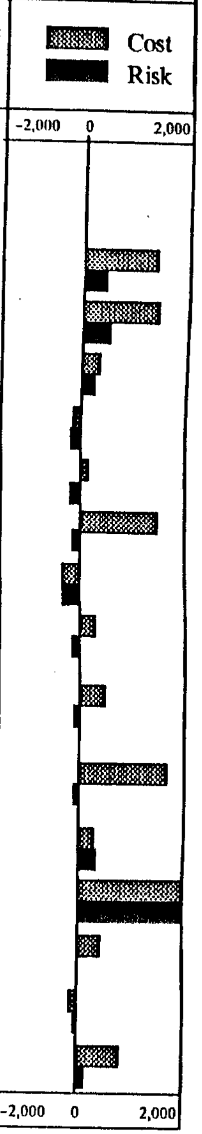
The Council wanted to know how capably the region's resource portfolio could respond to a ban on the development of coal and nuclear power plants. A study was done removing the 1,600 megawatts of WNP-1 and WNP-3 and approximately 5,000 megawatts of new coal-fired resources from the resource portfolio. This is a large enough shock that the portfolio was unable to compensate for the loss of such a large portion of the available generating resources. In this event, in load growth cases above the medium, the region maintains a large energy deficit. This essentially simulates a movement away from the critical water reliability standard the region currently uses. If this occurs, the cost of the region's resource portfolio increased by $4.9 billion over the base case resource portfolio. This large cost increase was due primarily to emergency purchases of electric power from outside the region. If this power was unavailable, then curtailment strategies would need to be implemented. The $4.9 billion estimate from Figure 10-37 does not incorporate costs of these curtailment strategies to society.

Concerns with Reliance on Gas

If there are perceptions that heavy reliance on combustion turbines and gas fired cogeneration is too risky a path, due to concerns about long-term fuel price or availability, there could be significant resistance to development of these resources. One alternative would be to rely more heavily on nuclear and coal resources. If WNP-3, WNP-1 and the first block of coal are moved ahead of the first blocks of turbines and cogeneration, the expected cost under the base case fuel price assumptions is about $460 million. However, if large thermal resources were emphasized over gas-fired resources and high natural gas prices were to materialize, this strategy produces a cost improvement over the base portfolio strategy of $160 million. Alternatively, if low gas prices occur, this strategy produces an expected value that's $900 million more expensive than the base portfolio where gas-fired resources have a higher priority.

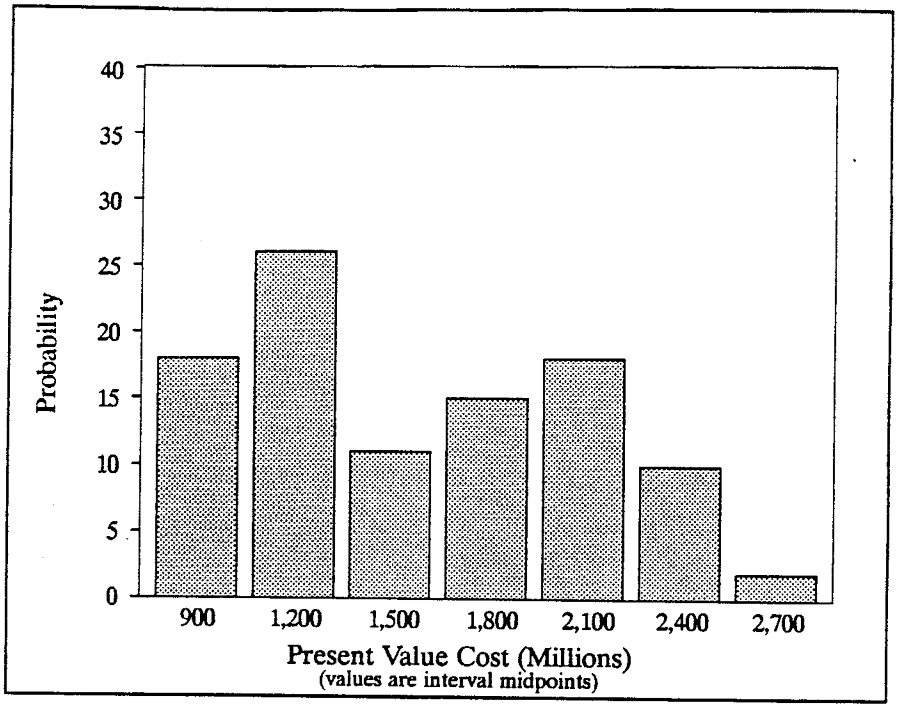
Table 10–4
Alternative Resource Portfolios

Scenario	Thermal Constraints	Resource Emphasis	Other Events	Relative Cost (Present Value millions $)	Relative Risk (Present Value millions $)
1	Base Case Assumptions	Least Cost	Base Case Assumptions	0	0
2			60% Conservation Penetration	1,560	470
3			Lose 730 MW of Existing Resource	1,580	560
4			25% Carbon Tax on Coal	350	260
5			1,000 MW More Geothermal	-160	-230
6	Slight Delay	Advance Gas Turbines and Cogeneration	Base Case	100	-200
7			High Gas Prices	1,660	-180
8			Low Gas Prices	-400	-380
9	Moderate Delay	Advance Turbines, Cogeneration and Some Renewables	Base Case	300	-150
10	Extended Delay	Advance Turbines, Cogeneration and Most Renewables	Base Case	510	-80
11	Maximum Delay	Conservation, Renewables and High Efficiency Before Large Thermal	Base Case	1,860	-100
12	WNP-1 and WNP-3 Unavailable	All Non-Nuclear	Base Case	300	390
13	Nuclear and Coal Unavailable	All Other Resources Acquired	Base Case	4,900	4,950
14	Concerns with Reliance on Gas	Advance WNP-3, WNP-1 and Coal	Base Case	460	-10
15			High Gas Prices	-160	-40
16			Low Gas Prices	900	130



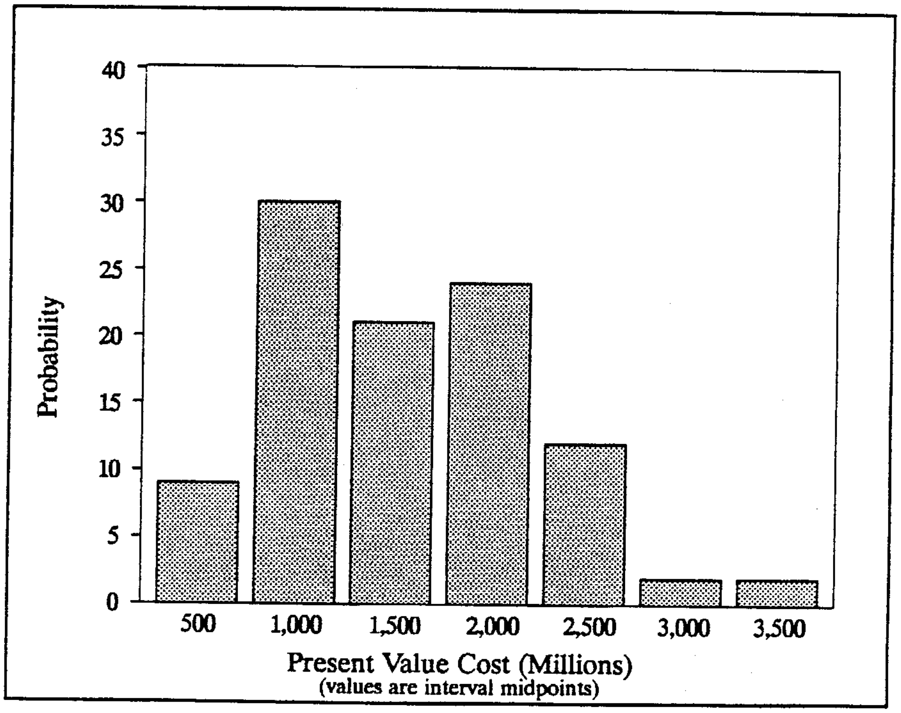
Cost Impacts

Figure 10–28
60–Percent Conservation Penetration



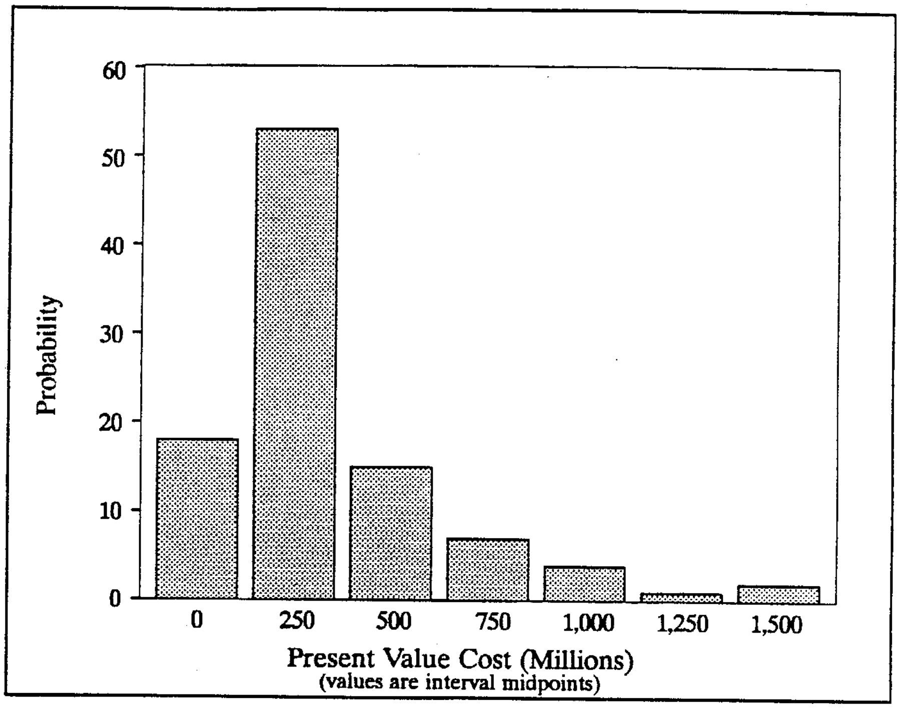
Cost Impacts

Figure 10–29
Losing an Existing Resource



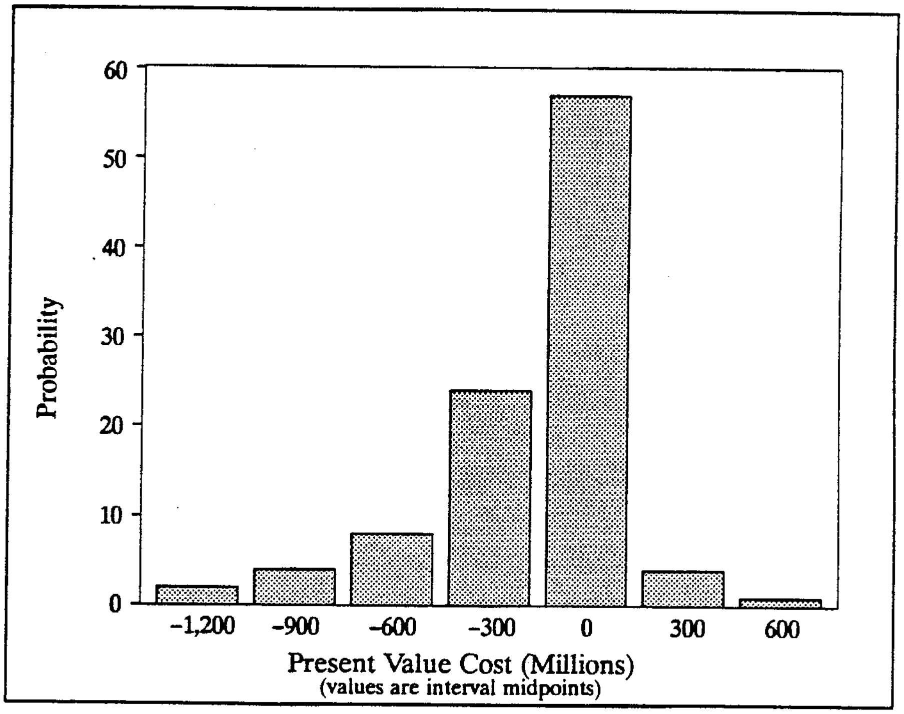
Cost Impacts

Figure 10–30
Carbon Tax
on Coal



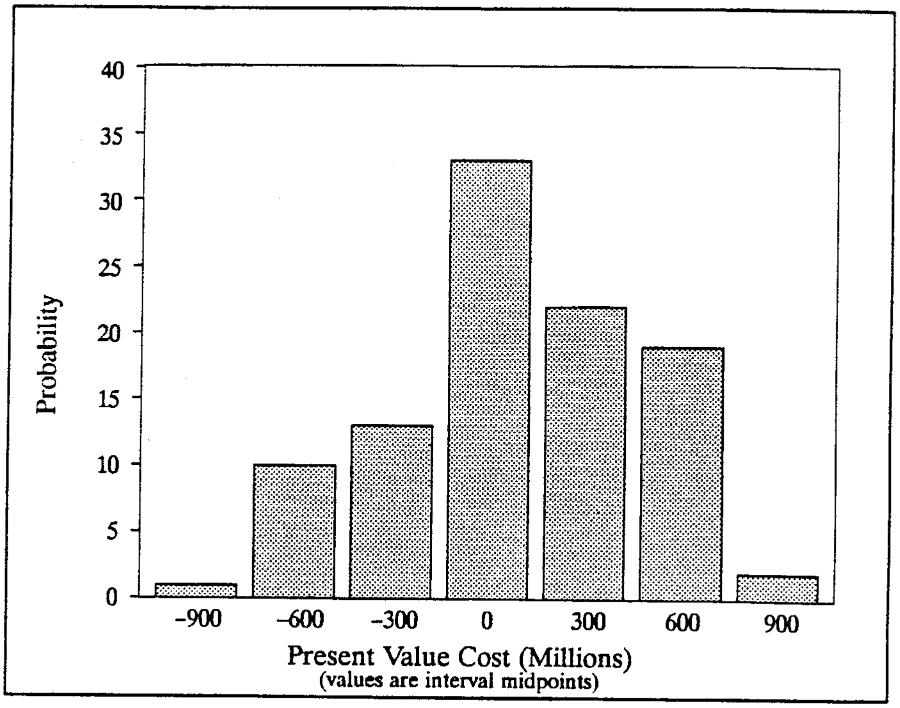
Cost Impacts

Figure 10–31
Increased
Geothermal Supply



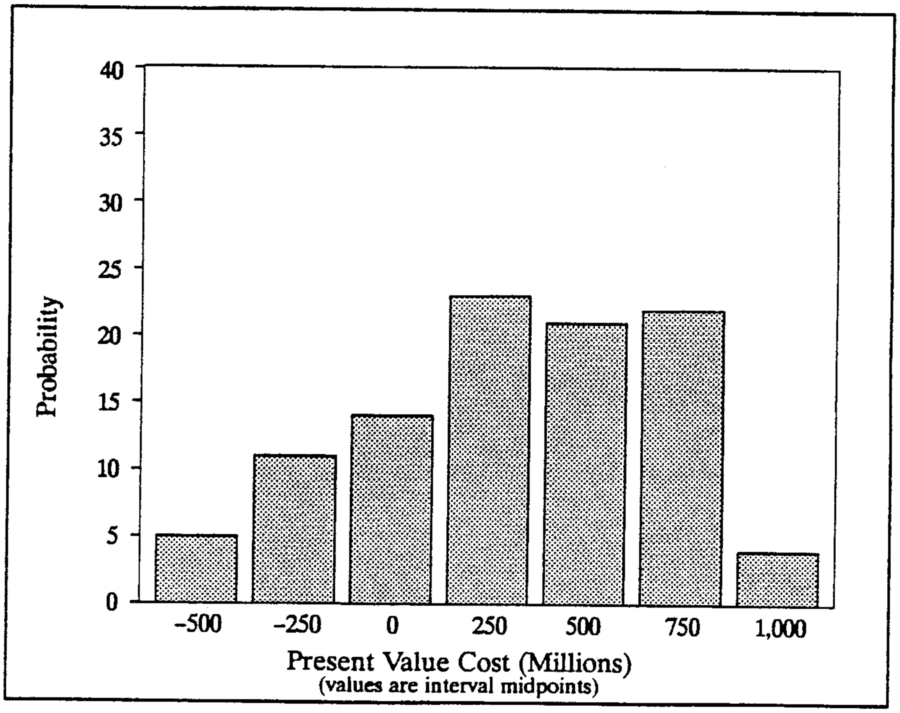
Cost Impacts

Figure 10–32
Slight Thermal Delay



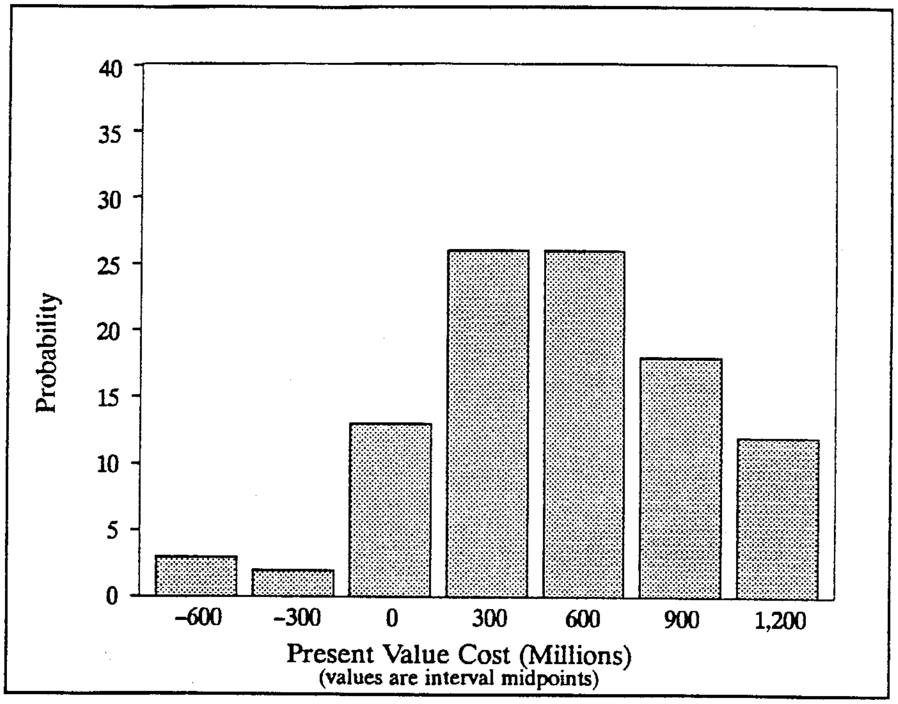
Cost Impacts

Figure 10–33
Moderate Thermal Delay



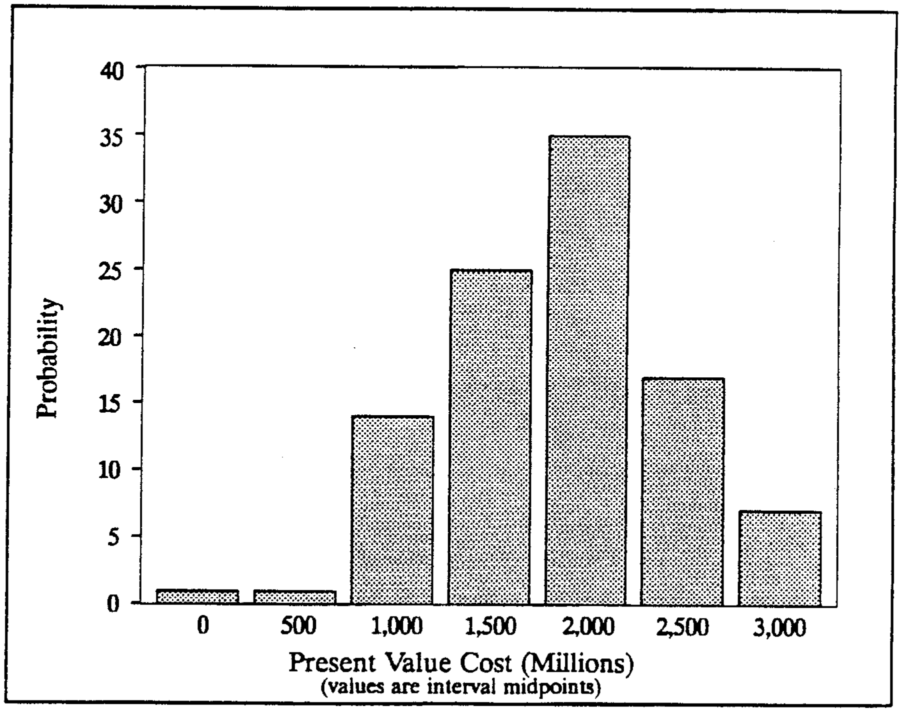
Cost Impacts

Figure 10–34
Extended Thermal Delay



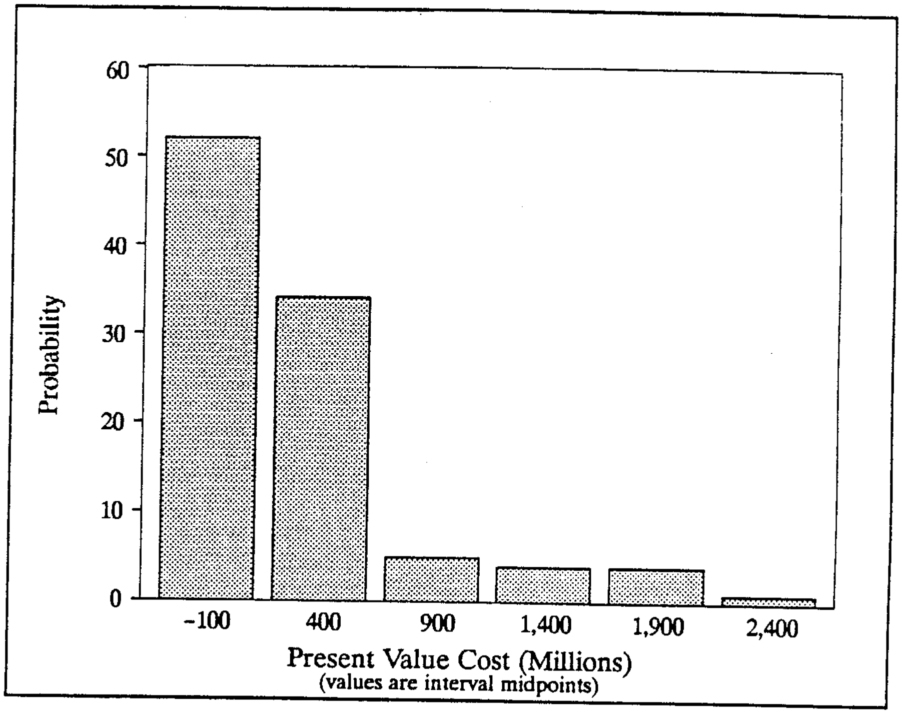
Cost Impacts

Figure 10–35
Maximum Thermal Delay



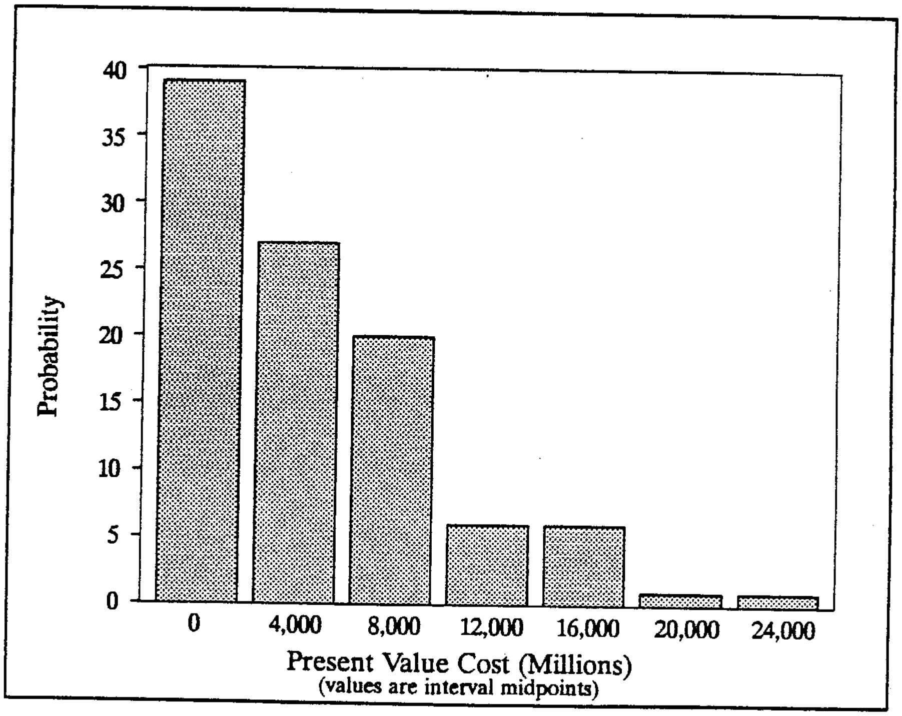
Cost Impacts

Figure 10–36
WNP–1 and WNP–3 Unavailable



Cost Impacts

Figure 10–37
Removing Coal and Nuclear from the Portfolio



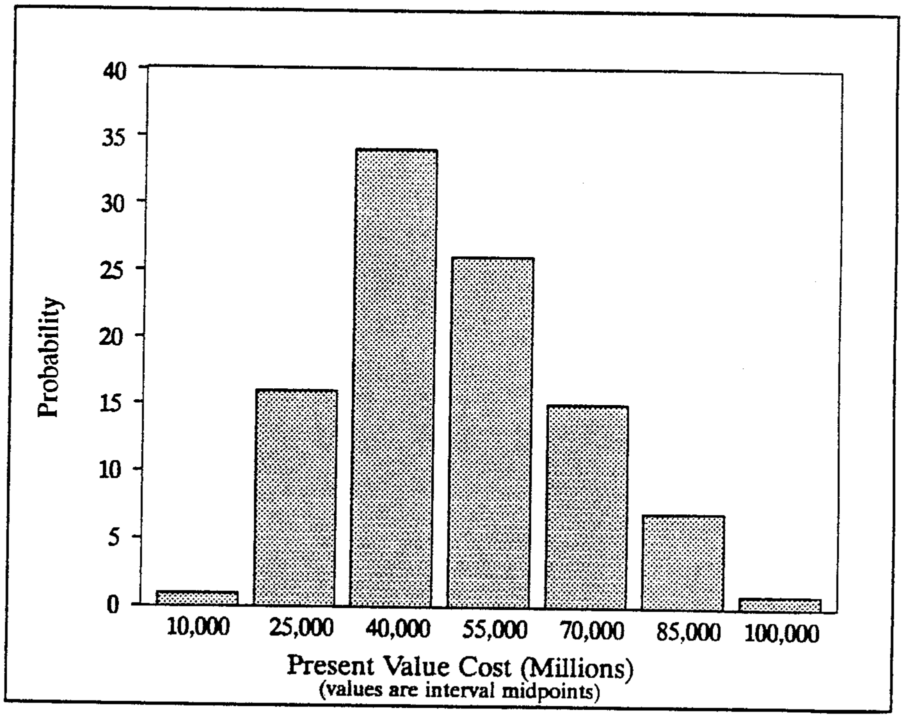
Cost versus Risk Assessment for Portfolio Selection

Extensive amounts of research have been conducted regarding the theory and practice of selecting financial investment portfolios. This research has identified two primary attributes of alternative portfolios. The first and most obvious is the expected rate of return that can be achieved from a portfolio containing a selection of financial investments. In the context of the Council's planning, the surrogate for this attribute is the expected cost of constructing, operating and maintaining the existing and future resources needed to meet the region's needs. Where financial portfolio theory strives to maximize the expected return, the Council's resource portfolio strives to minimize the expected cost.

The second attribute from financial portfolio theory is the variability of the return expected. Variability is normally characterized in a statistic called the standard deviation or the variance and is a measure of the risk inherent in the portfolio. The resource portfolio exhibits a high level of variability in costs. This can be seen from Figure 10-38, which illustrates the probability density function for the Council's resource portfolio. In this figure the most likely cost of the region's portfolio over the next 70 years is $40 billion (i.e., most probable outcome). Under extremely low load conditions, very few resources are built, and in combination with good water years we could see a cost as low as $10 billion. At the other end of the spectrum, if loads grow quickly and large quantities of very expensive resources are secured, or the region frequently experiences poor water conditions, the costs could be as high as $100 billion. The expected, or average value from this distribution is about $50 billion.

Range of Costs

Figure 10-38
System Cost Distribution



When the Council compares two alternative resource portfolios, the difference between the expected values is normally what is expressed as the cost or benefit of moving from one portfolio to another. The standard deviation is that distance above and below the expected value that normally will incorporate approximately 68 percent of all cost outcomes.

In choosing the base resource portfolio, the Council looks at both the expected costs and the standard deviations from a variety of alternative resource portfolios. By balancing cost and risk, the Council attempts to identify the "best" resource portfolio.

In terms of the Council's planning, the best resource portfolio has the attributes of being the lowest expected cost while also providing the highest degree of certainty possible. A difficult part of selecting a resource portfolio is that it may be easy to achieve a highly certain cost by undertaking very high-cost actions. For example, if the region were to acquire significant amounts of very expensive non-displaceable power, the region's resource portfolio would have a high expected cost, but also a high degree of certainty. Another example might be that a highly certain resource portfolio can be achieved by purchasing extreme amounts of insurance against all possible uncertainties. In either case, these portfolios are judged not to be preferable to a more balanced, lower cost resource portfolio that incorporates some degree of risk.

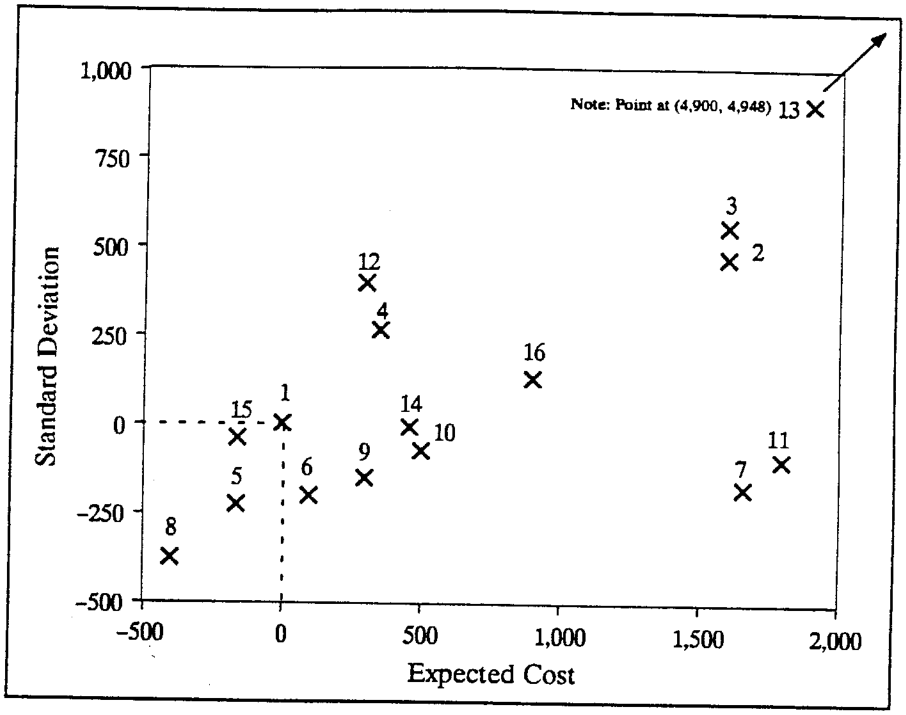
In choosing between two alternative resource portfolios, the Council obviously prefers a portfolio that has lower expected cost and lower risk. In portfolio theory this relationship is called stochastic dominance. Stochastic dominance occurs between two alternative portfolios when one portfolio has both a lower expected cost and a lower standard deviation than the alternative.

Table 10-4 illustrates some of the various scenarios that the Council looked at when selecting a base-case resource portfolio. The details of these scenarios were discussed previously, but it is important to note that some of these scenarios are sensitivity studies rather than complete scenarios. As sensitivity studies, one key but uncertain parameter was set at a particular value. This helps the Council to understand how sensitive the resource portfolio is to a specific parameter. Because it is not possible for the Council or the region to preordain the desired level of these parameters, these sensitivity studies are not physically achievable. On the other hand, some of the resource scenarios involved alternative priorities for resource development. These are choices that the region can make as to how the future resource mix will be modified or changed over the next 20 years.

Figure 10-39 illustrates the trade off between the expected cost of each of these scenarios and the standard deviations associated with those scenarios. Because the standard deviations represent the amount of dispersion around the expected value, they are an indication of the degree of risk. The numbered points on this graph correspond to the scenario numbers from Table 10-4.

Alternative Portfolios

Figure 10–39
Cost/Risk Analysis



Scenario number 1 is the base case resource portfolio that the Council uses as the backbone of this plan. Fifteen alternative scenarios were evaluated and plotted on Figure 10-39 to illustrate the trade offs between risk and expected cost. The vertical axis of the figure represents the standard deviation of the various resource portfolios. Larger amounts of standard deviation indicate a higher degree of risk in the resource portfolio. The horizontal axis in the figure illustrates the relative expected cost of the resource portfolio. Both the standard deviation and expected cost are relative estimates of the change in these two attributes when each portfolio is measured with respect to the base case. For this reason, the portfolio labeled number 1 is by definition the resource portfolio with no expected cost and no standard deviation in this plot. In reality, the base case resource portfolio has an expected cost of $50 billion and a standard deviation of $17 billion.

The base case resource portfolio number 1 is clearly preferable in terms of cost and risk to any portfolio that is in the upper right quadrant of the diagram. Any portfolio that falls here has both a higher expected cost and a higher associated risk than the base case portfolio. The base case portfolio is said to be stochastically dominant over these resource portfolios. For resource portfolios that have a significantly higher expected cost and only slightly different standard deviations (for example, Portfolios number 7, 11, 14 and 10), the base case resource portfolio is judged by the Council to be preferable. The resource portfolios of Scenarios 8, 5 and 15 appear to have both superior cost and risk characteristics to the base case portfolio, while Scenarios number 2 and 8 have higher costs, but reduced risk. It appears that these scenarios are potential competitors with the base portfolio. A discussion of these competing portfolios follows.

Scenarios 15 and 8 represent sensitivity studies around future gas prices. In portfolio 15, gas prices are assumed to be high, but the region has advanced the development of WNP-1 and WNP-3 and coal instead of building a large amount of gas-fired generation. In Scenario 8, future gas prices are assumed to be low and the region has decided to undertake the development of a significant amount of gas-fired generation. In these two scenarios, the future gas prices are assumed to be known at either high or low levels. These obviously are unattainable futures because the future price of natural gas is inherently uncertain.

Scenario number 5 illustrates how the region's resource portfolio would be improved through a successful geothermal demonstration program. It assumes the demonstration program confirms an additional 1,000 megawatts of cost-effective geothermal energy. This resource portfolio is stochastically dominant over the base case portfolio in that it has a lower expected cost and a lower standard deviation (less risk). However, as with fuel prices, it is not a future we can choose with certainty. There is some probability that an additional geothermal resource will not prove out at costs competitive with other portfolio resources. Scenario 5 illustrates the importance of undertaking a research and development effort on new geothermal resources in the region.

Scenarios number 6 and 9 are potential competitors with the base case resource portfolio. These two portfolios offer the trade off between a higher expected cost in exchange for a lower risk (standard deviation). Scenario 6 was a scenario attempting to delay WNP-1 and WNP-3 and the development of new coal-fired power plants by advancing the development of cogeneration and gas-fired combustion turbines. In fact, this resource portfolio may not be lower-risk than the base case. These resource portfolios, like any of the resource portfolios analyzed here, cannot take into account all possible uncertainty or risk. In this case the future uncertainty in gas prices was not analyzed or incorporated into the estimate of the standard deviation for the resource portfolio. That is precisely why the Council looked at the sensitivity studies to see the impacts of rapidly escalating gas prices. Therefore, Scenario 6 offers some potential benefits; however, the analysis supporting Scenario 6 may not incorporate one of the more important uncertainties.

Scenario 9 offers a more complex trade off with the base case. In this case the costs are significantly higher than the base case although within the range of being potentially viable. Scenario 9 involves advancing the development of hydropower, geothermal and wind resources in an attempt to defer thermal power plant development as long as possible. Because of the potential advantages in terms of reducing risk that this scenario offers, the Council designed special action items to focus on the need to better understand the cost and availability of these renewable resources. If these resources can be confirmed and their cost of development reduced, then it is possible that the risk reduction benefits of Scenario 9 can be achieved without significantly increasing the expected cost of the resource portfolio.

Conclusion from Scenarios and Sensitivity Studies

In looking at the results of all of the sensitivity studies and scenarios, the Council observed several constant themes. First, it was evident that the best and most effective resource action to deal with the most likely uncertainties and shocks was successful acquisition of the conservation and efficiency improvements. In almost all scenarios, the resource that helps to buy the time needed to adapt to significant resource or load uncertainties is conservation. The Council saw that by acquiring conservation at aggressive targets near the medium-high level, the region's resource portfolio was better positioned to deal with the wide range of uncertainties.

Second, many of the resource scenarios illustrated the necessity of having an inventory of resources that can be brought on line without long delays. Among the best resources for responding to quick economic or other turnarounds are gas-fired technologies. Obviously, with the acquisition of significant amounts of gas-fired technologies, the region bears a larger and larger risk, due to future uncertainty surrounding gas availability and price. Nevertheless, the Council recommends that the region begin the process of identifying sites and obtaining the necessary licenses and approvals for gas-fired resources either operating in cogeneration mode or as stand-alone combined-cycle power plants to back up the region's existing hydropower system.

Additionally, in a number of the resource sensitivities and scenarios, significant amounts of new or existing resources were assumed to be delayed or unavailable. In these events, the primary resources that the Council and the region can turn to are newer, emerging technologies where we have less experience. For this reason, the Council has selected resource confirmation activities to improve on our understanding and our ability to predict the cost and availability of geothermal, wind and solar resources. Also, conservation technologies are rapidly changing. Because of this movement, it is important to stay at the forefront of currently available cost-effective conservation measures. Conservation research and development activities will help the region to assimilate new conservation measures rapidly as they become commercially available and cost effective.

Finally, it can be observed from these studies that nuclear and coal-fired resources continue to play a significant role in the Council's resource portfolio. The balancing of need, cost, and risk place them after conservation, hydro-firming, and the cheaper renewable and cogeneration resources in the portfolio order, but they still are needed to maintain future system reliability and are used to meet a significant amount of load in the middle to upper portions of the demand forecast range. However there are major uncertainties regarding the region's ability to complete and operate the unfinished nuclear projects, WNP-1 and WNP-3, or to site and construct significant amounts of new coal-fired resources. To know whether these resources can be counted on to meet the region's need under rapid load growth conditions, it is important to resolve the uncertainties regarding the development of these resources. To this end the Council has included in its Action Plan measures designed to gain better insight into the viability of these resources.

From the lessons learned through the analysis of the region's resource portfolio and the possible scenarios and sensitivities, the Council formulated its

Action Plan. This Action Plan is designed to secure the resources that are needed by the region at the lowest possible cost. Additional actions are identified to help us shorten lead times and better manage the risks and uncertainties that the region faces. Finally, a number of activities are designed to help determine the availability and costs of new resources that may be needed in the future. These research, development and demonstration activities will help the region respond to future energy needs with a diverse resource portfolio at lowest costs and with the fewest environmental impacts.

D:PS/GENERAL.AG3 V2 Ch10 Edit

APPENDIX 10-A

RESOURCE DATA SCHEDULE

Study ID : 29-NOV-90 11:34:31
Study Title: Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = BPA

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	2916	2874	2816	2799	2807	2822	2840	2855	2872	2887	2902	2915	2927	2946	2966
Observed Rate		-1.43%	-2.02%	-0.59%	0.28%	0.52%	0.64%	0.55%	0.60%	0.50%	0.53%	0.45%	0.41%	0.65%	0.66%
DSI Firm Load	1982	1781	1579	1378	1176	974	973	972	971	848	725	602	479	479	479
Existing Resources	7444	7462	7450	7438	7484	7530	7661	7792	7747	7703	7698	7692	7623	7553	7560
BPA Requirements	-2033	-2002	-1963	-1730	-1741	-1760	-1774	-1695	-1723	-1747	-1750	-1749	-1768	-1799	-1809
CONSERVATION PROGRAMS:															
SF Res MCS	1	1	2	2	2	3	3	4	4	4	5	5	6	6	7
MF Res MCS	1	1	1	1	2	2	2	2	3	3	3	4	4	4	5
Commercial MCS	0	0	1	1	2	3	4	5	6	7	8	10	11	12	14
Water Heat	0	0	0	0	0	2	3	5	7	9	11	13	15	16	18
Refrigerators	0	0	0	0	0	1	1	2	3	3	4	5	6	6	7
Freezers	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3
New Manuf Housing	0	1	1	1	1	2	2	2	3	3	3	4	4	5	5
BPA Contract Recall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cons. Volt. Reg.	0	2	6	10	14	18	23	27	31	35	35	35	35	35	35
Industrial	0	4	16	30	44	58	71	85	99	113	113	113	113	113	113
T&D Effic Impr	0	3	7	11	15	19	23	26	30	34	34	34	34	34	34
MF Res Weath	0	0	1	2	4	5	7	8	9	11	11	11	11	11	11
Existing Commercial	0	2	10	18	27	35	44	52	60	69	69	69	69	69	69
SF Res Weath	0	2	7	12	17	22	27	32	37	42	42	42	42	42	42
Irrigation	0	0	0	0	1	1	2	2	3	3	3	3	3	3	3
Subtotal	2	16	52	88	129	171	213	253	296	337	343	350	355	358	366
GENERATING RESOURCES:															
Hydro Eff Imp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Mont Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mun. Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Wash Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Oregon Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Wa/Or Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Resources	5412	5476	5538	5798	5873	5941	6099	6351	6320	6294	6291	6292	6208	6113	6116
Load/Resource Balance	514	822	1143	1621	1890	2145	2286	2523	2476	2559	2663	2775	2802	2687	2671

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Study ID   :  29-NOV-90 11:34:31
Study Title:  Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                              Pg    2

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = BPA
                                                                                          Game = 0001
Operating Year               05-06   06-07   07-08   08-09   09-10
                             -----   -----   -----   -----   -----
Observed Load                 2983    3004    3029    3054    3076
Observed Rate                0.57%   0.72%   0.82%   0.82%   0.73%
DSI Firm Load                  479     479     479     479     479

Existing Resources            7566    7572    7577    7583    7577

BPA Requirements             -1702   -1662   -1685   -1709   -1595

CONSERVATION PROGRAMS:
  SF Res MCS                     7       8       8       9       9
  MF Res MCS                     5       5       6       6       6
  Commercial MCS                15      17      18      20      21
  Water Heat                    19      21      22      24      26
  Refrigerators                  8       9      10      11      12
  Freezers                       3       3       4       4       5
  New Manuf Housing              5       6       6       7       7
  BPA Contract Recall            0       0       0       0       0
  Cons. Volt. Reg.              35      35      35      35      35
  Industrial                   113     113     113     113     113
  T&D Effic Impr                34      34      34      34      34
  MF Res Weath                  11      11      11      11      11
  Existing Commercial           69      69      69      69      69
  SF Res Weath                  42      42      42      42      42
  Irrigation                     3       3       3       3       3
                             -----   -----   -----   -----   -----
  Subtotal                     369     376     381     388     393

GENERATING RESOURCES:
  Hydro Eff Imp                  0       0       0       0       0
  Small Hydro 1                  0       0       0       0       0
  Small Hydro 2                  0       0       0       0       0
  Combined Cycle 1               0       0       0       0       0
  WNP 3                          0       0       0       0       0
  Combined Cycle 2               0       0       0       0       0
  Cogen 1                        0       0       0       0       0
  WNP 1                          0       0       0       0       0
  E. Mont Coal                   0       0       0       0       0
  Cogen 2                        0       0       0       0       0
  Geothermal                     0       0       0       0       0
  Mun. Solid Waste               0       0       0       0       0
  Small Hydro 3                  0       0       0       0       0
  E. Wash Coal                   0       0       0       0       0
  E. Oregon Coal                 0       0       0       0       0
  Wind 1                         0       0       0       0       0
  Nevada Coal                    0       0       0       0       0
  W. Wa/Or Coal                  0       0       0       0       0
  Small Hydro 4                  0       0       0       0       0
  Cogen 3                        0       0       0       0       0
  Wind 2                         0       0       0       0       0
  Cogen 4                        0       0       0       0       0
  Biomass                        0       0       0       0       0
  Replacement                    0       0       0       0       0
                             -----   -----   -----   -----   -----
  Subtotal                       0       0       0       0       0

Total Firm Resources          6234    6286    6273    6262    6376

Load/Resource Balance         2773    2802    2765    2729    2821
```

Study ID : 29-NOV-90 11:34:31
Study Title: Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

Pg 3

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = IOUs

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	8794	8646	8499	8439	8422	8421	8437	8444	8452	8451	8460	8459	8461	8487	8513
Observed Rate		-1.69%	-1.70%	-0.70%	-0.21%	-0.01%	0.19%	0.09%	0.09%	-0.01%	0.10%	0.00%	0.02%	0.30%	0.32%
Existing Resources	9342	9322	9270	9218	9145	9072	8907	8741	8621	8501	8450	8400	8379	8357	8313
BPA Requirements	107	138	188	0	0	0	0	0	0	0	0	0	0	0	0
CONSERVATION PROGRAMS:															
SF Res MCS	1	2	3	3	4	4	5	6	7	7	8	9	10	11	11
MF Res MCS	1	3	3	4	5	5	6	7	8	9	10	11	12	12	13
Commercial MCS	0	2	5	9	14	21	28	34	42	49	57	65	74	83	92
Water Heat	0	0	0	0	1	4	8	13	17	22	26	31	35	39	43
Refrigerators	0	0	0	0	0	2	4	6	7	9	11	14	16	18	20
Freezers	0	0	0	0	0	1	2	2	3	4	5	6	6	7	8
New Manuf Housing	1	1	2	3	4	4	5	6	7	8	9	10	11	12	13
Cons. Volt. Reg.	0	3	9	15	21	27	33	39	45	50	50	50	50	50	50
Industrial	0	4	16	32	48	64	81	97	113	129	129	129	129	129	129
T&D Effic Impr	0	2	7	12	17	22	27	31	36	41	41	41	41	41	41
MF Res Weath	0	1	6	12	17	22	27	33	38	41	41	41	41	41	41
Existing Commercial	0	6	22	45	67	90	112	135	157	180	180	180	180	180	180
SF Res Weath	0	2	9	18	28	38	48	58	62	62	62	62	62	62	62
Irrigation	0	1	5	10	15	19	24	29	34	39	39	39	39	39	39
Subtotal	3	27	87	163	241	323	410	496	576	650	668	688	706	724	742
GENERATING RESOURCES:															
Hydro Eff Imp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Mont Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mun. Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Wash Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Oregon Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Wa/Or Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Resources	9452	9487	9545	9380	9385	9396	9316	9237	9197	9151	9118	9087	9085	9082	9056
Load/Resource Balance	658	841	1046	941	964	975	879	792	745	699	659	628	624	595	543

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Study ID    :  29-NOV-90 11:34:31
Study Title:  Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = IOUs          Game = 0001

Operating Year             05-06   06-07   07-08   08-09   09-10
                           -----   -----   -----   -----   -----
Observed Load               8531    8567    8611    8657    8693
Observed Rate              0.21%   0.42%   0.52%   0.52%   0.42%

Existing Resources          8154    8101    8111    8131    7892

BPA Requirements               0       0       0       0       0

CONSERVATION PROGRAMS:
  SF Res MCS                  12      13      14      15      16
  MF Res MCS                  14      15      17      18      19
  Commercial MCS             101     110     119     129     139
  Water Heat                  47      51      55      59      64
  Refrigerators               23      25      27      30      33
  Freezers                     9       9      10      11      12
  New Manuf Housing           14      15      16      18      19
  Cons. Volt. Reg.            50      50      50      50      50
  Industrial                 129     129     129     129     129
  T&D Effic Impr              41      41      41      41      41
  MF Res Weath                41      41      41      41      41
  Existing Commercial        180     180     180     180     180
  SF Res Weath                62      62      62      62      62
  Irrigation                  39      39      39      39      39
                           -----   -----   -----   -----   -----
  Subtotal                   762     780     800     822     844

GENERATING RESOURCES:
  Hydro Eff Imp                0       0       0       0       0
  Small Hydro 1                0       0       0       0       0
  Small Hydro 2                0       0       0       0       0
  Combined Cycle 1             0       0       0       0       0
  WNP 3                        0       0       0       0       0
  Combined Cycle 2             0       0       0       0       0
  Cogen 1                      0       0       0       0       0
  WNP 1                        0       0       0       0       0
  E. Mont Coal                 0       0       0       0       0
  Cogen 2                      0       0       0       0       0
  Geothermal                   0       0       0       0       0
  Mun. Solid Waste             0       0       0       0       0
  Small Hydro 3                0       0       0       0       0
  E. Wash Coal                 0       0       0       0       0
  E. Oregon Coal               0       0       0       0       0
  Wind 1                       0       0       0       0       0
  Nevada Coal                  0       0       0       0       0
  W. Wa/Or Coal                0       0       0       0       0
  Small Hydro 4                0       0       0       0       0
  Cogen 3                      0       0       0       0       0
  Wind 2                       0       0       0       0       0
  Cogen 4                      0       0       0       0       0
  Biomass                      0       0       0       0       0
  Replacement                  0       0       0       0       0
                           -----   -----   -----   -----   -----
  Subtotal                     0       0       0       0       0

Total Firm Resources        8916    8882    8912    8952    8735

Load/Resource Balance        384     316     301     296      42
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Study ID   :  29-NOV-90 11:34:31
Study Title:  Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                                          Pg    5

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics
                                                                                                                      Game = 0001
Operating Year            90-91   91-92   92-93   93-94   94-95   95-96   96-97   97-98   98-99   99-00   00-01   01-02   02-03   03-04   04-05
                          -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----
Observed Load              4371    4296    4225    4198    4192    4195    4208    4217    4225    4228    4236    4239    4243    4259    4276
Observed Rate                    -1.72%  -1.65%  -0.65%  -0.13%   0.07%   0.31%   0.21%   0.18%   0.08%   0.18%   0.08%   0.09%   0.38%   0.39%

Existing Resources         2445    2432    2450    2468    2451    2435    2434    2433    2411    2390    2394    2398    2381    2365    2372

BPA Requirements           1926    1864    1775    1730    1741    1760    1774    1695    1723    1747    1750    1749    1768    1799    1809

CONSERVATION PROGRAMS:
  SF Res MCS                  1       1       2       2       2       3       3       3       4       4       4       5       5       6       6
  MF Res MCS                  1       1       1       1       2       2       2       2       3       3       3       3       4       4       4
  Commercial MCS              0       0       1       2       3       5       7       8      10      12      14      16      18      21      23
  Water Heat                  0       0       0       0       0       2       3       5       6       8      10      12      13      15      16
  Refrigerators               0       0       0       0       0       1       1       2       2       3       4       5       5       6       7
  Freezers                    0       0       0       0       0       0       1       1       1       1       1       2       2       2       3
  New Manuf Housing           0       1       1       1       1       2       2       2       3       3       3       4       4       4       5
                          -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----
  Subtotal                    2       3       5       6       8      15      19      23      29      34      39      47      51      58      64

GENERATING RESOURCES:
  Replacement                 0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
                          -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----
  Subtotal                    0       0       0       0       0       0       0       0       0       0       0       0       0       0       0

Total Firm Resources       4373    4299    4230    4204    4202    4209    4227    4151    4163    4170    4183    4193    4202    4222    4244

Load/Resource Balance         2       3       5       7       9      14      18     -66     -62     -58     -53     -46     -41     -37     -32
```

```
Study ID   :  29-NOV-90 11:34:31
Study Title:  Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                              Pg    6

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics
                                                                                                 Game = 0001
Operating Year            05-06  06-07  07-08  08-09  09-10
                          -----  -----  -----  -----  -----
Observed Load              4288   4308   4332   4357   4378
Observed Rate             0.28%  0.46%  0.57%  0.57%  0.47%

Existing Resources         2496   2559   2559   2559   2699

BPA Requirements           1702   1662   1685   1709   1595

CONSERVATION PROGRAMS:
  SF Res MCS                  6      7      7      8      8
  MF Res MCS                  5      5      5      6      6
  Commercial MCS             25     28     30     33     35
  Water Heat                 18     19     21     22     24
  Refrigerators               7      8      9     10     11
  Freezers                    3      3      3      4      4
  New Manuf Housing           5      5      6      6      7
                          -----  -----  -----  -----  -----
  Subtotal                   69     75     81     89     95

GENERATING RESOURCES:
  Replacement                 0      0      0      0      0
                          -----  -----  -----  -----  -----
  Subtotal                    0      0      0      0      0

Total Firm Resources       4268   4296   4326   4356   4389

Load/Resource Balance       -20    -12     -7     -1     12
```

```
Study ID    :  29-NOV-90 11:34:31
Study Title:   Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                             Pg    7

SYSTEM SUMMARY:   Observed Loads and Resources (Avg MW),       PARTY = REGION
                                                                                                               Game = 0001
Operating Year        90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                      -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load         16081  15816  15540  15437  15421  15438  15485  15517  15550  15567  15598  15614  15631  15692  15755
Observed Rate                -1.65% -1.74% -0.67% -0.10%  0.11%  0.31%  0.21%  0.21%  0.11%  0.20%  0.10%  0.11%  0.39%  0.40%
DSI Firm Load          1982   1781   1579   1378   1176    974    973    972    971    848    725    602    479    479    479

Existing Resources    19230  19216  19170  19124  19080  19037  19002  18966  18780  18594  18542  18490  18383  18275  18245

CONSERVATION PROGRAMS:
  SF Res MCS              3      4      7      7      8     10     11     13     15     15     17     19     21     23     24
  MF Res MCS              3      5      5      6      9      9     10     11     14     15     16     18     20     20     22
  Commercial MCS          0      2      7     12     19     29     39     47     58     68     79     91    103    116    129
  Water Heat              0      0      0      0      1      8     14     23     30     39     47     56     63     70     77
  Refrigerators           0      0      0      0      0      4      6     10     12     15     19     24     27     30     34
  Freezers                0      0      0      0      0      1      4      4      5      6      8     10     10     11     14
  New Manuf Housing       1      3      4      5      6      8      9     10     13     14     15     18     19     21     23
  BPA Contract Recall     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cons. Volt. Reg.        0      5     15     25     35     45     56     66     76     85     85     85     85     85     85
  Industrial              0      8     32     62     92    122    152    182    212    242    242    242    242    242    242
  T&D Effic Impr          0      5     14     23     32     41     50     57     66     75     75     75     75     75     75
  MF Res Weath            0      1      7     14     21     27     34     41     47     52     52     52     52     52     52
  Existing Commercial     0      8     32     63     94    125    156    187    217    249    249    249    249    249    249
  SF Res Weath            0      4     16     30     45     60     75     90     99    104    104    104    104    104    104
  Irrigation              0      1      5     10     16     20     26     31     37     42     42     42     42     42     42
                      -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                7     46    144    257    378    509    642    772    901   1021   1050   1085   1112   1140   1172

GENERATING RESOURCES:
  Hydro Eff Imp           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 1           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 2           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 1        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  WNP 3                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 1                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  WNP 1                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 2                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Geothermal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                      -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0

Total Firm Resources  19237  19262  19314  19383  19460  19546  19642  19739  19680  19614  19592  19572  19495  19416  19416

Load/Resource Balance  1173   1666   2194   2569   2863   3134   3183   3249   3158   3200   3269   3356   3385   3245   3182
```

```
Study ID   :  29-NOV-90 11:34:31
Study Title:  Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                Pg    8

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                                                 Game = 0001
Operating Year                05-06   06-07   07-08   08-09   09-10
                              -----   -----   -----   -----   -----
Observed Load                 15802   15879   15973   16068   16147
Observed Rate                 0.30%   0.49%   0.59%   0.59%   0.49%
DSI Firm Load                   479     479     479     479     479

Existing Resources            18216   18232   18247   18273   18168

CONSERVATION PROGRAMS:
  SF Res MCS                     25      28      29      32      33
  MF Res MCS                     24      25      28      30      31
  Commercial MCS                141     155     167     182     195
  Water Heat                     84      91      98     105     114
  Refrigerators                  38      42      46      51      56
  Freezers                       15      15      17      19      21
  New Manuf Housing              24      26      28      31      33
  BPA Contract Recall             0       0       0       0       0
  Cons. Volt. Reg.               85      85      85      85      85
  Industrial                    242     242     242     242     242
  T&D Effic Impr                 75      75      75      75      75
  MF Res Weath                   52      52      52      52      52
  Existing Commercial           249     249     249     249     249
  SF Res Weath                  104     104     104     104     104
  Irrigation                     42      42      42      42      42
                              -----   -----   -----   -----   -----
  Subtotal                     1200    1231    1262    1299    1332

GENERATING RESOURCES:
  Hydro Eff Imp                   0       0       0       0       0
  Small Hydro 1                   0       0       0       0       0
  Small Hydro 2                   0       0       0       0       0
  Combined Cycle 1                0       0       0       0       0
  WNP 3                           0       0       0       0       0
  Combined Cycle 2                0       0       0       0       0
  Cogen 1                         0       0       0       0       0
  WNP 1                           0       0       0       0       0
  E. Mont Coal                    0       0       0       0       0
  Cogen 2                         0       0       0       0       0
  Geothermal                      0       0       0       0       0
  Mun. Solid Waste                0       0       0       0       0
  Small Hydro 3                   0       0       0       0       0
  E. Wash Coal                    0       0       0       0       0
  E. Oregon Coal                  0       0       0       0       0
  Wind 1                          0       0       0       0       0
  Nevada Coal                     0       0       0       0       0
  W. Wa/Or Coal                   0       0       0       0       0
  Small Hydro 4                   0       0       0       0       0
  Cogen 3                         0       0       0       0       0
  Wind 2                          0       0       0       0       0
  Cogen 4                         0       0       0       0       0
  Biomass                         0       0       0       0       0
  Replacement                     0       0       0       0       0
                              -----   -----   -----   -----   -----
  Subtotal                        0       0       0       0       0

Total Firm Resources          19418   19464   19511   19570   19500

Load/Resource Balance          3137    3106    3059    3023    2874
```

Study ID : 29-NOV-90 11:33:46
Study Title: Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = BPA

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	2976	2973	2952	2963	2996	3033	3074	3112	3148	3185	3220	3253	3282	3321	3366
Observed Rate		-0.13%	-0.70%	0.39%	1.10%	1.26%	1.33%	1.25%	1.17%	1.17%	1.09%	1.00%	0.92%	1.18%	1.36%
DSI Firm Load	2106	1973	1839	1705	1571	1437	1437	1436	1436	1436	1435	1435	1435	1434	1434
Existing Resources	7444	7462	7450	7438	7484	7530	7661	7792	7747	7703	7698	7692	7623	7553	7560
BPA Requirements	-2147	-2181	-2206	-2019	-2074	-2134	-2185	-2120	-2180	-2240	-2269	-2295	-2340	-2400	-2448
CONSERVATION PROGRAMS:															
SF Res MCS	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17
MF Res MCS	1	1	2	2	3	3	3	4	4	5	5	6	6	7	7
Commercial MCS	0	1	2	3	4	6	7	8	10	11	13	15	16	18	20
Water Heat	0	0	0	0	0	2	4	6	8	10	13	15	18	20	22
Refrigerators	0	0	0	0	0	1	2	3	3	4	5	6	7	8	9
Freezers	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4
New Manuf Housing	0	1	2	2	3	3	4	5	5	6	7	7	8	9	9
BPA Contract Recall	0	0	0	0	0	0	0	0	0	0	97	195	292	292	292
Cons. Volt. Reg.	0	2	6	10	14	18	23	27	31	35	35	35	35	35	35
Industrial	0	4	16	30	44	58	71	85	99	113	113	113	113	113	113
T&D Effic Impr	0	3	7	11	15	19	23	26	30	34	34	34	34	34	34
MF Res Weath	0	0	1	2	4	5	7	8	9	11	11	11	11	11	11
Existing Commercial	0	2	10	18	27	35	44	52	60	69	69	69	69	69	69
SF Res Weath	0	2	7	12	17	22	27	32	37	42	42	42	42	42	42
Irrigation	0	0	0	0	1	1	2	2	3	3	3	3	3	3	3
Subtotal	3	19	57	95	138	180	226	268	310	356	461	567	671	680	687
GENERATING RESOURCES:															
Hydro Eff Imp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WNP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Mont Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mun. Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Wash Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Oregon Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Wa/Or Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Resources	5299	5300	5301	5516	5548	5578	5701	5940	5880	5820	5890	5965	5954	5832	5799
Load/Resource Balance	216	355	511	848	981	1107	1191	1392	1296	1199	1234	1277	1237	1076	999

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Study ID   :  29-NOV-90 11:33:46
Study Title:  Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = BPA                    Game = 0001

Operating Year           05-06   06-07   07-08   08-09   09-10
                         -----   -----   -----   -----   -----
Observed Load             3409    3455    3505    3555    3606
Observed Rate            1.27%   1.35%   1.43%   1.44%   1.44%
DSI Firm Load             1434    1433    1433    1433    1433

Existing Resources        7566    7572    7577    7583    7577

BPA Requirements         -2379   -2375   -2436   -2498   -2427

CONSERVATION PROGRAMS:
  SF Res MCS                18      19      20      21      22
  MF Res MCS                 8       8       8       9       9
  Commercial MCS            22      24      26      28      30
  Water Heat                24      26      28      30      33
  Refrigerators             10      11      13      14      15
  Freezers                   4       5       5       5       6
  New Manuf Housing         10      11      11      12      13
  BPA Contract Recall      292     292     292     292     292
  Cons. Volt. Reg.          35      35      35      35      35
  Industrial               113     113     113     113     113
  T&D Effic Impr            34      34      34      34      34
  MF Res Weath              11      11      11      11      11
  Existing Commercial       69      69      69      69      69
  SF Res Weath              42      42      42      42      42
  Irrigation                 3       3       3       3       3
                         -----   -----   -----   -----   -----
  Subtotal                 695     703     710     718     727

GENERATING RESOURCES:
  Hydro Eff Imp              0       0       0       0       0
  Small Hydro 1              0       0       0       0       0
  Small Hydro 2              0       0       0       0       0
  Combined Cycle 1           0       0       0       0       0
  WNP 3                      0       0       0       0       0
  Combined Cycle 2           0       0       0       0       0
  Cogen 1                    0       0       0       0       0
  WNP 1                      0       0       0       0       0
  E. Mont Coal               0       0       0       0       0
  Cogen 2                    0       0       0       0       0
  Geothermal                 0       0       0       0       0
  Mun. Solid Waste           0       0       0       0       0
  Small Hydro 3              0       0       0       0       0
  E. Wash Coal               0       0       0       0       0
  E. Oregon Coal             0       0       0       0       0
  Wind 1                     0       0       0       0       0
  Nevada Coal                0       0       0       0       0
  W. Wa/Or Coal              0       0       0       0       0
  Small Hydro 4              0       0       0       0       0
  Cogen 3                    0       0       0       0       0
  Wind 2                     0       0       0       0       0
  Cogen 4                    0       0       0       0       0
  Biomass                    0       0       0       0       0
  Replacement                0       0       0       0       0
                         -----   -----   -----   -----   -----
  Subtotal                   0       0       0       0       0

Total Firm Resources      5882    5899    5851    5804    5877

Load/Resource Balance     1038    1010     913     816     838
```

Study ID : 29-NOV-90 11:33:46
Study Title: Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = IOUs

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	9000	8983	8965	9002	9074	9157	9249	9333	9407	9482	9549	9607	9667	9756	9866
Observed Rate		-0.19%	-0.19%	0.41%	0.81%	0.91%	1.00%	0.91%	0.80%	0.80%	0.71%	0.61%	0.63%	0.92%	1.13%
Existing Resources	9342	9322	9270	9218	9145	9072	8907	8741	8621	8501	8450	8400	8379	8357	8313
BPA Requirements	107	138	188	0	0	0	0	0	0	0	0	0	0	0	0
CONSERVATION PROGRAMS:															
SF Res MCS	2	4	6	8	10	12	14	15	17	19	21	23	25	27	29
MF Res MCS	2	3	5	6	7	9	10	11	12	14	15	17	18	19	21
Commercial MCS	0	6	13	21	29	38	48	58	68	78	88	99	110	121	133
Water Heat	0	0	0	0	1	5	10	15	20	26	31	37	43	48	54
Refrigerators	0	0	0	0	1	3	5	8	10	12	15	18	21	23	26
Freezers	0	0	0	0	0	1	2	3	4	5	6	7	9	9	10
New Manuf Housing	1	2	4	5	7	9	10	12	14	15	17	19	21	23	25
Cons. Volt. Reg.	0	3	9	15	21	27	33	39	45	50	55	59	59	59	59
Industrial	0	4	16	32	48	64	81	97	113	129	145	161	177	178	178
T&D Effic Impr	0	2	7	12	17	22	27	31	36	41	46	51	56	60	65
MF Res Weath	0	1	6	12	17	22	27	33	38	41	41	41	41	41	41
Existing Commercial	0	6	22	45	67	90	112	135	157	180	203	225	247	248	248
SF Res Weath	0	2	9	18	28	38	48	58	62	62	62	62	62	62	62
Irrigation	0	1	5	10	15	19	24	29	34	39	44	46	46	46	46
Subtotal	5	34	102	184	268	359	451	544	630	711	789	865	935	964	997
GENERATING RESOURCES:															
Hydro Eff Imp	0	0	0	0	0	5	15	25	35	35	35	35	35	35	35
Small Hydro 1	0	0	0	0	0	0	0	0	33	57	57	57	57	57	57
Small Hydro 2	0	0	0	0	0	0	0	18	43	69	72	72	72	72	72
Combined Cycle 1	0	0	0	0	0	0	0	0	0	0	349	349	349	349	349
WNP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 1	0	0	0	0	0	0	0	0	0	60	60	60	60	60	100
WNP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Mont Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Mun. Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Wash Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Oregon Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Wa/Or Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	5	15	43	111	221	573	573	573	573	621
Total Firm Resources	9454	9495	9560	9401	9412	9436	9373	9328	9364	9433	9814	9840	9888	9899	9933
Load/Resource Balance	454	512	595	399	338	279	124	-4	-43	-49	265	232	220	143	68

```
Study ID    :  29-NOV-90 11:33:46
Study Title:  Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                         Pg    4

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = IOUs                          Game = 0001

Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load                9967   10079   10203   10328   10454
Observed Rate               1.02%   1.13%   1.22%   1.23%   1.22%

Existing Resources           8154    8101    8111    8131    7892

BPA Requirements                0       0       0       0       0

CONSERVATION PROGRAMS:
  SF Res MCS                   31      33      35      37      40
  MF Res MCS                   22      24      25      26      28
  Commercial MCS              144     156     169     182     195
  Water Heat                   59      64      70      75      81
  Refrigerators                29      32      35      38      41
  Freezers                     11      13      14      15      16
  New Manuf Housing            26      28      30      32      33
  Cons. Volt. Reg.             59      59      59      59      59
  Industrial                  178     178     178     178     178
  T&D Effic Impr               70      75      80      84      89
  MF Res Weath                 41      41      41      41      41
  Existing Commercial         248     248     248     248     248
  SF Res Weath                 62      62      62      62      62
  Irrigation                   46      46      46      46      46
                            -----   -----   -----   -----   -----
  Subtotal                   1026    1059    1092    1123    1157

GENERATING RESOURCES:
  Hydro Eff Imp                35      35      35      35      35
  Small Hydro 1                57      57      57      57      57
  Small Hydro 2                72      72      72      72      72
  Combined Cycle 1            349     349     349     349     349
  WNP 3                         0       0       0       0       0
  Combined Cycle 2            349     349     349     349     349
  Cogen 1                     100     100     160     220     240
  WNP 1                         0       0       0       0       0
  E. Mont Coal                  0       0       0       0     300
  Cogen 2                       8       8       8      24      24
  Geothermal                    0       0       0       0       0
  Mun. Solid Waste              0       0       0       0       0
  Small Hydro 3                 0       0       0       0       0
  E. Wash Coal                  0       0       0       0       0
  E. Oregon Coal                0       0       0       0       0
  Wind 1                        0       0       0       0       7
  Nevada Coal                   0       0       0       0       0
  W. Wa/Or Coal                 0       0       0       0       0
  Small Hydro 4                 0       0       0       0       0
  Cogen 3                       0       0       0       0       0
  Wind 2                        0       0       0       0       0
  Cogen 4                       0       0       0       0       0
  Biomass                       0       0       0       0       0
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                    970     970    1030    1106    1433

Total Firm Resources        10153   10132   10234   10362   10484

Load/Resource Balance ·       187      53      31      34      30
```

```
Study ID   :  29-NOV-90 11:33:46
Study Title:  Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                      Pg    5

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW).     PARTY = Generating Publics
                                                                                                             Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load             4485   4475   4467   4487   4525   4569   4619   4665   4706   4747   4782   4813   4845   4891   4948
Observed Rate                  -0.22% -0.16%  0.44%  0.86%  0.96%  1.09%  1.00%  0.88%  0.88%  0.74%  0.64%  0.66%  0.96%  1.16%

Existing Resources        2445   2432   2450   2468   2451   2435   2434   2433   2411   2390   2394   2398   2381   2365   2372

BPA Requirements          2040   2043   2018   2019   2074   2134   2185   2120   2180   2240   2269   2295   2340   2400   2448

CONSERVATION PROGRAMS:
  SF Res MCS                 1      3      4      5      6      7      8      9      9     10     11     12     13     14     15
  MF Res MCS                 1      1      2      2      2      3      3      4      4      4      5      5      6      6      7
  Commercial MCS             0      2      3      5      7      9     12     14     16     19     22     24     27     30     33
  Water Heat                 0      0      0      0      0      2      4      6      7      9     12     14     16     18     20
  Refrigerators              0      0      0      0      0      1      2      2      3      4      5      6      7      8      8
  Freezers                   0      0      0      0      0      0      1      1      1      2      2      2      3      3      3
  New Manuf Housing          0      1      1      2      3      3      4      4      5      6      6      7      7      8      9
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   2      7     10     14     18     25     34     40     45     54     63     70     79     87     95

GENERATING RESOURCES:
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0

Total Firm Resources      4487   4481   4478   4501   4544   4594   4651   4593   4638   4683   4725   4763   4801   4853   4915

Load/Resource Balance        2      6     10     14     18     25     32    -72    -68    -64    -57    -50    -44    -39    -33
```

```
Study ID    :  29-NOV-90 11:33:46                                                          Pg    6
Study Title:  Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics      Game = 0001

Operating Year            05-06   06-07   07-08   08-09   09-10
                          _____   _____   _____   _____   _____
Observed Load              5001    5059    5123    5188    5254
Observed Rate             1.06%   1.17%   1.26%   1.27%   1.26%

Existing Resources         2496    2559    2559    2559    2699

BPA Requirements           2379    2375    2436    2498    2427

CONSERVATION PROGRAMS:
  SF Res MCS                 16      17      18      19      20
  MF Res MCS                  7       7       8       8       9
  Commercial MCS             36      39      42      46      49
  Water Heat                 22      24      26      28      30
  Refrigerators               9      11      12      13      14
  Freezers                    4       4       5       5       6
  New Manuf Housing           9      10      10      11      12
                          _____   _____   _____   _____   _____
  Subtotal                  103     112     121     130     140

GENERATING RESOURCES:
  Replacement                 0       0       0       0       0
                          _____   _____   _____   _____   _____
  Subtotal                    0       0       0       0       0

Total Firm Resources       4980    5047    5117    5188    5267

Load/Resource Balance       -21     -12      -7      -1      13
```

```
Study ID    :  29-NOV-90 11:33:46
Study Title:   Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                      Pg    7

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = REGION
                                                                                                         Game = 0001
Operating Year               90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                             -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load                16461  16430  16384  16452  16595  16759  16941  17109  17261  17415  17552  17673  17795  17969  18181
Observed Rate                      -0.19% -0.28%  0.41%  0.87%  0.99%  1.09%  0.99%  0.89%  0.89%  0.79%  0.69%  0.69%  0.98%  1.18%
DSI Firm Load                 2106   1973   1839   1705   1571   1437   1437   1436   1436   1436   1435   1435   1435   1434   1434

Existing Resources           19230  19216  19170  19124  19080  19037  19002  18966  18780  18594  18542  18490  18383  18275  18245

CONSERVATION PROGRAMS:
  SF Res MCS                     5     10     14     18     22     26     30     33     36     40     44     48     52     57     61
  MF Res MCS                     4      5      9     10     12     15     16     19     20     23     25     28     30     32     35
  Commercial MCS                 0      9     18     29     40     53     67     80     94    108    123    138    153    169    186
  Water Heat                     0      0      0      0      1      9     18     27     35     45     56     66     77     86     96
  Refrigerators                  0      0      0      0      1      5      9     13     16     20     25     30     35     39     43
  Freezers                       0      0      0      0      0      1      4      5      6      9     10     12     15     15     17
  New Manuf Housing              1      4      7      9     13     15     18     21     24     27     30     33     36     40     43
  BPA Contract Recall            0      0      0      0      0      0      0      0      0      0     97    195    292    292    292
  Cons. Volt. Reg.               0      5     15     25     35     45     56     66     76     85     90     94     94     94     94
  Industrial                     0      8     32     62     92    122    152    182    212    242    258    274    290    291    291
  T&D Effic Impr                 0      5     14     23     32     41     50     57     66     75     80     85     90     94     99
  MF Res Weath                   0      1      7     14     21     27     34     41     47     52     52     52     52     52     52
  Existing Commercial            0      8     32     63     94    125    156    187    217    249    272    294    316    317    317
  SF Res Weath                   0      4     16     30     45     60     75     90     99    104    104    104    104    104    104
  Irrigation                     0      1      5     10     16     20     26     31     37     42     47     49     49     49     49
                             -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                      10     60    169    293    424    564    711    852    985   1121   1313   1502   1685   1731   1779

GENERATING RESOURCES:
  Hydro Eff Imp                  0      0      0      0      0      5     15     25     35     35     35     35     35     35     35
  Small Hydro 1                  0      0      0      0      0      0      0      0     33     57     57     57     57     57     57
  Small Hydro 2                  0      0      0      0      0      0      0     18     43     69     72     72     72     72     72
  Combined Cycle 1               0      0      0      0      0      0      0      0      0      0    349    349    349    349    349
  WNP 3                          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 1                        0      0      0      0      0      0      0      0      0     60     60     60     60     60    100
  WNP 1                          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 2                        0      0      0      0      0      0      0      0      0      0      0      0      0      0      8
  Geothermal                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                        0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                             -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                       0      0      0      0      0      5     15     43    111    221    573    573    573    573    621

Total Firm Resources         19240  19276  19338  19417  19504  19608  19725  19861  19882  19937  20429  20567  20643  20583  20648

Load/Resource Balance          672    874   1115   1261   1338   1412   1347   1316   1185   1086   1442   1460   1413   1180   1033
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Study ID   :  29-NOV-90 11:33:46
Study Title:  Med Low Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                          Pg    8

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION                                      Game = 0001

Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load               18377   18594   18831   19072   19314
Observed Rate               1.08%   1.18%   1.27%   1.28%   1.27%
DSI Firm Load                1434    1433    1433    1433    1433

Existing Resources          18216   18232   18247   18273   18168

CONSERVATION PROGRAMS:
  SF Res MCS                   65      69      73      77      82
  MF Res MCS                   37      39      41      43      46
  Commercial MCS              202     219     237     256     274
  Water Heat                  105     114     124     133     144
  Refrigerators                48      54      60      65      70
  Freezers                     19      22      24      25      28
  New Manuf Housing            45      49      51      55      58
  BPA Contract Recall         292     292     292     292     292
  Cons. Volt. Reg.             94      94      94      94      94
  Industrial                  291     291     291     291     291
  T&D Effic Impr              104     109     114     118     123
  MF Res Weath                 52      52      52      52      52
  Existing Commercial         317     317     317     317     317
  SF Res Weath                104     104     104     104     104
  Irrigation                   49      49      49      49      49
                            -----   -----   -----   -----   -----
  Subtotal                   1824    1874    1923    1971    2024

GENERATING RESOURCES:
  Hydro Eff Imp                35      35      35      35      35
  Small Hydro 1                57      57      57      57      57
  Small Hydro 2                72      72      72      72      72
  Combined Cycle 1            349     349     349     349     349
  WNP 3                         0       0       0       0       0
  Combined Cycle 2            349     349     349     349     349
  Cogen 1                     100     100     160     220     240
  WNP 1                         0       0       0       0       0
  E. Mont Coal                  0       0       0       0     300
  Cogen 2                       8       8       8      24      24
  Geothermal                    0       0       0       0       0
  Mun. Solid Waste              0       0       0       0       0
  Small Hydro 3                 0       0       0       0       0
  E. Wash Coal                  0       0       0       0       0
  E. Oregon Coal                0       0       0       0       0
  Wind 1                        0       0       0       0       7
  Nevada Coal                   0       0       0       0       0
  W. Wa/Or Coal                 0       0       0       0       0
  Small Hydro 4                 0       0       0       0       0
  Cogen 3                       0       0       0       0       0
  Wind 2                        0       0       0       0       0
  Cogen 4                       0       0       0       0       0
  Biomass                       0       0       0       0       0
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                    970     970    1030    1106    1433

Total Firm Resources        21015   21078   21201   21353   21628

Load/Resource Balance        1204    1051     938     849     881
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Study ID   :  29-NOV-90 11:33:00
Study Title:  Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                                        Pg    1

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),       PARTY = BPA
                                                                                                                          Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load             3028   3055   3066   3095   3140   3190   3242   3292   3342   3393   3442   3491   3540   3595   3655
Observed Rate                   0.88%  0.36%  0.94%  1.46%  1.60%  1.62%  1.54%  1.53%  1.53%  1.43%  1.43%  1.38%  1.57%  1.66%
DSI Firm Load             2184   2154   2123   2093   2063   2032   2002   2002   2002   2002   2002   2002   2002   2002   2002

Existing Resources        7444   7462   7450   7438   7484   7530   7661   7792   7747   7703   7698   7692   7623   7553   7560

BPA Requirements         -2255  -2352  -2438  -2287  -2364  -2447  -2521  -2463  -2544  -2626  -2677  -2729  -2802  -2885  -2953

CONSERVATION PROGRAMS:
  SF Res MCS                 2      4      6      7      9     10     12     13     14     16     17     19     20     22     23
  MF Res MCS                 1      1      2      2      3      3      4      4      5      5      6      6      7      7      8
  Commercial MCS             0      1      3      4      5      7      9     10     12     14     16     18     20     22     24
  Water Heat                 0      0      0      0      0      2      4      6      9     11     13     16     19     21     24
  Refrigerators              0      0      0      0      0      1      2      3      4      5      6      7      8      9     10
  Freezers                   0      0      0      0      0      0      1      1      2      2      2      3      3      4      4
  New Manuf Housing          1      1      2      3      3      4      5      5      6      7      8      8      9     10     11
  BPA Contract Recall        0      0      0      0      0      0     97    195    292    292    292    292    292    292    292
  Cons. Volt. Reg.           0      2      6     10     14     18     23     27     31     35     39     41     41     41     41
  Industrial                 0      4     16     30     44     58     71     85     99    113    128    144    160    176    193
  T&D Effic Impr             0      3      7     11     15     19     23     26     30     34     39     44     49     54     60
  MF Res Weath               0      0      1      2      4      5      7      8      9     11     12     12     12     12     12
  Existing Commercial        0      2     10     18     27     35     44     52     60     69     78     88     97    107    117
  SF Res Weath               0      2      7     12     17     22     27     32     37     42     50     60     68     68     68
  Irrigation                 0      0      0      0      1      1      2      2      3      3      3      3      4      6      9
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   4     20     60     99    142    185    331    469    613    659    709    761    809    851    896

GENERATING RESOURCES:
  Hydro Eff Imp              0      0      0      0      0      0      0      0     15     30     30     45     60     75     75
  Small Hydro 1              0      0      0      0      0      0      0      0      0      0      0      0      0     14     29
  Small Hydro 2              0      0      0      0      0      0      0      0      0      0      0      0      0     11     22
  Combined Cycle 1           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  WNP 3                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 1                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  WNP 1                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 2                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Geothermal                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0      0      0      0      0      0      0     15     30     30     45     60    100    126

Total Firm Resources      5192   5131   5071   5251   5262   5270   5468   5800   5831   5765   5758   5769   5690   5619   5627

Load/Resource Balance      -21    -78   -118     64     60     48    224    506    487    370    315    276    148     22    -29
```

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Study ID    :  29-NOV-90 11:33:00                                                              Pg    2
Study Title:  Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW).      PARTY = BPA                 Game = 0001

Operating Year            05-06   06-07   07-08   08-09   09-10
                          -----   -----   -----   -----   -----
Observed Load              3719    3784    3850    3917    3982
Observed Rate             1.75%   1.75%   1.75%   1.75%   1.66%
DSI Firm Load              2002    2002    2002    2002    2002

Existing Resources         7566    7572    7577    7583    7577

BPA Requirements          -2914   -2937   -3020   -3104   -3050

CONSERVATION PROGRAMS:
  SF Res MCS                 25      26      28      29      31
  MF Res MCS                  8       8       9       9      10
  Commercial MCS             26      28      31      33      35
  Water Heat                 26      29      31      33      36
  Refrigerators              11      12      14      15      17
  Freezers                    5       5       6       6       7
  New Manuf Housing          12      12      13      14      15
  BPA Contract Recall       292     292     292     292     292
  Cons. Volt. Reg.           41      41      41      41      41
  Industrial                198     198     198     198     198
  T&D Effic Impr             65      70      75      80      86
  MF Res Weath               12      12      12      12      12
  Existing Commercial       119     119     119     119     119
  SF Res Weath               68      68      68      68      68
  Irrigation                 13      16      19      22      26
                          -----   -----   -----   -----   -----
  Subtotal                  921     936     956     971     993

GENERATING RESOURCES:
  Hydro Eff Imp              75      75      75      75      75
  Small Hydro 1              29      29      29      29      29
  Small Hydro 2              33      36      36      36      36
  Combined Cycle 1            0       0     349     349     349
  WNP 3                       0       0       0       0       0
  Combined Cycle 2            0       0       0       0       0
  Cogen 1                     0       0       0       0       0
  WNP 1                       0       0       0       0       0
  E. Mont Coal                0       0       0       0       0
  Cogen 2                     0       0       0       0       0
  Geothermal                  0       0       0       0       0
  Mun. Solid Waste            0       0       0       0       0
  Small Hydro 3               0       0       0       0       0
  E. Wash Coal                0       0       0       0       0
  E. Oregon Coal              0       0       0       0       0
  Wind 1                      0       0       0       0       0
  Nevada Coal                 0       0       0       0       0
  W. Wa/Or Coal               0       0       0       0       0
  Small Hydro 4               0       0       0       0       0
  Cogen 3                     0       0       0       0       0
  Wind 2                      0       0       0       0       0
  Cogen 4                     0       0       0       0       0
  Biomass                     0       0       0       0       0
  Replacement                 0       0       0       0       0
                          -----   -----   -----   -----   -----
  Subtotal.                 137     140     489     489     489

Total Firm Resources       5707    5711    6000    5940    6005

Load/Resource Balance       -13     -74     148      21      21
```

Study ID : 29-NOV-90 11:33:00
Study Title: Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = IOUs

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	9192	9294	9397	9502	9617	9742	9880	10010	10130	10252	10368	10484	10602	10744	10897
Observed Rate		1.11%	1.11%	1.12%	1.21%	1.30%	1.41%	1.32%	1.21%	1.20%	1.12%	1.12%	1.13%	1.33%	1.43%
Existing Resources	9342	9322	9270	9218	9145	9072	8907	8741	8621	8501	8450	8400	8379	8357	8313
BPA Requirements	107	138	188	0	0	0	0	0	0	0	0	0	0	0	0
CONSERVATION PROGRAMS:															
SF Res MCS	3	6	9	11	14	16	19	22	24	27	30	32	35	38	41
MF Res MCS	2	3	5	6	8	9	11	12	13	15	16	18	19	21	22
Commercial MCS	0	9	18	28	37	48	60	72	83	96	108	120	133	147	160
Water Heat	0	0	0	0	1	6	11	16	22	27	33	40	46	52	58
Refrigerators	0	0	0	0	1	3	6	8	11	13	16	20	23	25	28
Freezers	0	0	0	0	0	1	2	4	5	6	7	8	10	11	12
New Manuf Housing	1	3	4	6	8	10	12	14	16	18	20	22	24	26	28
Cons. Volt. Reg.	0	3	9	15	21	27	33	39	45	50	55	59	59	59	59
Industrial	0	4	16	32	48	64	81	97	113	129	145	161	177	193	198
T&D Effic Impr	0	2	7	12	17	22	27	31	36	41	46	51	56	60	65
MF Res Weath	0	1	6	12	17	22	27	33	38	41	41	41	41	41	41
Existing Commercial	0	6	22	45	67	90	112	135	157	180	203	225	247	270	272
SF Res Weath	0	2	9	18	28	38	48	58	62	62	62	62	62	62	62
Irrigation	0	1	5	10	15	19	24	29	34	39	44	46	46	46	46
Subtotal	6	40	110	195	282	375	473	570	659	744	826	905	978	1051	1092
GENERATING RESOURCES:															
Hydro Eff Imp	0	0	5	15	25	30	30	35	35	35	35	35	35	35	35
Small Hydro 1	0	0	0	0	0	0	33	57	57	57	57	57	57	57	57
Small Hydro 2	0	0	0	0	0	0	25	51	69	72	72	72	72	72	72
Combined Cycle 1	0	0	0	0	0	0	349	349	349	349	349	349	349	349	349
WNP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle 2	0	0	0	0	0	0	0	0	0	0	0	349	349	349	349
Cogen 1	0	0	0	0	0	20	20	80	140	180	220	220	220	220	240
WNP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Mont Coal	0	0	0	0	0	0	0	0	0	300	300	300	300	300	300
Cogen 2	0	0	0	0	0	0	0	32	32	32	32	32	32	32	32
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mun. Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Wash Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Oregon Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Wa/Or Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Hydro 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	5	15	25	50	457	604	682	1025	1065	1414	1414	1414	1434
Total Firm Resources	9454	9500	9574	9428	9451	9498	9836	9913	9962	10271	10343	10721	10773	10824	10842
Load/Resource Balance	263	207	177	-74	-165	-244	-44	-96	-168	18	-25	237	170	81	-55

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Study ID   :  29-NOV-90 11:33:00                                                    Pg    4
Study Title:  Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = IOUs            Game = 0001

Operating Year             05-06   06-07   07-08   08-09   09-10
                           -----   -----   -----   -----   -----
Observed Load              11064   11233   11405   11578   11743
Observed Rate              1.53%   1.53%   1.53%   1.52%   1.42%

Existing Resources          8154    8101    8111    8131    7892

BPA Requirements               0       0       0       0       0

CONSERVATION PROGRAMS:
  SF Res MCS                  44      47      49      52      55
  MF Res MCS                  24      25      26      28      29
  Commercial MCS             174     188     202     216     232
  Water Heat                  64      70      76      82      88
  Refrigerators               31      35      38      41      45
  Freezers                    13      14      15      17      18
  New Manuf Housing           30      32      34      36      38
  Cons. Volt. Reg.            59      59      59      59      59
  Industrial                 198     198     198     198     198
  T&D Effic Impr              70      75      80      84      89
  MF Res Weath                41      41      41      41      41
  Existing Commercial        272     272     272     272     272
  SF Res Weath                62      62      62      62      62
  Irrigation                  46      46      46      46      46
                           -----   -----   -----   -----   -----
  Subtotal                  1128    1164    1198    1234    1272

GENERATING RESOURCES:
  Hydro Eff Imp               35      35      35      35      35
  Small Hydro 1               57      57      57      57      57
  Small Hydro 2               72      72      72      72      72
  Combined Cycle 1           349     349     349     349     349
  WNP 3                        0       0       0       0       0
  Combined Cycle 2           349     349     349     349     349
  Cogen 1                    260     260     260     280     300
  WNP 1                        0       0       0       0       0
  E. Mont Coal               600     901     901     901    1201
  Cogen 2                     32      32      32      32      32
  Geothermal                  50      75     100     150     200
  Mun. Solid Waste             0       0       0       0      15
  Small Hydro 3                0       0       0       0       0
  E. Wash Coal                 0       0       0       0       0
  E. Oregon Coal               0       0       0       0       0
  Wind 1                       0       0       0       0       0
  Nevada Coal                  0       0       0       0       0
  W. Wa/Or Coal                0       0       0       0       0
  Small Hydro 4                0       0       0       0       0
  Cogen 3                      0       0       0       0       0
  Wind 2                       0       0       0       0       0
  Cogen 4                      0       0       0       0       0
  Biomass                      0       0       0       0       0
  Replacement                  0       0       0       0       0
                           -----   -----   -----   -----   -----
  Subtotal                  1804    2130    2155    2225    2610

Total Firm Resources       11088   11396   11466   11592   11776

Load/Resource Balance         24     163      61      13      33
```

Study ID : 29-NOV-90 11:33:00
Study Title: Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY: Observed Loads and Resources (Avg MW), PARTY = Generating Publics

Game = 0001

Operating Year	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
Observed Load	4593	4646	4700	4755	4816	4882	4955	5026	5089	5154	5212	5271	5331	5402	5480
Observed Rate		1.16%	1.16%	1.16%	1.28%	1.37%	1.51%	1.42%	1.27%	1.27%	1.13%	1.13%	1.14%	1.34%	1.44%
Existing Resources	2445	2432	2450	2468	2451	2435	2434	2433	2411	2390	2394	2398	2381	2365	2372
BPA Requirements	2148	2214	2250	2287	2364	2447	2521	2463	2544	2626	2677	2729	2802	2885	2953
CONSERVATION PROGRAMS:															
SF Res MCS	2	4	5	7	8	9	11	12	13	15	16	17	19	20	22
MF Res MCS	1	1	2	2	3	3	3	4	4	5	5	6	6	7	7
Commercial MCS	0	2	5	7	9	12	14	17	20	23	26	30	33	36	40
Water Heat	0	0	0	0	0	2	4	6	8	10	12	15	17	20	22
Refrigerators	0	0	0	0	0	1	2	3	4	4	5	7	8	8	9
Freezers	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4
New Manuf Housing	0	1	2	2	3	4	4	5	6	6	7	8	8	9	10
Subtotal	3	8	14	18	23	31	39	48	56	65	73	86	94	103	114
GENERATING RESOURCES:															
Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Firm Resources	4596	4655	4713	4773	4839	4913	4995	4944	5012	5081	5146	5212	5277	5354	5438
Load/Resource Balance	3	8	13	18	23	31	39	-82	-78	-73	-66	-59	-53	-48	-42

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Study ID   :  29-NOV-90 11:33:00
Study Title:  Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                   Pg    6

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics
                                                                                                    Game = 0001
Operating Year               05-06  06-07  07-08  08-09  09-10
                             -----  -----  -----  -----  -----
Observed Load                 5564   5650   5737   5826   5910
Observed Rate                1.54%  1.54%  1.54%  1.54%  1.44%

Existing Resources            2496   2559   2559   2559   2699

BPA Requirements              2914   2937   3020   3104   3050

CONSERVATION PROGRAMS:
  SF Res MCS                    23     24     26     27     28
  MF Res MCS                     7      8      8      9      9
  Commercial MCS                43     47     51     55     59
  Water Heat                    24     26     28     31     33
  Refrigerators                 10     11     13     14     15
  Freezers                       4      5      5      6      6
  New Manuf Housing             11     11     12     13     13
                             -----  -----  -----  -----  -----
  Subtotal                     122    132    143    155    163

GENERATING RESOURCES:
  Replacement                    0      0      0      0      0
                             -----  -----  -----  -----  -----
  Subtotal                       0      0      0      0      0

Total Firm Resources          5534   5629   5721   5816   5914

Load/Resource Balance          -30    -21    -16    -10      4
```

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Study ID   :  29-NOV-90 11:33:00
Study Title:  Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                          Pg    7

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = REGION
                                                                                                          Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load            16813  16995  17163  17352  17572  17814  18077  18327  18562  18800  19022  19246  19473  19741  20032
Observed Rate                   1.08%  0.99%  1.10%  1.27%  1.38%  1.48%  1.38%  1.28%  1.28%  1.18%  1.18%  1.18%  1.38%  1.47%
DSI Firm Load             2184   2154   2123   2093   2063   2032   2002   2002   2002   2002   2002   2002   2002   2002   2002

Existing Resources       19230  19216  19170  19124  19080  19037  19002  18966  18780  18594  18542  18490  18383  18275  18245

CONSERVATION PROGRAMS:
  SF Res MCS                 7     14     20     25     31     35     42     47     51     58     63     68     74     80     86
  MF Res MCS                 4      5      9     10     14     15     18     20     22     25     27     30     32     35     37
  Commercial MCS             0     12     26     39     51     67     83     99    115    133    150    168    186    205    224
  Water Heat                 0      0      0      0      1     10     19     28     39     48     58     71     82     93    104
  Refrigerators              0      0      0      0      1      5     10     14     19     22     27     34     39     42     47
  Freezers                   0      0      0      0      0      1      4      6      8     10     11     14     16     18     20
  New Manuf Housing          2      5      8     11     14     18     21     24     28     31     35     38     41     45     49
  BPA Contract Recall        0      0      0      0      0      0     97    195    292    292    292    292    292    292    292
  Cons. Volt. Reg.           0      5     15     25     35     45     56     66     76     85     94    100    100    100    100
  Industrial                 0      8     32     62     92    122    152    182    212    242    273    305    337    369    391
  T&D Effic Impr             0      5     14     23     32     41     50     57     66     75     85     95    105    114    125
  MF Res Weath               0      1      7     14     21     27     34     41     47     52     53     53     53     53     53
  Existing Commercial        0      8     32     63     94    125    156    187    217    249    281    313    344    377    389
  SF Res Weath               0      4     16     30     45     60     75     90     99    104    112    122    130    130    130
  Irrigation                 0      1      5     10     16     20     26     31     37     42     47     49     50     52     55
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                  13     68    184    312    447    591    843   1087   1328   1468   1608   1752   1881   2005   2102

GENERATING RESOURCES:
  Hydro Eff Imp              0      0      5     15     25     30     30     35     50     65     65     80     95    110    110
  Small Hydro 1              0      0      0      0      0      0     33     57     57     57     57     57     57     71     86
  Small Hydro 2              0      0      0      0      0      0     25     51     69     72     72     72     72     83     94
  Combined Cycle 1           0      0      0      0      0      0    349    349    349    349    349    349    349    349    349
  WNP 3                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2           0      0      0      0      0      0      0      0      0      0      0    349    349    349    349
  Cogen 1                    0      0      0      0      0     20     20     80    140    180    220    220    220    220    240
  WNP 1                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal               0      0      0      0      0      0      0      0      0    300    300    300    300    300    300
  Cogen 2                    0      0      0      0      0      0      0     32     32     32     32     32     32     32     32
  Geothermal                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0      5     15     25     50    457    604    697   1055   1095   1459   1474   1514   1560

Total Firm Resources     19242  19286  19358  19452  19552  19681  20299  20657  20805  21117  21247  21701  21740  21797  21907

Load/Resource Balance      245    137     71      7    -82   -165    220    328    241    315    223    454    265     55   -126
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Study ID    :  29-NOV-90 11:33:00
Study Title:   Medium Loads, MHIGH Discr Cons Schedule, Perfect Knowledge

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                               Game = 0001
Operating Year             05-06   06-07   07-08   08-09   09-10
                           -----   -----   -----   -----   -----
Observed Load              20347   20667   20992   21322   21635
Observed Rate              1.57%   1.57%   1.57%   1.57%   1.47%
DSI Firm Load               2002    2002    2002    2002    2002

Existing Resources         18216   18232   18247   18273   18168

CONSERVATION PROGRAMS:
  SF Res MCS                  92      97     103     108     114
  MF Res MCS                  39      41      43      46      48
  Commercial MCS             243     263     284     304     326
  Water Heat                 114     125     135     146     157
  Refrigerators               52      58      65      70      77
  Freezers                    22      24      26      29      31
  New Manuf Housing           53      55      59      63      66
  BPA Contract Recall        292     292     292     292     292
  Cons. Volt. Reg.           100     100     100     100     100
  Industrial                 396     396     396     396     396
  T&D Effic Impr             135     145     155     164     175
  MF Res Weath                53      53      53      53      53
  Existing Commercial        391     391     391     391     391
  SF Res Weath               130     130     130     130     130
  Irrigation                  59      62      65      68      72
                           -----   -----   -----   -----   -----
  Subtotal                  2171    2232    2297    2360    2428

GENERATING RESOURCES:
  Hydro Eff Imp              110     110     110     110     110
  Small Hydro 1               86      86      86      86      86
  Small Hydro 2              105     108     108     108     108
  Combined Cycle 1           349     349     698     698     698
  WNP 3                        0       0       0       0       0
  Combined Cycle 2           349     349     349     349     349
  Cogen 1                    260     260     260     280     300
  WNP 1                        0       0       0       0       0
  E. Mont Coal               600     901     901     901    1201
  Cogen 2                     32      32      32      32      32
  Geothermal                  50      75     100     150     200
  Mun. Solid Waste             0       0       0       0      15
  Small Hydro 3                0       0       0       0       0
  E. Wash Coal                 0       0       0       0       0
  E. Oregon Coal               0       0       0       0       0
  Wind 1                       0       0       0       0       0
  Nevada Coal                  0       0       0       0       0
  W. Wa/Or Coal                0       0       0       0       0
  Small Hydro 4                0       0       0       0       0
  Cogen 3                      0       0       0       0       0
  Wind 2                       0       0       0       0       0
  Cogen 4                      0       0       0       0       0
  Biomass                      0       0       0       0       0
  Replacement                  0       0       0       0       0
                           -----   -----   -----   -----   -----
  Subtotal                  1941    2270    2644    2714    3099

Total Firm Resources       22329   22736   23187   23347   23695

Load/Resource Balance        -20      67     194      24      58
```

```
Study ID    :  29-NOV-90 10:54:18
Study Title:   Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                      Pg     1

SYSTEM SUMMARY:   Observed Loads and Resources (Avg MW),       PARTY = BPA
                                                                                                           Game = 0001
Operating Year          90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                        -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load            3076   3130   3170   3222   3285   3355   3431   3504   3571   3636   3701   3767   3833   3908   3987
Observed Rate                  1.78%  1.26%  1.66%  1.95%  2.11%  2.29%  2.11%  1.91%  1.82%  1.79%  1.80%  1.75%  1.93%  2.03%
DSI Firm Load            2282   2230   2237   2244   2228   2212   2211   2211   2211   2210   2197   2183   2170   2170   2170

Existing Resources       7444   7462   7450   7438   7484   7530   7661   7792   7747   7703   7698   7692   7623   7553   7560

BPA Requirements        -2347  -2497  -2639  -2536  -2653  -2778  -2893  -2849  -2964  -3076  -3154  -3234  -3335  -3449  -3548

CONSERVATION PROGRAMS:
  SF Res MCS                3      5      8     10     12     14     16     18     20     22     24     26     28     30     33
  MF Res MCS                1      1      2      2      3      3      4      4      5      5      6      6      7      7      8
  Commercial MCS            0      2      4      6      8     10     12     14     16     18     20     22     25     27     30
  Water Heat                0      0      0      0      1      3      5      7      9     12     14     17     20     23     26
  Refrigerators             0      0      0      0      0      1      2      3      4      5      6      8      9     10     11
  Freezers                  0      0      0      0      0      1      1      1      2      2      3      3      4      4      5
  New Manuf Housing         1      1      2      3      4      4      5      6      7      8      8      9     10     11     12
  BPA Contract Recall      64    128    192    242    242    242    242    292    292    292    292    292    292    292    292
  Cons. Volt. Reg.          0      2      6     10     14     18     23     27     31     35     37     37     39     41     41
  Industrial                0      4     16     30     44     58     71     85     99    113    123    129    139    154    170
  T&D Effic Impr            0      3      7     11     15     19     23     26     30     34     36     36     38     43     49
  MF Res Weath              0      0      1      2      4      5      7      8      9     11     12     12     12     12     12
  Existing Commercial       0      2     10     18     27     35     44     52     60     69     75     78     84     93    103
  SF Res Weath              0      2      7     12     17     22     27     32     37     42     45     46     52     61     68
  Irrigation                0      0      0      0      1      1      2      2      3      3      3      3      4      6      9
                        -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                 69    150    255    346    392    436    484    577    624    671    704    724    763    814    869

GENERATING RESOURCES:
  Hydro Eff Imp             0      0     15     30     45     45     45     45     60     60     60     65     65     65     65
  Small Hydro 1             0      0      0      0      0      0      0      0      0     14     29     29     29     29     29
  Small Hydro 2             0      0      0      0      0      0      0      0      0     11     22     22     22     22     22
  Combined Cycle 1          0      0      0      0      0    349    349    349    349    349    697    697    697    697    697
  WNP 3                     0      0      0      0      0      0      0      0      0      0      0      0    868    868    868
  Combined Cycle 2          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 1                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  WNP 1                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 2                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Geothermal                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                        -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                  0      0     15     30     45    394    394    394    409    434    808    813   1681   1681   1681

Total Firm Resources     5164   5115   5080   5279   5266   5582   5644   5914   5816   5732   6055   5996   6730   6598   6558

Load/Resource Balance    -194   -245   -327   -187   -247     16      1    199     35   -114    157     45    726    521    401
```

```
Study ID   :  29-NOV-90 10:54:18
Study Title:  Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                      Pg    2

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = BPA
                                                                                                              Game = 0001
Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load                4068    4146    4229    4322    4413
Observed Rate               2.03%   1.92%   2.01%   2.19%   2.11%
DSI Firm Load                2170    2170    2170    2170    2170

Existing Resources           7566    7572    7577    7583    7577

BPA Requirements            -3538   -3583   -3694   -3821   -3810

CONSERVATION PROGRAMS:
  SF Res MCS                   35      37      39      41      43
  MF Res MCS                    8       9       9      10      10
  Commercial MCS               33      35      38      41      44
  Water Heat                   28      31      33      36      39
  Refrigerators                12      14      15      16      18
  Freezers                      5       6       6       7       8
  New Manuf Housing            13      14      15      15      16
  BPA Contract Recall         292     292     292     292     292
  Cons. Volt. Reg.             41      41      41      41      41
  Industrial                  186     202     218     221     221
  T&D Effic Impr               54      59      64      69      74
  MF Res Weath                 12      12      12      12      12
  Existing Commercial         113     123     132     142     142
  SF Res Weath                 68      68      68      68      68
  Irrigation                   13      16      19      22      26
                            -----   -----   -----   -----   -----
  Subtotal                    913     959    1001    1033    1054

GENERATING RESOURCES:
  Hydro Eff Imp                65      65      65      75      75
  Small Hydro 1                29      29      29      29      29
  Small Hydro 2                22      22      22      33      36
  Combined Cycle 1            697     697     697     697     697
  WNP 3                       868     868     868     868     868
  Combined Cycle 2              0       0       0       0       0
  Cogen 1                       0       0       0       0      40
  WNP 1                         0       0       0       0       0
  E. Mont Coal                  0       0       0       0       0
  Cogen 2                       0       0       0       0      16
  Geothermal                    0       0       0       0       0
  Mun. Solid Waste              0       0       0       0       0
  Small Hydro 3                 0       0       0       0       0
  E. Wash Coal                  0       0       0       0       0
  E. Oregon Coal                0       0       0       0       0
  Wind 1                        0       0       0       7       7
  Nevada Coal                   0       0       0       0       0
  W. Wa/Or Coal                 0       0       0       0       0
  Small Hydro 4                 0       0       0       0       0
  Cogen 3                       0       0       0       0      40
  Wind 2                        0       0       0       0       0
  Cogen 4                       0       0       0       0       0
  Biomass                       0       0       0       0       0
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                   1681    1681    1681    1709    1808

Total Firm Resources         6619    6625    6564    6503    6627

Load/Resource Balance         382     310     165      12      45
```

```
Study ID    :  29-NOV-90 10:54:18
Study Title:   Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                    Pg   3

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = IOUs
                                                                                                      Game = 0001
Operating Year                90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                              -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load                  9360   9567   9781   9979  10171  10377  10596  10799  10983  11158  11327  11500  11675  11876  12092
Observed Rate                         2.22%  2.23%  2.03%  1.92%  2.03%  2.12%  1.92%  1.70%  1.60%  1.52%  1.52%  1.52%  1.72%  1.82%

Existing Resources             9342   9322   9270   9218   9145   9072   8907   8741   8621   8501   8450   8400   8379   8357   8313

BPA Requirements                107    138    188      0      0      0      0      0      0      0      0      0      0      0      0

CONSERVATION PROGRAMS:
  SF Res MCS                      4      8     12     16     20     23     27     31     34     38     42     45     49     53     57
  MF Res MCS                      2      3      5      7      8      9     11     12     14     15     17     18     20     21     23
  Commercial MCS                  0     12     25     38     52     65     79     93    108    123    137    152    168    184    200
  Water Heat                      0      0      0      0      1      6     11     17     23     29     36     42     49     56     63
  Refrigerators                   0      0      0      0      1      3      6      9     12     15     18     22     25     28     31
  Freezers                        0      0      0      0      0      1      3      4      5      6      8      9     11     12     13
  New Manuf Housing               1      3      5      7      9     11     13     15     18     20     22     24     27     29     31
  Cons. Volt. Reg.                0      3      9     15     21     27     33     39     45     50     55     59     59     59     59
  Industrial                      0      4     16     32     48     64     81     97    113    129    145    161    177    193    210
  T&D Effic Impr                  0      2      7     12     17     22     27     31     36     41     46     51     56     60     65
  MF Res Weath                    0      1      6     12     17     22     27     33     38     41     41     41     41     41     41
  Existing Commercial             0      6     22     45     67     90    112    135    157    180    203    225    247    270    292
  SF Res Weath                    0      2      9     18     28     38     48     58     62     62     62     62     62     62     62
  Irrigation                      0      1      5     10     15     19     24     29     34     39     44     46     46     46     46
                              -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                        7     45    121    212    304    400    502    603    699    788    876    957   1037   1114   1193

GENERATING RESOURCES:
  Hydro Eff Imp                   0      0      5     15     25     35     35     35     35     35     35     35     35     35     35
  Small Hydro 1                   0      0      0      0      0      0     33     57     57     57     57     57     57     57     57
  Small Hydro 2                   0      0      0      0      0      0     25     51     69     69     72     72     72     72     72
  Combined Cycle 1                0      0      0      0      0    349    349    349    349    349    349    349    349    349    349
  WNP 3                           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2                0      0      0      0      0      0      0      0      0      0      0    349    349    349    349
  Cogen 1                         0      0      0      0     60    120    180    240    260    260    280    280    280    300    300
  WNP 1                           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal                    0      0      0      0      0      0      0      0      0    600    600    600    600    600    901
  Cogen 2                         0      0      0      0     32     32     32     32     32     32     32     32     32     32     32
  Geothermal                      0      0      0      0      0     50    100    100    100    100    100    100    100    150    150
  Mun. Solid Waste                0      0      0      0      0      0      0      0      0      0      0      0      0      8      8
  Small Hydro 3                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      4
  E. Wash Coal                    0      0      0      0      0      0      0    500    500    500    500    500    500    500    500
  E. Oregon Coal                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                          0      0      0      0      0      0      0      0      0      0      0      0      0     13     13
  Nevada Coal                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                          0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                              -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                        0      0      5     15    117    586    754   1364   1402   2002   2025   2374   2374   2465   2770

Total Firm Resources           9455   9505   9584   9444   9566  10060  10164  10708  10721  11291  11351  11734  11791  11938  12276

Load/Resource Balance            96    -63   -197   -535   -605   -317   -433    -91   -261    133     23    234    116     62    184
```

```
Study ID   :  29-NOV-90 10:54:18
Study Title:  Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                Pg    4

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = IOUs
                                                                                     Game = 0001
Operating Year            05-06   06-07   07-08   08-09   09-10
                          -----   -----   -----   -----   -----
Observed Load             12313   12525   12754   13012   13263
Observed Rate             1.82%   1.73%   1.83%   2.02%   1.93%

Existing Resources         8154    8101    8111    8131    7892

BPA Requirements              0       0       0       0       0

CONSERVATION PROGRAMS:
  SF Res MCS                 61      65      69      73      77
  MF Res MCS                 24      26      27      29      30
  Commercial MCS            216     233     250     268     286
  Water Heat                 69      76      82      89      96
  Refrigerators              34      38      41      45      49
  Freezers                   14      16      17      19      20
  New Manuf Housing          34      36      38      41      43
  Cons. Volt. Reg.           59      59      59      59      59
  Industrial                221     221     221     221     221
  T&D Effic Impr             70      75      80      84      89
  MF Res Weath               41      41      41      41      41
  Existing Commercial       315     326     326     326     326
  SF Res Weath               62      62      62      62      62
  Irrigation                 46      46      46      46      46
                          -----   -----   -----   -----   -----
  Subtotal                 1266    1320    1359    1403    1445

GENERATING RESOURCES:
  Hydro Eff Imp              35      35      35      35      35
  Small Hydro 1              57      57      57      57      57
  Small Hydro 2              72      72      72      72      72
  Combined Cycle 1          349     349     349     349     349
  WNP 3                       0       0       0       0       0
  Combined Cycle 2          349     349     349     349     349
  Cogen 1                   300     320     320     320     320
  WNP 1                       0       0       0       0       0
  E. Mont Coal             1201    1201    1201    1201    1201
  Cogen 2                    32      32      32      32      32
  Geothermal                175     225     250     250     250
  Mun. Solid Waste            8      15      15      15      15
  Small Hydro 3               4      15      41      66      66
  E. Wash Coal              500     500     500     500     500
  E. Oregon Coal              0       0       0     250     250
  Wind 1                     13      13      13      13      13
  Nevada Coal                 0       0       0       0     500
  W. Wa/Or Coal               0       0       0       0       0
  Small Hydro 4               0       0       0       0       0
  Cogen 3                     0       0       0       0       0
  Wind 2                      0       0       0       0       0
  Cogen 4                     0       0       0       0       0
  Biomass                     0       0       0       0       0
  Replacement                 0       0       0       0       0
                          -----   -----   -----   -----   -----
  Subtotal                 3095    3183    3234    3509    4009

Total Firm Resources      12516   12604   12706   13043   13349

Load/Resource Balance       203      79     -48      31      86
```

```
Study ID   :  29-NOV-90 10:54:18
Study Title:  Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                              Pg    5

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = Generating Publics
                                                                                                                    Game = 0001
Operating Year            90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load              4685   4791   4901   5004   5104   5213   5327   5433   5532   5627   5713   5802   5892   5995   6107
Observed Rate                    2.27%  2.29%  2.09%  2.02%  2.12%  2.19%  1.99%  1.83%  1.72%  1.54%  1.54%  1.56%  1.76%  1.86%

Existing Resources         2445   2432   2450   2468   2451   2435   2434   2433   2411   2390   2394   2398   2381   2365   2372

BPA Requirements           2240   2359   2451   2536   2653   2778   2893   2849   2964   3076   3154   3234   3335   3449   3548

CONSERVATION PROGRAMS:
  SF Res MCS                  3      5      7      9     11     13     15     17     19     21     22     24     26     28     30
  MF Res MCS                  1      1      2      2      3      3      3      4      4      5      5      6      6      7      7
  Commercial MCS              0      3      6     10     13     16     19     23     26     30     33     37     41     46     50
  Water Heat                  0      0      0      0      0      2      4      6      8     11     13     16     19     21     24
  Refrigerators               0      0      0      0      0      1      2      3      4      5      6      7      8      9     10
  Freezers                    0      0      0      0      0      0      1      1      2      2      2      3      3      4      4
  New Manuf Housing           0      1      2      3      3      4      5      6      6      7      8      9      9     10     11
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                    4     10     17     24     30     39     49     60     69     81     89    102    112    125    136

GENERATING RESOURCES:
  Replacement                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0

Total Firm Resources       4688   4802   4918   5027   5135   5253   5376   5342   5445   5545   5638   5733   5830   5938   6056

Load/Resource Balance         4     10     17     24     31     40     50    -91    -87    -82    -76    -68    -62    -57    -51
```

```
Study ID   :  29-NOV-90 10:54:18
Study Title:  Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                               Pg    6

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics
                                                                                                        Game = 0001
Operating Year             05-06  06-07  07-08  08-09  09-10
                           -----  -----  -----  -----  -----
Observed Load               6220   6330   6448   6581   6710
Observed Rate              1.86%  1.76%  1.86%  2.06%  1.96%

Existing Resources          2496   2559   2559   2559   2699

BPA Requirements            3538   3583   3694   3821   3810

CONSERVATION PROGRAMS:
  SF Res MCS                  32     34     36     38     40
  MF Res MCS                   8      8      9      9      9
  Commercial MCS              54     58     63     68     72
  Water Heat                  26     28     31     33     36
  Refrigerators               11     12     14     15     17
  Freezers                     5      5      6      6      7
  New Manuf Housing           12     13     13     14     15
                           -----  -----  -----  -----  -----
  Subtotal                   148    158    172    183    196

GENERATING RESOURCES:
  Replacement                  0      0      0      0      0
                           -----  -----  -----  -----  -----
  Subtotal                     0      0      0      0      0

Total Firm Resources        6182   6301   6424   6563   6705

Load/Resource Balance        -39    -29    -23    -18     -4
```

```
Study ID    :  29-NOV-90 10:54:18
Study Title:   Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                  Pg    7

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                                                      Game = 0001
Operating Year            90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load             17120  17489  17851  18205  18560  18944  19354  19735  20085  20421  20742  21069  21400  21779  22186
Observed Rate                    2.16%  2.07%  1.98%  1.95%  2.07%  2.17%  1.97%  1.77%  1.67%  1.57%  1.58%  1.57%  1.77%  1.87%
DSI Firm Load              2282   2230   2237   2244   2228   2212   2211   2211   2211   2210   2197   2183   2170   2170   2170

Existing Resources        19230  19216  19170  19124  19080  19037  19002  18966  18780  18594  18542  18490  18383  18275  18245

CONSERVATION PROGRAMS:
  SF Res MCS                 10     18     27     35     43     50     58     66     73     81     88     95    103    111    120
  MF Res MCS                  4      5      9     11     14     15     18     20     23     25     28     30     33     35     38
  Commercial MCS              0     17     35     54     73     91    110    130    150    171    190    211    234    257    280
  Water Heat                  0      0      0      0      2     11     20     30     40     52     63     75     88    100    113
  Refrigerators               0      0      0      0      1      5     10     15     20     25     30     37     42     47     52
  Freezers                    0      0      0      0      0      2      5      6      9     10     13     15     18     20     22
  New Manuf Housing           2      5      9     13     16     19     23     27     31     35     38     42     46     50     54
  BPA Contract Recall        64    128    192    242    242    242    242    292    292    292    292    292    292    292    292
  Cons. Volt. Reg.            0      5     15     25     35     45     56     66     76     85     92     96     98    100    100
  Industrial                  0      8     32     62     92    122    152    182    212    242    268    290    316    347    380
  T&D Effic Impr              0      5     14     23     32     41     50     57     66     75     82     87     94    103    114
  MF Res Weath                0      1      7     14     21     27     34     41     47     52     53     53     53     53     53
  Existing Commercial         0      8     32     63     94    125    156    187    217    249    278    303    331    363    395
  SF Res Weath                0      4     16     30     45     60     75     90     99    104    107    108    114    123    130
  Irrigation                  0      1      5     10     16     20     26     31     37     42     47     49     50     52     55
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   80    205    393    582    726    875   1035   1240   1392   1540   1669   1783   1912   2053   2198

GENERATING RESOURCES:
  Hydro Eff Imp               0      0     20     45     70     80     80     80     95     95     95    100    100    100    100
  Small Hydro 1               0      0      0      0      0      0     33     57     57     71     86     86     86     86     86
  Small Hydro 2               0      0      0      0      0      0     25     51     69     80     94     94     94     94     94
  Combined Cycle 1            0      0      0      0      0    698    698    698    698    698   1046   1046   1046   1046   1046
  WNP 3                       0      0      0      0      0      0      0      0      0      0      0      0    868    868    868
  Combined Cycle 2            0      0      0      0      0      0      0      0      0      0      0    349    349    349    349
  Cogen 1                     0      0      0      0     60    120    180    240    260    260    280    280    280    300    300
  WNP 1                       0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal                0      0      0      0      0      0      0      0      0    600    600    600    600    600    901
  Cogen 2                     0      0      0      0     32     32     32     32     32     32     32     32     32     32     32
  Geothermal                  0      0      0      0      0     50    100    100    100    100    100    100    100    150    150
  Mun. Solid Waste            0      0      0      0      0      0      0      0      0      0      0      0      0      8      8
  Small Hydro 3               0      0      0      0      0      0      0      0      0      0      0      0      0      0      4
  E. Wash Coal                0      0      0      0      0      0      0    500    500    500    500    500    500    500    500
  E. Oregon Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                      0      0      0      0      0      0      0      0      0      0      0      0      0     13     13
  Nevada Coal                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                 0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                          -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                    0      0     20     45    162    980   1148   1758   1811   2436   2833   3187   4055   4146   4451

Total Firm Resources      19308  19422  19582  19750  19967  20895  21184  21964  21982  22568  23043  23463  24350  24475  24890

Load/Resource Balance       -94   -297   -506   -699   -821   -260   -382     18   -313    -63    105    211    780    526    535
```

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Study ID   :  29-NOV-90 10:54:18
Study Title:  Med High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                    Pg    8

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                                         Game = 0001
Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load               22601   23001   23431   23915   24385
Observed Rate               1.87%   1.77%   1.87%   2.07%   1.97%
DSI Firm Load                2170    2170    2170    2170    2170

Existing Resources          18216   18232   18247   18273   18168

CONSERVATION PROGRAMS:
  SF Res MCS                  128     136     144     152     160
  MF Res MCS                   40      43      45      48      49
  Commercial MCS              303     326     351     377     402
  Water Heat                  123     135     146     158     171
  Refrigerators                57      64      70      76      84
  Freezers                     24      27      29      32      35
  New Manuf Housing            59      63      66      70      74
  BPA Contract Recall         292     292     292     292     292
  Cons. Volt. Reg.            100     100     100     100     100
  Industrial                  407     423     439     442     442
  T&D Effic Impr              124     134     144     153     163
  MF Res Weath                 53      53      53      53      53
  Existing Commercial         428     449     458     468     468
  SF Res Weath                130     130     130     130     130
  Irrigation                   59      62      65      68      72
                            -----   -----   -----   -----   -----
  Subtotal                   2327    2437    2532    2619    2695

GENERATING RESOURCES:
  Hydro Eff Imp               100     100     100     110     110
  Small Hydro 1                86      86      86      86      86
  Small Hydro 2                94      94      94     105     108
  Combined Cycle 1           1046    1046    1046    1046    1046
  WNP 3                       868     868     868     868     868
  Combined Cycle 2            349     349     349     349     349
  Cogen 1                     300     320     320     320     360
  WNP 1                         0       0       0       0       0
  E. Mont Coal               1201    1201    1201    1201    1201
  Cogen 2                      32      32      32      32      48
  Geothermal                  175     225     250     250     250
  Mun. Solid Waste              8      15      15      15      15
  Small Hydro 3                 4      15      41      66      66
  E. Wash Coal                500     500     500     500     500
  E. Oregon Coal                0       0       0     250     250
  Wind 1                       13      13      13      20      20
  Nevada Coal                   0       0       0       0     500
  W. Wa/Or Coal                 0       0       0       0       0
  Small Hydro 4                 0       0       0       0       0
  Cogen 3                       0       0       0       0      40
  Wind 2                        0       0       0       0       0
  Cogen 4                       0       0       0       0       0
  Biomass                       0       0       0       0       0
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                   4776    4864    4915    5218    5817

Total Firm Resources        25317   25530   25694   26109   26681

Load/Resource Balance         547     359      93      25     126
```

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Study ID   :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                   Pg    1

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = BPA
                                                                                                      Game = 0001
Operating Year         90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                       -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load           3148   3247   3336   3435   3536   3638   3740   3838   3938   4044   4145   4245   4350   4466   4586
Observed Rate                 3.15%  2.74%  2.97%  2.93%  2.90%  2.80%  2.63%  2.60%  2.69%  2.49%  2.40%  2.48%  2.67%  2.68%
DSI Firm Load           2336   2314   2335   2357   2356   2355   2354   2354   2353   2352   2326   2301   2275   2275   2275

Existing Resources      7444   7462   7450   7438   7484   7530   7661   7792   7747   7703   7698   7692   7623   7553   7560

BPA Requirements       -2483  -2719  -2952  -2934  -3118  -3302  -3465  -3440  -3604  -3778  -3918  -4055  -4221  -4403  -4568

CONSERVATION PROGRAMS:
  SF Res MCS               4      9     13     17     21     24     28     31     34     37     41     44     47     51     55
  MF Res MCS               1      1      2      2      3      3      4      5      5      6      6      7      7      8      8
  Commercial MCS           0      3      6      9     12     14     17     20     23     26     29     32     35     38     42
  Water Heat               0      0      0      0      1      3      5      8     10     13     16     20     24     27     30
  Refrigerators            0      0      0      0      0      2      3      4      5      6      8      9     11     12     13
  Freezers                 0      0      0      0      0      1      1      2      2      3      3      4      5      5      6
  New Manuf Housing        0      1      2      3      3      4      5      5      6      7      8      8      9     10     11
  BPA Contract Recall    192    192    192    242    242    242    242    292    292    292    292    292    292    292    292
  Cons. Volt. Reg.         0      2      6     10     14     18     23     27     31     35     39     41     41     41     41
  Industrial               0      4     16     30     44     58     71     85     99    113    128    144    160    176    193
  T&D Effic Impr           0      3      7     11     15     19     23     26     30     34     39     44     49     54     60
  MF Res Weath             0      0      1      2      4      5      7      8      9     11     12     12     12     12     12
  Existing Commercial      0      2     10     18     27     35     44     52     60     69     78     88     97    107    117
  SF Res Weath             0      2      7     12     17     22     27     32     37     42     50     60     68     68     68
  Irrigation               0      0      0      0      1      1      2      2      3      3      4      7     10     13     17
                       -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal               197    219    262    356    404    451    502    599    646    697    753    812    867    914    965

GENERATING RESOURCES:
  Hydro Eff Imp            0      0     15     30     45     60     75     75     75     75     75     75     75     75     75
  Small Hydro 1            0      0      0      0      0      0     14     29     29     29     29     29     29     29     29
  Small Hydro 2            0      0      0      0      0      0     11     22     22     33     36     36     36     36     36
  Combined Cycle 1         0      0      0      0      0    349    697    697    697    697    697    697    697    697    697
  WNP 3                    0      0      0      0      0      0      0      0    868    868    868    868    868    868    868
  Combined Cycle 2         0      0      0      0      0      0      0      0      0      0    349    349    697   1046   1046
  Cogen 1                  0      0      0      0     40     40     40     40     40     80     80     80     80     80    120
  WNP 1                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 2                  0      0      0      0      0      0      0      0      0     16     16     16     16     16     16
  Geothermal               0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Mun. Solid Waste         0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 3            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Wash Coal             0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Oregon Coal           0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 1                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Nevada Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  W. Wa/Or Coal            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4            0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 3                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Wind 2                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Cogen 4                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Biomass                  0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                       -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                 0      0     15     30     85    449    837    863   1731   1798   2150   2150   2498   2847   2887

Total Firm Resources    5158   4961   4774   4891   4854   5129   5534   5814   6522   6420   6682   6599   6767   6911   6842

Load/Resource Balance   -326   -600   -897   -900  -1037   -865   -561   -378    231     23    210     54    142    170    -19
```

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Study ID   :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                    Pg    2

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = BPA                Game = 0001

Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load                4705    4827    4952    5080    5213
Observed Rate               2.59%   2.59%   2.59%   2.60%   2.61%
DSI Firm Load                2275    2275    2275    2275    2275

Existing Resources           7566    7572    7577    7583    7577

BPA Requirements            -4618   -4733   -4910   -5093   -5146

CONSERVATION PROGRAMS:
  SF Res MCS                   58      62      65      69      72
  MF Res MCS                    9      10      10      11      11
  Commercial MCS               45      48      52      55      59
  Water Heat                   33      37      40      43      46
  Refrigerators                15      16      18      20      22
  Freezers                      6       7       8       9      10
  New Manuf Housing            12      13      13      14      15
  BPA Contract Recall         292     292     292     292     292
  Cons. Volt. Reg.             41      41      41      41      41
  Industrial                  209     225     241     257     273
  T&D Effic Impr               65      70      75      80      86
  MF Res Weath                 12      12      12      12      12
  Existing Commercial         127     137     146     156     166
  SF Res Weath                 68      68      68      68      68
  Irrigation                   20      23      26      29      31
                            -----   -----   -----   -----   -----
  Subtotal                   1012    1061    1107    1156    1204

GENERATING RESOURCES:
  Hydro Eff Imp                75      75      75      75      75
  Small Hydro 1                29      29      29      29      29
  Small Hydro 2                36      36      36      36      36
  Combined Cycle 1            697     697     697     697     697
  WNP 3                       868     868     868     868     868
  Combined Cycle 2           1046    1046    1046    1046    1046
  Cogen 1                     120     120     120     120     120
  WNP 1                       818     818     818     818     818
  E. Mont Coal                  0       0       0       0     300
  Cogen 2                      16      16      16      16      16
  Geothermal                    0       0       0       0       0
  Mun. Solid Waste              0       0       0       0       0
  Small Hydro 3                 0       0       0       0       0
  E. Wash Coal                  0       0       0       0       0
  E. Oregon Coal                0       0       0       0       0
  Wind 1                        0       0       0       0       0
  Nevada Coal                   0       0       0       0       0
  W. Wa/Or Coal                 0       0       0       0       0
  Small Hydro 4                 0       0       0       0       0
  Cogen 3                       0       0       0       0       0
  Wind 2                        0       0       0       0       0
  Cogen 4                       0       0       0       0       0
  Biomass                       0       0       0       0       0
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                   3705    3705    3705    3705    4005

Total Firm Resources         7663    7602    7478    7350    7638

Load/Resource Balance         684     501     252      -5     150
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Study ID   :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                                 Pg   3

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = IOUs
                                                                                                              Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load             9626  10004  10398  10766  11093  11418  11728  12022  12311  12618  12910  13196  13502  13842  14190
Observed Rate                   3.92%  3.94%  3.54%  3.04%  2.93%  2.71%  2.51%  2.40%  2.50%  2.31%  2.21%  2.32%  2.52%  2.52%

Existing Resources        9342   9322   9270   9218   9145   9072   8907   8741   8621   8501   8450   8400   8379   8357   8313

BPA Requirements           107    138    188      0      0      0      0      0      0      0      0      0      0      0      0

CONSERVATION PROGRAMS:
  SF Res MCS                 6     12     19     27     33     40     46     52     58     64     70     76     83     89     96
  MF Res MCS                 2      3      5      7      8     10     12     13     15     17     18     20     22     23     25
  Commercial MCS             0     19     39     59     80     99    117    137    157    177    196    216    236    257    278
  Water Heat                 0      0      0      0      1      7     13     20     26     33     41     49     57     65     74
  Refrigerators              0      0      0      0      1      4      8     11     14     18     22     26     30     34     37
  Freezers                   0      0      0      0      0      2      3      5      6      8     10     12     13     15     16
  New Manuf Housing          1      2      4      6      8     10     12     14     16     18     20     22     24     27     29
  Cons. Volt. Reg.           0      3      9     15     21     27     33     39     45     50     55     59     59     59     59
  Industrial                 0      4     16     32     48     64     81     97    113    129    145    161    177    193    210
  T&D Effic Impr             0      2      7     12     17     22     27     31     36     41     46     51     56     60     65
  MF Res Weath               0      1      6     12     17     22     27     33     38     41     41     41     41     41     41
  Existing Commercial        0      6     22     45     67     90    112    135    157    180    203    225    247    270    292
  SF Res Weath               0      2      9     18     28     38     48     58     62     62     62     62     62     62     62
  Irrigation                 0      1      5     10     15     19     24     29     34     39     44     46     46     46     46
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   9     55    141    243    344    454    563    674    777    877    973   1066   1153   1241   1330

GENERATING RESOURCES:
  Hydro Eff Imp              0      0     10     20     30     35     35     35     35     35     35     35     35     35     35
  Small Hydro 1              0      0      0      0      0      0     33     57     57     57     57     57     57     57     57
  Small Hydro 2              0      0      0      0      0      0     25     51     69     72     72     72     72     72     72
  Combined Cycle 1           0      0      0      0      0    349    349    349    349    349    349    349    349    349    349
  WNP 3                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Combined Cycle 2           0      0      0      0      0      0      0      0      0      0      0    349    349    349    349
  Cogen 1                    0      0      0      0     60    120    180    240    260    280    280    280    300    300    300
  WNP 1                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal               0      0      0      0      0      0      0      0      0    600   1201   1201   1201   1201   1201
  Cogen 2                    0      0      0      0     32     32     32     32     32     32     32     32     32     32     32
  Geothermal                 0      0      0      0      0     50     50    100    150    200    200    200    200    225    225
  Mun. Solid Waste           0      0      0      0      0      0      0      0      0      0      0      0      0      8      8
  Small Hydro 3              0      0      0      0      0      0      0      0     26     52     52     52     52     59     59
  E. Wash Coal               0      0      0      0      0      0    500    500    500    500    500    500    500    500    500
  E. Oregon Coal             0      0      0      0      0      0      0      0      0      0      0      0      0    250    500
  Wind 1                     0      0      0      0     13     13     13     13     13     13     13     13     13     13     13
  Nevada Coal                0      0      0      0      0      0      0    500    500    500    500    500    500    500    500
  W. Wa/Or Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4              0      0      0      0      0      0      0      0     25     25     25     25     25     25     33
  Cogen 3                    0      0      0      0    136    136    136    272    272    272    272    272    344    344    472
  Wind 2                     0      0      0      0      0      0      0      0      0      0      0      0     25     49     66
  Cogen 4                    0      0      0      0     32     32     32     32     32     32     32     32     32     32     32
  Biomass                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0     10     20    303    767   1385   2181   2320   3019   3620   3969   4086   4400   4803

Total Firm Resources      9457   9516   9610   9480   9794  10293  10855  11595  11719  12398  13043  13436  13619  14001  14447

Load/Resource Balance     -169   -488   -789  -1287  -1299  -1125   -873   -427   -592   -221    133    240    117    159    257
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Study ID   :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                          Pg    4

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = IOUs
                                                                                          Game = 0001
Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load               14533   14885   15243   15611   15988
Observed Rate               2.42%   2.42%   2.41%   2.41%   2.41%

Existing Resources           8154    8101    8111    8131    7892

BPA Requirements                0       0       0       0       0

CONSERVATION PROGRAMS:
  SF Res MCS                  103     109     116     122     129
  MF Res MCS                   27      28      30      32      33
  Commercial MCS              299     320     341     364     387
  Water Heat                   82      90      97     106     114
  Refrigerators                41      45      49      54      58
  Freezers                     18      20      21      23      25
  New Manuf Housing            31      33      35      37      39
  Cons. Volt. Reg.             59      59      59      59      59
  Industrial                  226     242     258     274     286
  T&D Effic Impr               70      75      80      84      89
  MF Res Weath                 41      41      41      41      41
  Existing Commercial         315     337     360     382     388
  SF Res Weath                 62      62      62      62      62
  Irrigation                   46      46      46      46      46
                            -----   -----   -----   -----   -----
  Subtotal                   1420    1507    1595    1686    1756

GENERATING RESOURCES:
  Hydro Eff Imp                35      35      35      35      35
  Small Hydro 1                57      57      57      57      57
  Small Hydro 2                72      72      72      72      72
  Combined Cycle 1            349     349     349     349     349
  WNP 3                         0       0       0       0       0
  Combined Cycle 2            349     349     349     349     349
  Cogen 1                     320     320     320     320     320
  WNP 1                         0       0       0       0       0
  E. Mont Coal               1201    1201    1201    1201    1201
  Cogen 2                      32      32      32      32      32
  Geothermal                  250     250     250     250     250
  Mun. Solid Waste             15      15      15      15      15
  Small Hydro 3                81      81      81      81      81
  E. Wash Coal                500     500     500     500     500
  E. Oregon Coal              500     500     500     500     500
  Wind 1                       13      13      13      13      13
  Nevada Coal                 500     500     500     500     500
  W. Wa/Or Coal                 0       0       0     500     500
  Small Hydro 4                58      58      58      58      58
  Cogen 3                     608     736     752     752     752
  Wind 2                       90     115     140     164     189
  Cogen 4                      80     160     264     264     336
  Biomass                       0      18      54      54      72
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                   5110    5361    5542    6066    6181

Total Firm Resources        14685   14971   15250   15885   15833

Load/Resource Balance         151      87       7     274    -155
```

```
Study ID    :  29-NOV-90 11:32:09
Study Title:   High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                              Pg     5

SYSTEM SUMMARY:   Observed Loads and Resources (Avg MW),      PARTY = Generating Publics
                                                                                                               Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load             4821   5014   5214   5401   5569   5737   5899   6054   6205   6366   6518   6666   6824   7000   7180
Observed Rate                   4.00%  3.99%  3.59%  3.12%  3.01%  2.82%  2.62%  2.50%  2.60%  2.38%  2.28%  2.37%  2.57%  2.57%

Existing Resources        2445   2432   2450   2468   2451   2435   2434   2433   2411   2390   2394   2398   2381   2365   2372

BPA Requirements          2376   2581   2764   2934   3118   3302   3465   3440   3604   3778   3918   4055   4221   4403   4568

CONSERVATION PROGRAMS:
  SF Res MCS                 4      8     12     15     19     22     25     28     31     34     38     41     44     47     50
  MF Res MCS                 1      1      2      2      3      3      4      4      5      5      6      6      7      7      8
  Commercial MCS             0      5     10     15     20     24     28     33     38     43     48     53     58     64     69
  Water Heat                 0      0      0      0      1      3      5      7     10     12     15     18     22     25     28
  Refrigerators              0      0      0      0      0      1      3      4      5      6      7      9     10     11     12
  Freezers                   0      0      0      0      0      1      1      2      2      3      3      4      4      5      5
  New Manuf Housing          0      1      2      2      3      4      4      5      6      6      7      8      9      9     10
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   5     15     26     34     46     58     70     83     97    109    124    139    154    168    182

GENERATING RESOURCES:
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0      0      0      0      0      0      0      0      0      0      0      0      0      0

Total Firm Resources      4826   5029   5239   5436   5615   5795   5970   5956   6111   6277   6435   6591   6755   6936   7123

Load/Resource Balance        5     15     25     35     45     58     71    -98    -94    -89    -83    -75    -69    -64    -58
```

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Study ID   :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                Pg    6

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),     PARTY = Generating Publics
                                                                                                  Game = 0001
Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load                7358    7541    7728    7920    8116
Observed Rate               2.48%   2.48%   2.48%   2.48%   2.48%

Existing Resources           2496    2559    2559    2559    2699

BPA Requirements             4618    4733    4910    5093    5146

CONSERVATION PROGRAMS:
  SF Res MCS                   54      57      60      63      67
  MF Res MCS                    8       9       9      10      10
  Commercial MCS               75      80      86      92      98
  Water Heat                   31      34      37      39      42
  Refrigerators                14      15      17      18      20
  Freezers                      6       7       7       8       9
  New Manuf Housing            11      12      12      13      14
                            -----   -----   -----   -----   -----
  Subtotal                    199     214     228     243     260

GENERATING RESOURCES:
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                      0       0       0       0       0

Total Firm Resources         7313    7504    7697    7895    8105

Load/Resource Balance         -45     -36     -31     -24     -11
```

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Study ID    :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                                                          Pg    7

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                                                                    Game = 0001
Operating Year           90-91  91-92  92-93  93-94  94-95  95-96  96-97  97-98  98-99  99-00  00-01  01-02  02-03  03-04  04-05
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
Observed Load            17595  18265  18948  19603  20198  20794  21367  21914  22454  23029  23573  24107  24676  25308  25956
Observed Rate                   3.81%  3.74%  3.45%  3.04%  2.95%  2.76%  2.56%  2.46%  2.56%  2.36%  2.27%  2.36%  2.56%  2.56%
DSI Firm Load             2336   2314   2335   2357   2356   2355   2354   2354   2353   2352   2326   2301   2275   2275   2275

Existing Resources       19230  19216  19170  19124  19080  19037  19002  18966  18780  18594  18542  18490  18383  18275  18245

CONSERVATION PROGRAMS:
  SF Res MCS                14     29     44     59     73     86     99    111    123    135    149    161    174    187    201
  MF Res MCS                 4      5      9     11     14     16     20     22     25     28     30     33     36     38     41
  Commercial MCS             0     27     55     83    112    137    162    190    218    246    273    301    329    359    389
  Water Heat                 0      0      0      0      3     13     23     35     46     58     72     87    103    117    132
  Refrigerators              0      0      0      0      1      7     14     19     24     30     37     44     51     57     62
  Freezers                   0      0      0      0      0      4      5      9     10     14     16     20     22     25     27
  New Manuf Housing          1      4      8     11     14     18     21     24     28     31     35     38     42     46     50
  BPA Contract Recall      192    192    192    242    242    242    242    292    292    292    292    292    292    292    292
  Cons. Volt. Reg.           0      5     15     25     35     45     56     66     76     85     94    100    100    100    100
  Industrial                 0      8     32     62     92    122    152    182    212    242    273    305    337    369    403
  T&D Effic Impr             0      5     14     23     32     41     50     57     66     75     85     95    105    114    125
  MF Res Weath               0      1      7     14     21     27     34     41     47     52     53     53     53     53     53
  Existing Commercial        0      8     32     63     94    125    156    187    217    249    281    313    344    377    409
  SF Res Weath               0      4     16     30     45     60     75     90     99    104    112    122    130    130    130
  Irrigation                 0      1      5     10     16     20     26     31     37     42     48     53     56     59     63
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                 211    289    429    633    794    963   1135   1356   1520   1683   1850   2017   2174   2323   2477

GENERATING RESOURCES:
  Hydro Eff Imp              0      0     25     50     75     95    110    110    110    110    110    110    110    110    110
  Small Hydro 1              0      0      0      0      0      0     47     86     86     86     86     86     86     86     86
  Small Hydro 2              0      0      0      0      0      0     36     73     91    105    108    108    108    108    108
  Combined Cycle 1           0      0      0      0      0    698   1046   1046   1046   1046   1046   1046   1046   1046   1046
  WNP 3                      0      0      0      0      0      0      0      0    868    868    868    868    868    868    868
  Combined Cycle 2           0      0      0      0      0      0      0      0      0      0    349    698   1046   1395   1395
  Cogen 1                    0      0      0      0    100    160    220    280    300    360    360    360    380    380    420
  WNP 1                      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  E. Mont Coal               0      0      0      0      0      0      0      0      0    600   1201   1201   1201   1201   1201
  Cogen 2                    0      0      0      0     32     32     32     32     32     48     48     48     48     48     48
  Geothermal                 0      0      0      0      0     50     50    100    150    200    200    200    200    225    225
  Mun. Solid Waste           0      0      0      0      0      0      0      0      0      0      0      0      0      8      8
  Small Hydro 3              0      0      0      0      0      0      0      0     26     52     52     52     52     59     59
  E. Wash Coal               0      0      0      0      0      0    500    500    500    500    500    500    500    500    500
  E. Oregon Coal             0      0      0      0      0      0      0      0      0      0      0      0      0    250    500
  Wind 1                     0      0      0      0     13     13     13     13     13     13     13     13     13     13     13
  Nevada Coal                0      0      0      0      0      0      0    500    500    500    500    500    500    500    500
  W. Wa/Or Coal              0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Small Hydro 4              0      0      0      0      0      0      0      0     25     25     25     25     25     25     33
  Cogen 3                    0      0      0      0    136    136    136    272    272    272    272    272    344    344    472
  Wind 2                     0      0      0      0      0      0      0      0      0      0      0      0     25     49     66
  Cogen 4                    0      0      0      0     32     32     32     32     32     32     32     32     32     32     32
  Biomass                    0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
  Replacement                0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
                         -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----  -----
  Subtotal                   0      0     25     50    388   1216   2222   3044   4051   4817   5770   6119   6584   7247   7690

Total Firm Resources     19441  19506  19623  19807  20263  21217  22359  23365  24352  25094  26160  26626  27141  27847  28411

Load/Resource Balance     -490  -1072  -1661  -2152  -2291  -1932  -1363   -903   -455   -287    261    218    191    265    181
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Study ID    :  29-NOV-90 11:32:09
Study Title:  High Loads, MHIGH Discr Cons Schedule, Perfect Knowledge                    Pg    8

SYSTEM SUMMARY:  Observed Loads and Resources (Avg MW),      PARTY = REGION
                                                                                     Game = 0001
Operating Year              05-06   06-07   07-08   08-09   09-10
                            -----   -----   -----   -----   -----
Observed Load               26596   27252   27923   28611   29317
Observed Rate               2.47%   2.47%   2.46%   2.47%   2.47%
DSI Firm Load                2275    2275    2275    2275    2275

Existing Resources          18216   18232   18247   18273   18168

CONSERVATION PROGRAMS:
  SF Res MCS                  215     228     241     254     268
  MF Res MCS                   44      47      49      53      54
  Commercial MCS              419     448     479     511     544
  Water Heat                  146     161     174     188     202
  Refrigerators                70      76      84      92     100
  Freezers                     30      34      36      40      44
  New Manuf Housing            54      58      60      64      68
  BPA Contract Recall         292     292     292     292     292
  Cons. Volt. Reg.            100     100     100     100     100
  Industrial                  435     467     499     531     559
  T&D Effic Impr              135     145     155     164     175
  MF Res Weath                 53      53      53      53      53
  Existing Commercial         442     474     506     538     554
  SF Res Weath                130     130     130     130     130
  Irrigation                   66      69      72      75      77
                            -----   -----   -----   -----   -----
  Subtotal                   2631    2782    2930    3085    3220

GENERATING RESOURCES:
  Hydro Eff Imp               110     110     110     110     110
  Small Hydro 1                86      86      86      86      86
  Small Hydro 2               108     108     108     108     108
  Combined Cycle 1           1046    1046    1046    1046    1046
  WNP 3                       868     868     868     868     868
  Combined Cycle 2           1395    1395    1395    1395    1395
  Cogen 1                     440     440     440     440     440
  WNP 1                       818     818     818     818     818
  E. Mont Coal               1201    1201    1201    1201    1501
  Cogen 2                      48      48      48      48      48
  Geothermal                  250     250     250     250     250
  Mun. Solid Waste             15      15      15      15      15
  Small Hydro 3                81      81      81      81      81
  E. Wash Coal                500     500     500     500     500
  E. Oregon Coal              500     500     500     500     500
  Wind 1                       13      13      13      13      13
  Nevada Coal                 500     500     500     500     500
  W. Wa/Or Coal                 0       0       0     500     500
  Small Hydro 4                58      58      58      58      58
  Cogen 3                     608     736     752     752     752
  Wind 2                       90     115     140     164     189
  Cogen 4                      80     160     264     264     336
  Biomass                       0      18      54      54      72
  Replacement                   0       0       0       0       0
                            -----   -----   -----   -----   -----
  Subtotal                   8815    9066    9247    9771   10186

Total Firm Resources        29661   30078   30426   31130   31577

Load/Resource Balance         790     552     228     244     -16
```

CHAPTER 13

FINANCIAL ASSUMPTIONS

Chapter 13
Table of Contents

Page No.

Introduction

The Council's planning process involves a number of analytical steps, including estimation of quantities and costs of resources, projection of future demand for electricity under a variety of assumptions, and simulation of the operation of the regional power system to meet demands with alternative sets of resources. All of these analytical steps require that values for a number of financial variables be assumed. Consideration of these assumptions is important for two reasons. First, the values used directly influence the outcome of the analysis, and second, the values used in the various components of analysis must be consistent.

A number of financial variables influence the Council's planning process. Like many components of the Council's analysis, the values of these variables cannot be known with absolute certainty. This chapter describes the major issues and the reasoning behind the values adopted by the Council. It also provides an explanation of terms used throughout this chapter: nominal dollars, real dollars, present value, levelized cost and discount rate. Following this explanation, two categories of variables are examined: 1) cost of capital, including the general level of prices, home mortgage rates and the cost of capital for regional resource acquisition; and 2) the social discount rate--the rate used for converting streams of regional costs to present values.

The values used in the Draft 1991 Power Plan are summarized and compared to those of the 1986 Power Plan in Table 13-1.

Table 13-1
Financial and Economic Assumptions
1986 Plan and 1991 Plan

Variable	1986 Real	1991 Real	1991 Nominal[a]
Inflation	-----[b]	-----	5%
Home Mortgages	6.2%	5%	10.3%
Resource Acquisition			
Debt (Private Utilities)	7%	6%	11.3%
Equity (Private Utilities)	8.5%	7.5%	12.9%
Debt (Public Utilities)	4%	3%	8.2%
Debt (Bonneville)	5%	4%	9.2%
Social Discount Rate	3%	3%	8.15%

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[a] Nominal values calculated using 5 percent inflation.

[b] 1986 plan assumed 5 percent inflation.

Explanation of Terms

Nominal Dollars and Real Dollars

Inflation distorts the apparent costs of any energy resource, making it appear to cost more if it is purchased at a later time. To control for this distortion, three concepts are used. *Nominal dollars* are the actual expenditure of dollars over time and include the effects of inflation. Therefore, nominal dollars are dollars that, at the time they are spent, have no adjustments made for the amount of inflation that has affected their value over time. *Real dollars* adjust nominal expenditures to account for the effects of inflation. By correcting for the impact of inflation on a dollar's purchasing power, a real dollar represents constant purchasing power or "real" value. That is, a real dollar has the same value relative to the ability to purchase goods and services in 1995 that it had in 1988. To convert nominal dollar costs to real dollar costs, a *base year* is chosen, and all costs are converted to that year's dollars, i.e., the inflation that occurs between years is removed. Real dollars can be compared across the board, regardless of the year, because they represent equal purchasing power. The Council used a 1988 base year and a forecast inflation rate of 5 percent per year.

Present Value and Levelized Cost

Even after costs are converted to real 1988 dollars, it is difficult to compare the costs of different resources, because costs occur in different years. For instance, a hydropower project involves a large outlay at the beginning for construction, but the fuel (water) is essentially free after completion. An oil- or gas-fired combustion turbine has a low construction cost, but the fuel cost is high and may even escalate in real terms (i.e., it may get more expensive to run even after removing the effect of inflation).

Because of the various resources available in the region and the different capital and operating cost structures associated with each, two methods may be used to place them on even footing for cost comparison. *Present value* and *levelized cost* are the methods used. Present value implies that money has a time value. That is, *when* money is spent is as important as the *amount* of money spent. A dollar is worth more today than it is a year from now because it could be invested during the year to earn a financial return. A year from now, a dollar is converted back to its present value by calculating, over the year, the interest or return foregone. Present value then allows the equal comparison of costs of energy resources by using a standard discount rate to convert all costs, no matter when they occur, back to a lump sum at the start of the plan. The uniform series of costs that has the same present value as a resource's particular non-uniform series of costs is called the resource's *levelized cost*. For instance, the lump sum amount borrowed from a bank is the present-value cost of buying a house; the mortgage payment is the levelized cost.

Values can be levelized in either real or nominal terms. A resource's lifetime is important in the calculation of a nominal levelized cost. Even assuming that the resource is replaced by the same kind of resource at the end of its lifetime, which is typically done in this kind of calculation, a nominal levelized value will vary depending on lifetime compared to a real levelized value for the same resource. These concepts are illustrated in Figures 13-1 through 13-4 and are discussed further below.

Discount Rate

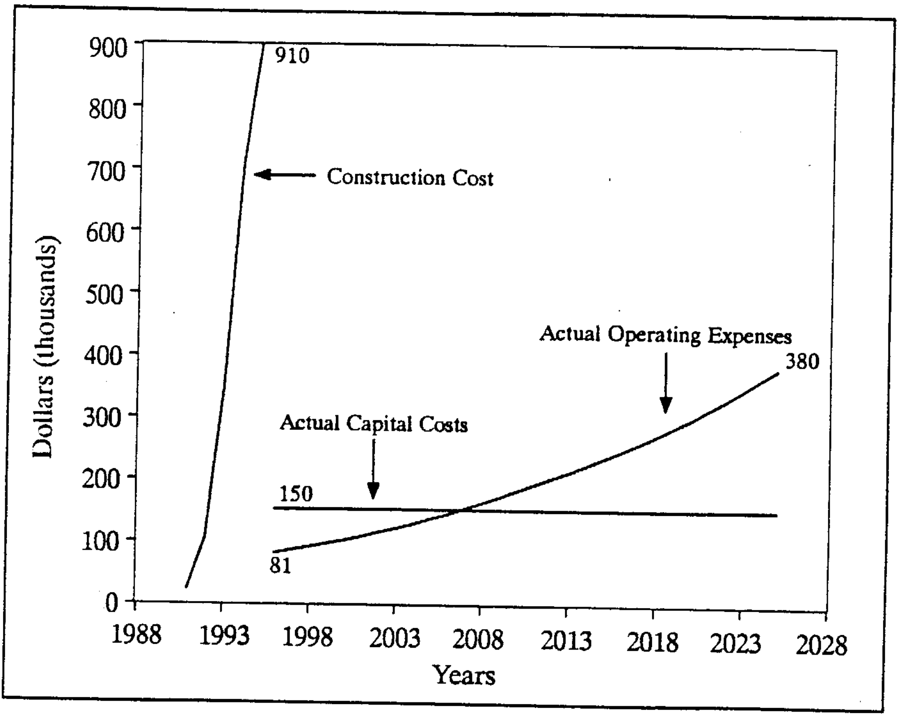
The value of money over time to the Northwest ratepayer is used in calculating present values and levelized costs and is called the *discount rate.* The discount rate used for the Council's analyses was an inflation-free, real rate of 3 percent. Nominal interest rates consist of a real rate and an inflation premium. To convert nominal costs to present values, a nominal discount rate of 8.15 percent that combines the real discount rate of 3 percent with a 5 percent rate of inflation is used.

Example

The application of all these concepts to a generic generating plant is illustrated in Figures 13-1 through 13-4. This is only a numerical example, and the costs for this hypothetical generating plant do not necessarily agree with any specific plants used in the resource portfolio. The concepts are the same for all resources; only the actual costs would differ. The example plant produces 250 average megawatts and comes online in 1996. Figure 13-1 shows the *nominal* (actual) expenditures for the plant through construction and during its operation. The line labeled "Construction Cost" represents the cumulative construction costs from the start of the project in 1991 to the time it comes online in 1996. The total capital cost is $910 million, which includes labor and materials of $746 million and interest of $164 million. For the purpose of this example, it is assumed that these construction costs and other associated capital costs, such as income taxes and property taxes, are repaid to lenders at a uniform rate of $150 million a year beginning in 1996. Those annual payments are represented by the "Actual Capital Costs" line. The line labeled "Actual Operating Expenses" rises faster than the rate of inflation due to real increases in the cost of fuel. Operating expenses start at $81 million per year and rise to $380 million per year by the end of the plant's 30-year life. Again, all costs in this chart include the effects of inflation over time.

Nominal Dollar Expenditures

Figure 13-1
Actual Nominal Dollar Expenditures



Capital Costs

Figure 13-2
Capital Costs

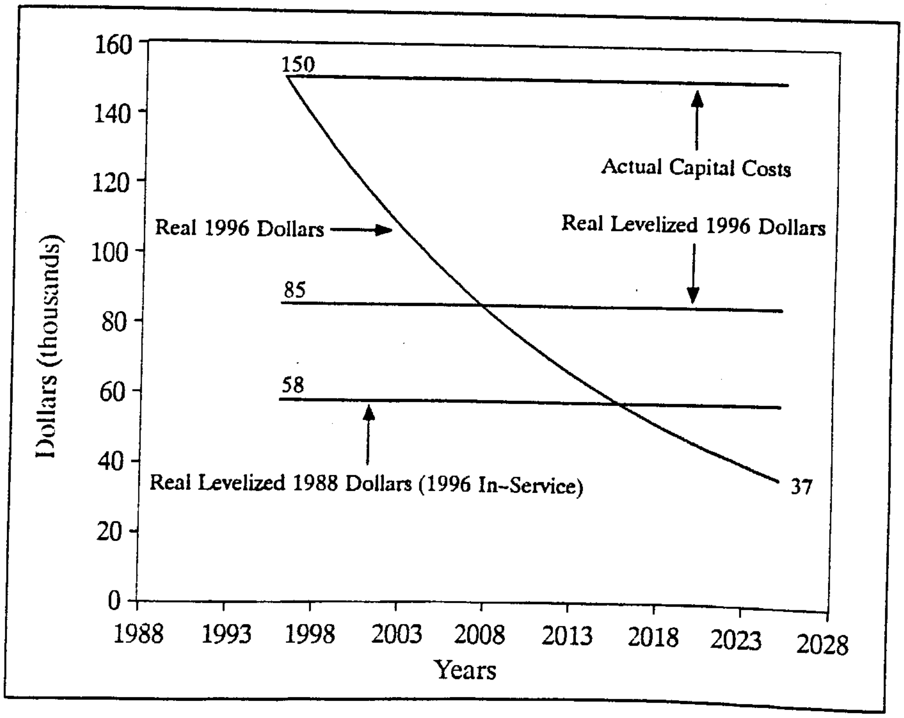


Figure 13-2 takes the "Actual Capital Costs" line from Figure 13-1 and demonstrates the conversion of nominal dollars to real dollars applying the present value and levelized cost concepts. The line labeled "Actual Capital Costs" represents the repayment of the construction and other capital costs from 1996 forward. Those costs remain constant despite inflation over time. By converting to real costs, hence adjusting for inflation (line labeled "Real 1996 Dollars"), the effect of inflation upon the nominal repayment costs is illustrated. Starting in 1996, capital recovery commences at a fixed payment of $150 million per year. Over the years, repayment is subject to general inflation, but cannot rise to reflect it. Therefore, by the end of the repayment period, the nominal repayment amount of $150 million is worth $37 million in 1996 dollars. Inflation has decreased the impact of a fixed payment, because other wages and costs have risen with inflation. The declining real costs then are annualized to levelized real costs (line labeled "Real Levelized 1996 Dollars"). This line represents the constant capital recovery payments restated to control for inflation. Finally, using the line labeled "Real Levelized 1988 Dollars," the capital recovery payments are restated to $58 million in base year 1988 dollars by removing inflation from 1988 to 1996. This process allows the comparison of capital costs of different resource projects by taking into account different real escalation rates during construction, while controlling for inflation and interest rates.

Operating Costs

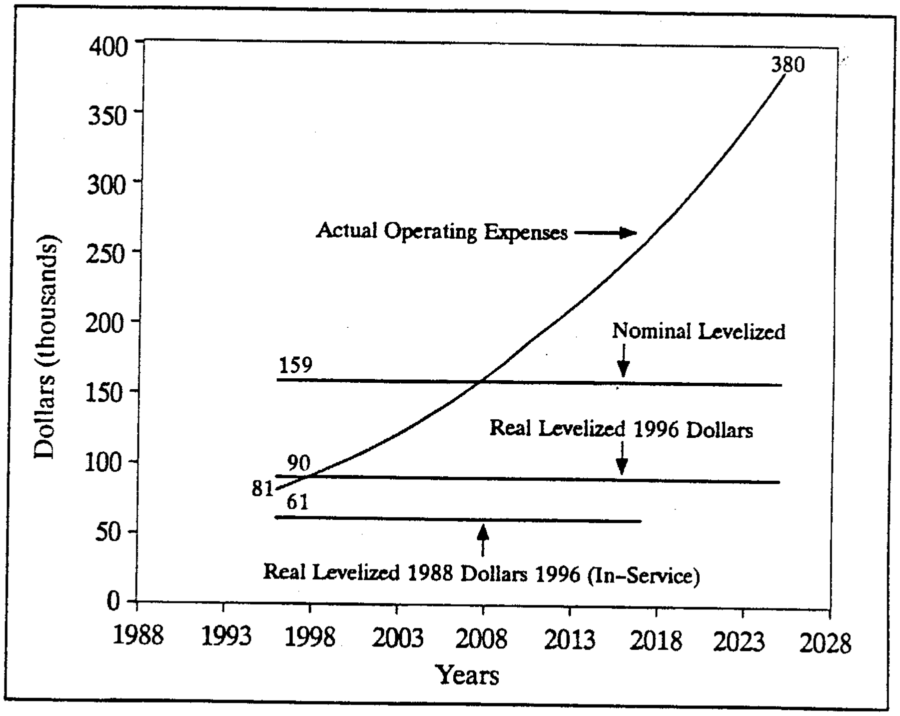


Figure 13–3
Operating Costs

Figure 13-3 goes through the same process, but uses the operating expenses line from Figure 13-1 to analyze operating costs. Operating costs start at $81 million a year in 1996, and rise in nominal terms (line labeled "Actual Operating Expenses") to $380 million by the end of the plant's life. These costs rise faster than general inflation due to the costs of fuel. If this actual stream of operating costs were converted to a constant stream that would not change from year to year, the result would be the "Nominal Levelized" line in Figure 13-3. Converting the stream of actual costs to a stream that would be constant in terms of purchasing power would yield the line labeled "Real Levelized 1996 Dollars." This line begins slightly higher, at $90 million, than the actual stream of costs, because the costs include small real increases, beyond increases due just to inflation. If there were no real increases built into the actual costs, the "Real Levelized 1996 Dollars" line would begin at the same point, $81 million. "Real Levelized 1988 Dollars," then, takes the levelized 1996 costs back to 1988 levelized costs by controlling for inflation between those years, getting us to $61 million annually.

The various numbers that can describe the same plant are summarized in Table 13-2. The capital cost in nominal dollars is $910 million. The first-year cost, as it would actually affect rates in 1996, the first year of operation, is $231 million ($150 million plus $81 million) or 10.6 cents per kilowatt-hour. Converted to the base year used in the Council analysis, the levelized cost is $119 million ($58 million plus $61 million) or 5.4 cents per kilowatt-hour. Levelized in nominal terms, it is $210 million or 9.6 cents per kilowatt-hour. The components of the last calculation are not shown on the graphs, but the conversion from real levelized 1988 dollars simply involves taking the present value at 3 percent and relevelizing at 8.15 percent. The last value, nominal levelized cost in base year (1988) dollars, is the index that is used in this plan, rather than the index used in previous Council plans, real levelized base-year dollars.[1]

Table 13-2
Cost Analysis Summary

Total Capital Cost	$910	million
Direct Construction	$746	million
First Year Cost (1996)	10.6	cents per kilowatt-hour
Real Levelized 1988 Dollars	5.4	cents per kilowatt-hour
Nominal Levelized	9.6	cents per kilowatt-hour

Finally, Figure 13-4 illustrates the effect of lifetime on the calculation of real and nominal levelized values. A resource that has an overall real levelized cost of $119 million per year (5.4 cents per kilowatt-hour), such as our example resource, also could be described as having a nominal levelized cost of $210 million per year (9.6 cents per kilowatt-hour), if the present value were converted to annual costs using a nominal discount rate of 8.15 percent rather than the corresponding 3

1./ This holds true for all analysis in the Draft 1991 Power Plan, <u>except</u> for the conservation costs in Volume II, Chapter 7. These costs are in base year 1990 dollars. There were converted to base year 1988 dollars before they were used with other resource costs in the Council's portfolio analysis.

percent real discount rate. These are just two different ways of expressing the cost of the same resource. A third way of expressing the cost is the rising curve in Figure 13-4, which starts at $119 million per year and increases at five percent per year (the Council's assumed rate of future inflation).

Suppose, however, that we are considering a resource with a 15-year life, which also has a real levelized cost of $119 million per year (5.4 cents per kilowatt-hour). How would we compare its cost to the 30-year resource which costs the same in real terms? For the sake of simplicity, we assume that the resource is replaced by the same kind of resource, which costs the same except for the 15 years of inflation between the installation of the first resource and the second. Now the two cases are comparable: a 30-year resource and two 15-year resources. The real levelized cost of each of these three resources is the same, that is, $119 million (5.4 cents) in 1988 base year dollars.

However, the nominal levelized costs of the three are all different. The nominal levelized cost of the 30-year resource is $210 million (9.6 cents per kilowatt-hour), that of the first 15-year resource is $167 million (7.6 cents per kilowatt-hour) and that of the second, replacement 15-year resource is $348 million (15.9 cents per kilowatt-hour). This means that, even assuming replacement by an identical resource, as we did in this example, we cannot directly compare the costs of resources with different lives in nominal levelized terms unless we include directly the replacement resource's costs. When nominal levelized terms are used in Volume I or in Table 10-1 and the cost-effectiveness discussion in Chapter 14 of Volume II of the Council's plan, they have all been appropriately adjusted to comparable 40-year lifetimes and they are calculated as if construction or program ramp-up began in September 1990 (rounded to January, 1991 in this example). That is, they are comparable to the value $210 million per year (9.6 cents per kilowatt-hour) in Figure 13-4.[2]

2./ Nominal levelized costs in the tables in Volume II, Chapter 8, are calculated on a slightly different basis, however. These numbers assume a common in-service date, January 1988, with an assumed construction start earlier, rather than the common start date of September, 1990 for all resources and in-service dates that vary as a function of lead times.

Lifetime Effect

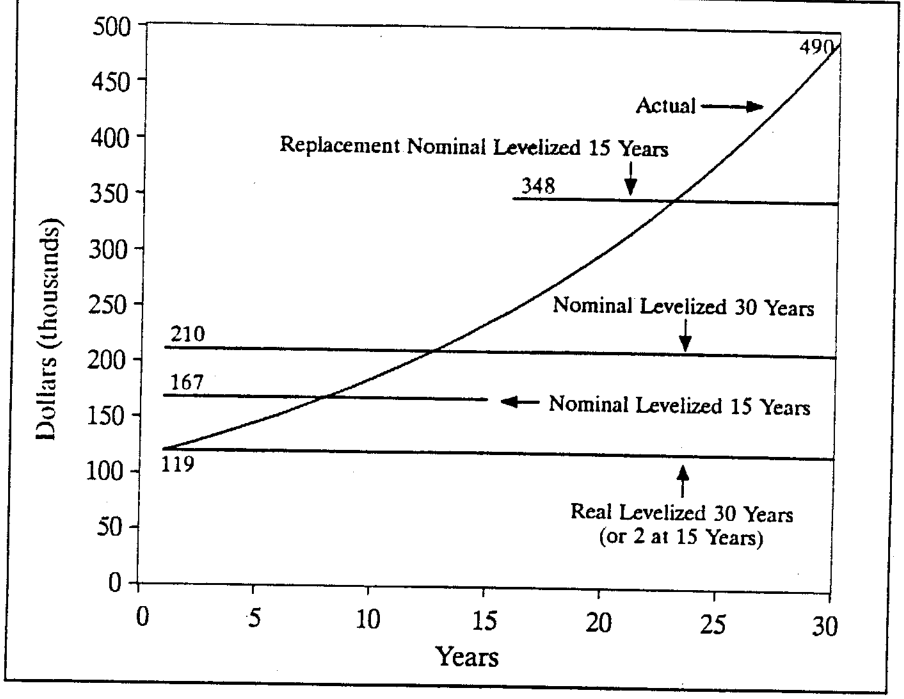


Figure 13-4
Levelizing—Effect of Lifetime

It is important to remember that the process described above is used to put resource cost estimates on a consistent basis. It is not a prediction of the impact of any given resource on consumer rates in a given year. In fact, the two example resources mentioned earlier (the hydropower plant and the combustion turbine) could have quite different effects on rates in any given year. The hydropower plant is the most expensive in the first year. Because the capital cost is fixed, its real cost declines through time as other costs and wages rise with inflation. Grand Coulee Dam, for example, was a very expensive project when it was finished in the early 1940s. It is only the succeeding 40 years of inflation that have made the cost of about 0.2 cent per kilowatt-hour relatively cheap compared to the cost of new power plants.

A combustion turbine, on the other hand, has a large percentage of its total cost in its fuel cost. If operated at reasonable levels of annual output, its total cost (capital plus fuel) could be lower in the first years of its operation than the hydropower plant. However, its fuel cost will continue to rise with inflation, if not faster, and its relative rate impact will be much higher 20 years from now than would that of a hydropower plant built now. A resource, such as the hydropower plant, could have the lowest present-value and levelized cost although it has the highest first-year cost. The Council's resource choice was not based on the rate impacts in any given year but was based on the present-value cost, taking into account the costs and their timing over the life of the resources.

Levelized cost numbers are appropriate for rough comparison of resources. For the final analysis, the resources' operating characteristics were simulated in the Council's decision analysis model, Integrated System for the Analysis of Acquisitions (ISAAC), and the costs from that simulation were converted to present values. This is a very important distinction, because levelized costs usually do not take into account the changes in system operations that will result when resources with different operating characteristics are added. The system models that the Council uses for evaluating the present-value system cost of each resource added to the Northwest's existing system provide the best test of the cost-effectiveness of each resource.

Cost of Capital

Inflation

The rate of inflation affects all components of the Council's analytical process. It is impossible to project the effect of changes in costs without considering the changes from both the real and nominal perspective. For example, prices of electricity are determined in part by historical (nominal) construction costs, but projection of demand usually is based on the inflation-corrected (real) path of electricity prices. The necessary translation between real and nominal values requires a set of assumptions regarding the rate of inflation. The Draft 1991 Power Plan uses an average inflation rate of 5 percent.

Home Mortgages

One of the most intensively analyzed resources for future electricity conservation is improved thermal efficiency in new homes. The cost of this improved efficiency, both to the individual homeowner and to the region, is influenced by the extra construction cost due to energy-efficiency measures. These increased costs are mortgaged, and therefore the present value cost is a function of the interest rate charged on the mortgage. Mortgage rates, as projected by the WEFA Group[3] change over time as the overall state of the national economy changes. Because these rates influence the costs of thermal efficiency, the use of varying mortgage rates would result in varying levels of optimal thermal efficiency. From a practical perspective, this would complicate the planning process prohibitively, so the choice of a single mortgage rate assumption that is a reasonable long-run average seems more appropriate. The Council used a 5 percent real after tax rate or 10.3 percent nominal before tax for the mortgage rate assumption. This rate compares with the 6.2 percent real assumption used in the 1986 plan.

3./ The WEFA Group develops the national economic forecasts the Council uses in its planning process.

Resource Acquisitions by Bonneville

The cost of capital for resources acquired by Bonneville for the region should reflect the actual regional cost of capital for the companies or organizations expected to develop the resources. The region's cost of capital is reduced by any federal tax benefits accruing to the owner of the resource, but includes any risk premium that the financial markets can be expected to attach to the investment. The assumptions for the real cost of capital in the 1986 plan, based on suggestions by the region's utilities, were 7 percent for debt financed by investor-owned utilities, 8.5 percent for equity of investor-owned utilities, 4 percent for debt financed by publicly owned utilities and 5 percent for Bonneville borrowing. Based on the analysis below and comments by the utilities and others, these assumptions now appear high. Therefore, the Council adopted lower values of 6 percent, 7.5 percent, 3 percent and 4 percent, respectively, for these real costs of capital.

Ownership and Capital Structure

The net financial cost of resources is a function of who owns them and what capital structure is used. In the 1986 plan, the Council assumed that, with Bonneville acquisition available under the Act, generating projects would be financed by investor-owned utilities, using a capital structure of 80-percent debt and 20-percent equity. In this plan, the Council recognized that independent resource development has become a more likely scenario, and used more-typical capital structures of 50-percent debt and 50-percent equity for the investor-owned utilities. Bonneville and generating public utility acquisitions are financed at 100-percent debt.

Conservation also was evaluated using utility financing. Forty percent of the conservation was assumed to occur in public utility service territories and assumed to be financed by Bonneville. The remaining 60 percent in the investor-owned utility service territories was assumed to be financed by the investor-owned utilities at their normal ratio of 50-percent debt and 50-percent equity.

Representative financial characteristics for non-utility project developers also were assessed for this plan. For the portfolio analysis using ISAAC, all projects were assumed to be developed by utilities, so as not to bias results by an arbitrary choice of sponsor financing. The characteristics for these three major types of sponsors are summarized in Table 13-3.

Table 13-3
Representative Financial Characteristics
for Project Developers

	Consumer-Owned Utility	Investor-Owned Utility	Independent (Non-utility Developer
Cost of Equity (% nominal)	n/app	12.9%	20%
Cost of Debt (% nominal)	9.2%	11.3%	11.3%
Debt/Equity Ratio	100/0	50/50	80/20
Insurance (%/yr.)	0.25%	0.25%	0.25%
Federal Income Tax Rate (%)	0%	34%	34%
State Income Tax Rate (%)	0%	3.7%	3.7%
Gross Revenue Tax Rate (%)	2.2%	2.1%	2.1%
Property Tax Rate (%)	0%	1.4%	1.4%

Detailed Interest Rate Analysis

Interest rates, including mortgage rates, as projected by the WEFA Group change over time, as the overall state of the national economy changes. Because mortgage rates influence the costs of thermal efficiency, the use of time-varying rates would result in varying levels of optimal thermal efficiency (and model conservation standards). From a practical perspective, this would be prohibitively complicated, so the choice of a single mortgage rate assumption which is a reasonable long-run average seems more appropriate. Similar considerations apply to utility-financed resources.

The Council's analysis proceeded by looking at real interest rate spreads--the differences in rate due to the differences in risk or taxation borne by the lender. One of these is the premium that can be expected to be paid by Bonneville and the federal treasury, compared to the rate paid by a publicly owned utility (municipal borrowing). This is due to federal taxation of treasury interest payments, while interest from most municipal borrowing is exempt from federal taxation. Investor-owned utility bonds and home mortgages typically include a premium over treasury bonds due to the increased default risk they represent. Finally, investor-owned utility equity or common stock represents a further risk compared to the same utility's bonds because of the former's lower priority for available net revenue.

Each of the spreads is then added to an estimate of a long-term real municipal bond rate. The two most recent WEFA Group forecasts as of mid-1989 suggest long-term real rates of about 2 and 3 percent, respectively. The Council chose to use 3 percent real for this variable.

Because the objective was to arrive at a consistent set of interest rates, the Council looked at recent historical relationships. The WEFA Group's data on 10-year treasury bonds, BAA[4] utility bonds, 20-year municipal bonds and conventional

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[4] 4./ BAA is a medium-grade bond rating characteristic of most Northwest investor-owned utilities.

new-home mortgage rates, over the period 1983 through 1987 (the most recent five-year period available), are shown in Table 13-4. This period exhibits stable observed inflation rates, unlike the preceding five-year period. This table, like the following ones, will round the spreads to the nearest whole percent. It is not clear that the additional precision that could be gained in some cases would make the estimates better. In other cases, the estimates from the various data sources preclude a more precise estimate.

Table 13-4
1983 through 1987 Spread Between Real Interest Rates

		Rounded
Utility - Mortgage	1.17 percent	1 percent
Mortgage - Treasury	1.15 percent	1 percent
Utility - Treasury	2.32 percent	2 percent
Treasury - Municipal	1.27 percent	1 percent

While the BAA-rated utility bonds represent the appropriate index for the region's private utilities, the Treasury rates will be slightly low for Bonneville, who borrows at about 0.4 percent above the Treasury's 15-year bond rate, which in turn will have a slight term premium over the 10-year rate in the data. Additionally, the municipal bond data represents 20-year general obligation bonds. The longer-term revenue bonds used to finance utility investments typically would require a premium, probably on the order of 0.2 to 0.3 percent. These considerations imply that the mortgage-treasury and utility-treasury spreads might be slightly too big, but the treasury-municipal spread may still be about right. The rounded values take these considerations into account.

Current data (from early 1989, when the Council's decision on this matter was made) also were examined to determine the spreads between various kinds of bond interest rates. The utility bonds examined were higher rated than those of Northwest utilities and the type of municipal bond was not clear, so the relationship was not exactly what we were trying to measure, but it did give a good approximation. Generally, BAA-rated bonds yield 0.7 to 0.9 percent more than AA-rated bonds. Although yield curves were sharply inverted at the time, typically there is only a very small term premium for a 30-year bond compared to a 15-year bond. Table 13-5 calculates the spreads, adding 0.8 percent to the AA utility yield to get a BAA utility yield equivalent to that in Table 13-4.

Table 13-5
Mid-1989 Yield Spreads

		Rounded
Utility (BAA est.) - Treasury	1.89 percent	2 percent
AA Utility - Treasury	1.09 percent	1 percent
Treasury - Municipal	1.39 percent	1 percent

The long-term WEFA Group forecast (August 1987) projected the following 20-year average yield spreads (1988 through 2007) for the same rates as described for Table 13-4. The rounded estimate for the mortgage-treasury spread in this case conflicts with that based on 1983 through 1987 data; the Council relied on the historical data rather than the forecast.

Table 13-6
1988 through 2007 Spread Between Real Interest Rates

		Rounded
Utility - Mortgage	0.67 percent	1 percent
Mortgage - Treasury	1.81 percent	2 percent
Utility - Treasury	2.48 percent	2 percent
Treasury - Municipal	1.29 percent	1 percent

The more recent Fourth Quarter 1988 Trend Forecast from the WEFA Group had quite different relationships, which are suspect since they forecast mortgage rates and 10-year treasury yields to be almost identical, although they are instruments of quite different risk.

The cost of equity has been taken from the Federal Energy Regulatory Commission's benchmark return on equity determinations. The mid-1989 nominal value is 12.38 percent. Assuming 5-percent inflation, this equals a real rate of 7 percent, approximately 1.5 percent above the then-current BAA bond rate, estimated at 10.8 percent nominal. Representatives from investor-owned utilities suggested that this value was somewhat low, so the Council chose a value of 7.5 percent in real terms.

Social Discount Rate

A central feature of the Council's consideration of alternative strategies for providing adequate electricity to the region is the comparison of the strategies' costs. This step is not possible unless each strategy's stream of costs is translated into a present value which can be compared to those of the other strategies. In order to accomplish this translation, it is necessary to use a discount rate that represents society's willingness to exchange consumption now for consumption in the future. For example, if the region is indifferent to choosing between $1.00 of consumption now and $1.05 a year from now, the region's rate of time preference, or its "social discount rate," is 5 percent.

In general, the lower the social discount rate, the more weight is given to the future in planning decisions. Using a higher social discount rate results in lower present values of future costs and benefits; whereas using a lower social discount rate results in higher present values. Low social discount rates tend to favor resources with high fractions of capital costs, while high social discount rates tend to favor resources with high fractions of fuel and operation and maintenance costs.

While the concept of the social discount rate is fairly straightforward, its application is more complicated. The principal difficulty is in moving from the general concept of the social discount rate to a specific number to be used in quantitative analysis. It is possible to imagine a hypothetical economy, with no income taxes, perfect knowledge (no risk), no inflation and perfect capital markets. In such an economy, individuals save and invest until the rate of return on the last investment is equal to the last investor's rate of time preference. Capital markets would enable people to adjust their consumption and investment behavior so, while some of them would be net borrowers and some net investors, they would all attach the same relative values to consumption now and consumption a year from now (i.e., they would have the same rate of time preference).

This rate of time preference, shared by all individuals in the society, would be the social discount rate. In this hypothetical economy, the social discount rate would equal the market rate of interest, which also would equal the rate of return to the marginal investment. Thus, while the social discount rate could not be observed directly, its level could be determined by its equality with the easily observable market rate of interest.

The real world, of course, departs from the hypothetical economy described above in every respect:

Taxes

In the real world, corporations and individuals pay income taxes. This means that when a consumer postpones current consumption to invest, part of the return to the investment will go to pay income taxes. Therefore, the future consumption which that investment makes possible is less than that implied by the (pre-tax) return. As a result, individuals investing in a project with a 10-percent rate of return are not demonstrating a rate of time preference of 10 percent, but rather a somewhat lower rate.

A corporation's investment behavior will be even further removed from individuals' rates of time preference. The (pre-tax) rate of return to corporate investments will have to be sufficient to cover the corporation's tax obligation, plus the tax obligations of the individuals who provide the corporations' capital, plus those individuals' rates of time preference.

Risk

In the real world, knowledge is imperfect, and investments are risky. This riskiness varies from one investment to another and is reflected in varying costs of capital from one investment to another. Generally, the riskier the investment, the higher the cost of capital to finance it. Ordinarily, the rate of time preference is understood to be the willingness to trade (certain) consumption now for (certain) consumption in the future. The Council is faced, then, with the task of estimating how much of observed rates of return are risk premiums and how much risk premium should be included in the regional social discount rate for use in the Council's evaluation process.

Access to Capital

In the real world, individuals (and organizations) are different. Individuals will demonstrate different investing and borrowing behavior. This will be due in part to differences in their income levels and their access to investment opportunities. Corporations, too, will show varied behavior, for many of the same reasons. Choosing an appropriate social discount rate for the region is equivalent to choosing an individual (or company) whose behavior is representative of the region.

Inflation

In the real world, inflation complicates the interpretation of observed costs of capital in terms of the social discount rate. Investors can be expected to insist on a rate of return which, in addition to covering their rate of time preference, tax obligation and risk premium, also will cover the expected rate of inflation. Thus, observable (nominal) costs of capital, even after income taxes and risk premiums are taken into account, will be greater than investors' rates of time preference by the amount of inflation they expect. Attempts to estimate the magnitude of inflation's effect on the cost of capital are complicated by the fact that although the inflation rate that the economy actually experiences can be measured, the inflation rate that investors <u>expect</u> cannot.

For reasons such as these, the estimation of an appropriate social discount rate from first principles is fairly complicated. A typical approach might begin with some estimate of typical return on investment in a given industry, translated to an after-tax return to the company based on some assumed corporate income tax rate for a representative company. The after-tax return to the stockholders of the representative company will be further reduced by their individual income tax rates. This rate of return would be translated to real terms by some estimate of expected inflation. Finally, the risk premium appropriate for the Council's planning process would be evaluated and compared to the risk premium included in the analyzed industry's cost of capital, and the appropriate adjustment made to arrive at the final estimate of the social discount rate.

Each step in this process requires judgments (e.g., how risky are the investments examined, should any years' data be excluded, what is a representative company, how is expected inflation related to historical inflation, etc.) that affect the results of the process. As a result, even if two analysts agreed completely on the process to be followed in extracting a social discount rate from a given body of data, they could reasonably arrive at significantly different final results.

Corporate versus Individual Perspective

An example will show how the various factors described above can cause a dramatic difference between the return to a private firm and the ultimate rate of time preference revealed by the acceptable return to the firm's stockholders.

The example starts with an assumed 20-percent hurdle rate of return on equity for investment by the private firm. The hurdle rate is a standard that is used by a firm to evaluate potential investments. If the firm has sufficient capital to invest in all the opportunities available to it, the hurdle rate ought to be the cost of capital (debt and equity) to the firm, so that it makes all the investments that pay back at least its cost of borrowing money from lenders and investors. If the firm is capital constrained, it may set a higher hurdle rate so that only the most profitable investments are chosen. The assumed 20-percent return on equity is reasonable for the private sector.

Assume the firm actually earns its 20-percent, although in practice it may earn more or less. First, it must pay federal income taxes. At a corporate rate of 34 percent, the firm pays 6.8 percent of its return to the federal government, leaving 13.2 percent for its stockholders. The stockholders also must pay individual income taxes. Assuming there is no state or local income tax, and a federal marginal rate of 28 percent, the stockholder sends 3.7 percent of the return to Washington, D.C., leaving 9.5 percent. Assuming an inflation rate of 5 percent, the stockholder's real return is 4.3 percent of the original 20 percent.

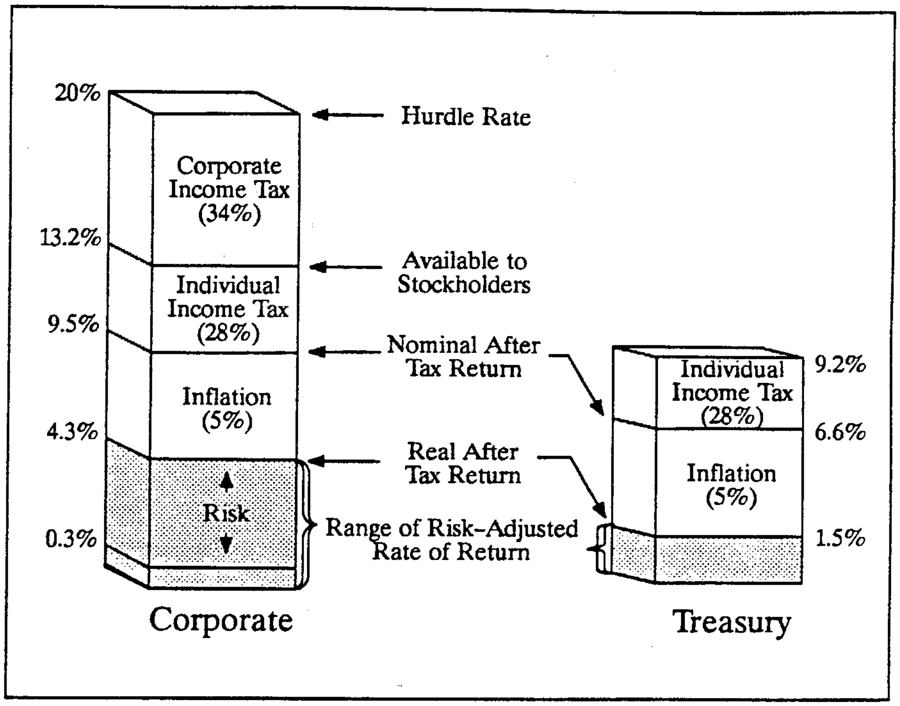
So far, the example has dealt with the equity return from a single firm. This return embodies a certain amount of business and financial risk, which raises it above a less risky return. The risk of investing in a single firm can be diversified away by investing in a number of different firms. This example will simply assume that risk is negligible, although in practice it is not. There remain the separate financial risk premiums for 1) investing in stock compared to corporate bonds that have a prior claim on the firm's net revenue, and 2) investing in corporate bonds compared to federal government bonds, which have virtually no default risk. Long-term historical data[5] suggests that the after-tax (at 28 percent) real risk premium for investing in diversified stocks compared to long-term federal government bonds is about 4 percent. This suggests that a risk adjusted after-tax real return for our example would be about 0.3 percent. The appropriate risk adjustment is difficult to determine and will be discussed below.

This is an artificial example, constructed to illustrate the relationships among the various measures of rates of return, but it is reasonably representative of long-term experience. The same long-term historical data referred to above suggests that the long-term return on diversified common stocks was 8.9 percent to stockholders over a period when the long-term inflation was only 2.5 percent. This return, together with a current tax rate of 28 percent, implies a long-term real after-tax return of 3.8 percent, close to the 4.3 percent of our example.

5./ Roger Ibbotson and Rex Sinquefield. *Stocks, Bonds, Bills and Inflation: Historical Returns (1926-1978).* Financial Analysts Research Foundation, 1979.

Social Discount Rate

Figure 13-5 Perspectives on Social Discount Rate



All of these factors for the example are summarized in Figure 13-5. The amount of the risk adjustment is left uncertain. Figure 13-5 also shows a similar breakdown of the rate of return for long-term Treasury bonds, assumed to be equal to Bonneville's cost of capital. Treatment of utilities' costs of capital appears later in this chapter.

Figure 13-5 demonstrates that a given investment can imply widely varying rates of return, depending on the perspective adopted. Many disagreements about the appropriate choice of social discount rate actually are disagreements about the appropriate perspective to adopt. Several perspectives have been advocated:

Office of Management and Budget

In our example, with inflation of 5 percent, the real return is 14.3 percent. The Office of Management and Budget (OMB) ruled in 1972 that the federal government should use a discount rate of 10 percent in real terms, because that was approximately the observed real rate of return in the private sector. Because it is not clear from the OMB document whether they were looking at return on equity or return on total capital, which would include some percentage of debt at lower cost, it would probably be conservative to assume the latter. This would imply that the 14.3 percent pre-tax real return on equity of the example is equivalent to the 10 percent pre-tax real return on capital of OMB.

The OMB argument is that using any lower rate for the government would simply divert capital and other resources from more productive to less productive uses. This argument does not take the perspective of the individual's rate of time preference. Rather, it looks at the effects of investment by the government and the private sector and attempts to keep them balanced in their level of productivity.

Moreover, the OMB criterion could generally be expected to be applied to investment decisions where benefits are calculated, but repayment of government costs was not expected. In addition, it could be expected to be applied to government decisions that were discretionary. Both of these conditions are different from those facing the Council, because repayment of costs of capital at market rates by customers is assumed, and spending is not discretionary if load is to be met.

Utility Perspective

Some have argued that the appropriate discount rate is the utility cost of capital, perhaps adjusted for the tax deductibility of bond interest payments. Assuming the values in this chapter for nominal costs of capital for investor-owned utilities, Bonneville and public agencies, the Council can do a calculation similar to that above as an example. With a capital structure of half debt and half equity, the weighted cost of capital for an investor-owned utility is 12.1 percent. In real terms, this is 6.8 percent. The after-tax return to an investor (in both bonds and stocks) is calculated somewhat differently than for the example, because the allowed return is after corporate income taxes rather than before. Adjusting only for the individual federal income tax and inflation, the investor's real after-tax return is 3.5 percent.

For Bonneville as well, only the individual federal income tax and inflation are applicable, and the 9.2 percent cost of capital yields 1.5 percent to the investor (see Figure 13-5). The real cost of capital to Bonneville using these values is 4 percent. For a public agency, only inflation is relevant, and the after-tax real return equals the real interest rate at 3 percent.

The argument for using the utility cost of capital for the corporate discount rate appears to be that shareholder wealth is maximized by making all investments that return more than the cost of capital. Therefore, the net present value of prospective investments is evaluated using the corporate cost of capital. The application to a governmental entity is by the analogy that the most efficient use of the capital supplied is to make investment decisions using the cost of capital as the entity's discount rate. This would ensure (assuming positive net benefits) that investments earn a return at least as great as the cost of the capital making the investment.

This cost of capital has the advantage of being relatively easy to estimate. The historical values are observable, and national projections of future values are available (see the previous section of this chapter dealing with cost of capital).

Problem of Two Utilities' Resources

If the utility cost of capital approach is taken, there could be conceptual difficulties. For instance, what social discount rate would the Council use to evaluate two different types of resources supplied (and financed) by two different kinds of utilities, such as a Bonneville conservation program and a combustion turbine offered for acquisition by an investor-owned utility. The costs of capital for the two resources would be substantially different, but the consumers who would use and ultimately pay for the resource might be the same people.

Individual Rate of Time Preference

There are two ways to get at the individual rate of time preference. One is that described above--to look at the actual, achievable after-tax real returns to individual investors, preferably over some long term. Historical data suggests that the return to the stock market is in the 4 to 5 percent range, and the risk adjustments can reduce that value to the 0 to 4 percent range, depending on the appropriate adjustment. In the past, the Council and Bonneville have taken this approach and estimated an appropriately risk-adjusted value at 3 percent in real terms. In this Draft 1991 Power Plan, the Council has continued to take this approach and has adopted the same 3 percent real value.

Another approach to the question of individual rates of time preference is to attempt to look at the typical individual. The range of individual investment and borrowing behavior is quite broad. One plausible end of the range might be the person whose marginal action is attempting to pay off a credit card bill that costs 18 percent, which implies approximately a 12-percent after-tax, real rate of return when tax deductibility is completely phased out. The other plausible end of the range could be the person whose marginal action is investing in a savings account at 5 percent, yielding a -0.7 percent real after-tax return (at a 15-percent marginal tax rate).

Calculating a typical individual's rate of return would be extremely difficult, especially since individuals often appear to demonstrate multiple discount rates with this approach. For example, an individual might deposit into the savings account one month and make an extra attempt to pay off the credit card bill the next. A serious attempt to implement this approach would need to take into account other dimensions of these investment alternatives, such as liquidity, perceived risk and minimum scale of investment.

For example, Table 8-75 in the 1989 *Economic Report of the President* shows total consumer credit in 1988 varying from $690 billion to $723 billion. This total, however, includes several components, such as loans for automobiles and mobile homes, whose rates of interest are significantly less than those of credit cards. The category most representative of credit cards, revolving credit, makes up about one-fourth ($162 billion to $181 billion) of the total. Moreover, it is not clear whether this amount represents the total of credit card billings (much of which is paid off each month) or the amount on which interest actually is paid, although the former seems more likely.

But individuals demonstrate their rates of time preference not only by borrowing, but also by lending and investing. Table B-68 of the *Economic Report* *of the President* shows that holdings in savings accounts and money market deposit accounts amounted to more than $900 billion ($400+ billion and $500+ billion, respectively) in 1988. These accounts bear interest at rates substantially below stated interest rates on credit cards, (typically, 0 percent or less, after-tax real) and therefore imply rates of time preference, which are lower as well. Furthermore, the volume of funds in these accounts is roughly five times that of revolving credit accounts.

In addition to charging things on credit cards and depositing in savings accounts, people make other decisions that suggest rates of time preference between the high levels indicated by credit cards and the low levels indicated by savings accounts. These other decisions include mortgage financing, auto financing and purchases of stocks and bonds.

This range of behavior means that it is impossible to impute a single rate of time preference to all the region's ratepayers, based on a single mode of behavior. Some individuals, no doubt, have fairly high rates of time preference, consistent with the real after-tax cost of credit card borrowing (although, as we have pointed out, those rates of time preference are likely to be significantly lower than the stated rate of interest). Many other individuals, however, demonstrate savings and investment behavior that is evidence of much lower rates of time preference. The Council's concern was to choose a social discount rate that is appropriate for the average ratepayer. This rate would have fallen between those of the credit card borrower and the savings account saver, if the Council had adopted this approach.

Consumer Credit as Indicator of Rate of Time Preference

Finally, even credit card debt alone does not imply that the appropriate rate for the average individual is 14 to 18 percent real, for several reasons.

First, many credit cards extend what amounts to 30-60 days' free credit before charging interest. This reduces the actual interest rate, calculated on the actual time the cardholder has the use of the money, below the stated interest rate. For example, a $100 purchase may be made 1 to 30 days before it appears on the credit card billing, 31 to 60 days before interest is charged on it, and 61 to 90 days before interest is paid. A stated 18-percent interest rate applied to a loan counted as one month could actually be as low as 6 percent when applied to the actual time between purchase and payment. Since these interest rates are being interpreted as evidence of the individual's rate of time preference, the imputed rate of time preference also is reduced by taking credit cards' grace periods into account.

Second, credit card loans are unsecured and somewhat risky to the lender. The expected average rate of interest, taking account of bad debts, will be somewhat lower than the stated rate. From the perspective of the average borrower, there is some probability that he or she will not pay the debt, so the expected average rate of interest is reduced from his or her perspective also.

Accounting for Risk in the Social Discount Rate

It is worth noting that the most important use of the social discount rate in the Council's power system analysis is in the Council's decision model--the Integrated System for Analysis of Acquisitions--where planning strategies are simulated over a large number of uncertain futures. In this Council model, resources are financed at market costs of capital, which include risk premiums and include taxes paid by lenders on their interest income. The social discount rate is used only to convert streams of revenue requirements to present values. Much of the uncertainty facing the region is modeled explicitly; the model simulates mistakes in timing of acquisition decisions, resources that don't perform up to expectations, and the like.

As a result, much of the cost of uncertainty is included in the expected value of revenue requirements over a large number of scenarios. The variation in revenue requirements simulated by the planning model is another means for planners to examine the impact of strategies on regional uncertainty. In this environment, the risk premium to be represented in the social discount rate is reduced below the level appropriate for an analysis of a single investment with a single projected outcome.

Discount Rates in Use

Table 13-7 includes a sample of discount rates suggested or used by various organizations. While it demonstrates a lack of perfect agreement among the sources represented, Table 13-7 also indicates a rough range of uncertainty for the social discount rate. Two of the sources, the Natural Resources Defense Council and the book *Discounting for Time and Risk in Energy Policy,* describe an estimation process much like that adopted by the Council. They both analyze data on long-run (1920s to 1970s) average returns to investments of various levels of risk and estimate real after-tax returns for the lowest-risk class of investment. They both conclude that these yields have varied from -2 percent to +2 percent, depending on the historical period. Furthermore, they both conclude that 1 percent real is a reasonable estimate for a long-run average return to low- or no-risk investments. With these estimates in mind, the discount rate of 3 percent, which has been used by the Council and Bonneville for power system analysis in the past, implies that the riskiness of power system investments justifies a 2-percent risk premium in their evaluation.

Table 13-7
Discount Rates Used for Present Value by Source

Organization	Discount Rate	Type of Project
Office of Management and Budget	10% real	Federal government projects (water projects use lower discount rate)
Northwest Power Planning Council (1986 20-year Plan)	3% real	Power system analysis
Bonneville Power Administration	3% real	Power system analysis
Bonneville Power Administration	4.5 to 5% real	Financial and rates analysis
Eugene Water and Electric Board (EWEB)	3% real	Power system analysis
Seattle City Light	3% real	Power system analysis
Investor-owned Utilities in PNW	5 to 7% real	Power system analysis
Northwest Conservation Act Coalition (NCAC)	0% real	Power system analysis
Natural Resources Defense Council (NRDC)	1% real	Zero-risk social discount rate
	2 to 3% real	Costing of conservation, generating resources
Robert C. Lind, et. al. <u>Discounting for Time and Risk in Energy Policy</u>	1% real	Evaluation of investments of risk comparable to U.S. Treasury bills
	2% real	Evaluation of investments of risk comparable to long-term U.S. government bonds
	4.6% real	Evaluation of investments of risk comparable to "market portfolio" (using 20 percent tax rate)

Sensitivity of Resource Portfolio to Social Discount Rate

Figure 13-6 shows some of the effects on the Council's resource portfolio of using a higher or a lower discount rate. Figure 13-6 compares the relative present value of two resources. The first resource labeled "capital" in the figure has a moderately high but constant stream of costs, corresponding, for instance, to the bond repayment on a conservation program or a hydro plant, which have virtually no operating costs. The second resource, labeled "fuel," has a stream of costs that start out lower than that of the first resource, but are substantially higher at the end of its life because of inflation and real escalation. This would correspond to, for instance, a combustion turbine. The example was constructed so the present values of the costs of these two resources were equal at the 3 percent real discount rate adopted by the Council.

Discount Rate Sensitivity

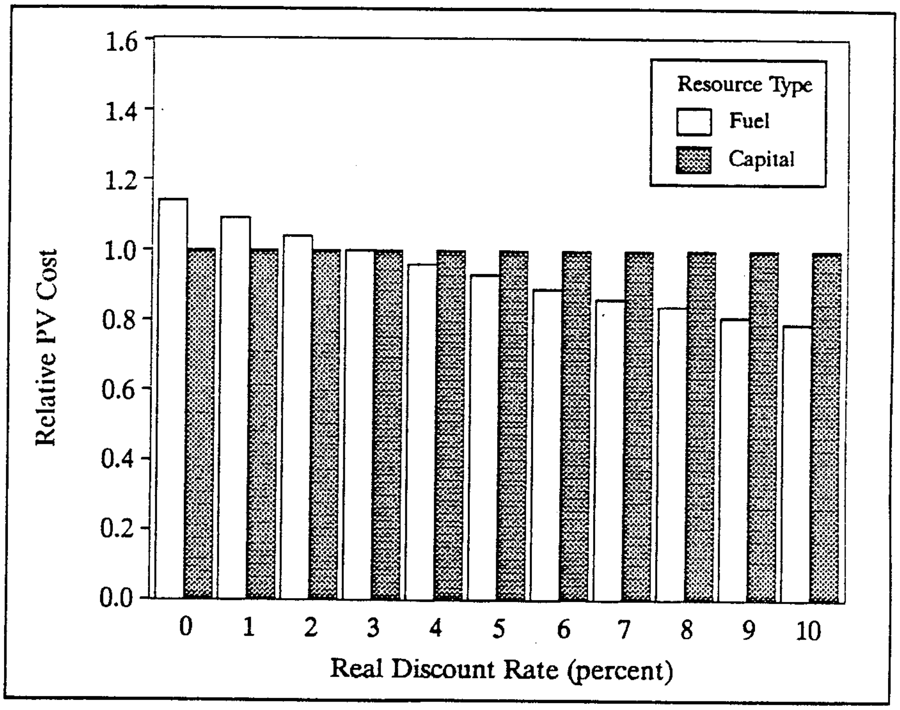


Figure 13–6
Sensitivity to Discount Rate

Figure 13-6 shows that a higher discount rate reduces the present-value cost of the fuel-intensive resource relative to the capital-intensive resource. While a higher rate reduces the present value of both, it reduces one more than the other. Figure 13-6 displays only the relative change in present values. This happens because a higher discount rate puts less weight on the future, which is the period in which costs of the fuel-intensive resource are higher than the costs of the other resource. A discount rate lower than 3 percent has the opposite effect on relative costs, because it puts greater weight on the future.

CHAPTER 14

RESOURCE COST-EFFECTIVENESS

Chapter 14
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Introduction

All resources included in the Council's resource portfolio are selected based on their relative cost-effectiveness. Cost-effectiveness is a measure of the relative cost of the contribution of a resource to the region's electrical power system. The Council has chosen, as the appropriate measure of cost-effectiveness, the net present value cost, including both capital and operating costs of each resource evaluated from the perspective of its operation in the entire regional power system, using the Integrated System for the Analysis of Acquisitions (ISAAC) computer model. This perspective is described further in the section on resource evaluation methodology. The computer model is described in Volume II, Chapter 15. The Council uses an estimate of the levelized life-cycle cost of each resource as a preliminary screening tool to select resources for detailed study in the resource portfolio analysis. The calculation of resource levelized costs is described in Volume II, Chapter 13, and the costs are shown in Volume II, Chapter 10, Table 10-1.

The cost-effectiveness analysis has two primary roles in the development of the Council's resource portfolio and Action Plan. The first role is to size the amount of each resource that may be available in the supply curves of conservation and generating resources over the planning horizon and to generally rank them in order of desirability.

The second role is to select from among these resource candidates those that are cost-effective for the region to secure now. Specific near-term acquisitions are difficult to predict in advance; however, a cost-effectiveness criterion will allow the region to select only those resources that contribute value to the region's power system. In the following sections, each of these roles of cost-effectiveness analysis will be discussed.

Cost-Effectiveness and Supply Curves

Cost-effectiveness analysis is used to cut off the resource supply curves for resources included in the Council's portfolio. It is important that the amount of each resource that is estimated to be available is consistent with the availability of other resources that will be acquired at the same time. Since many of the conservation programs and generating resource programs will be operated during the time when the Council's plan calls for securing options on new coal plants, the Council sizes the total amount of conservation and generating resources included in the plan based on a cost cap set at the estimated cost of a new coal plant in the region's power system.

Current estimates of the costs of new coal plants are between 7.8 and 9.8 cents per kilowatt-hour, levelized in nominal terms. The lowest-cost plants would be sited in eastern Montana and the highest in western Washington and Oregon or in Nevada. These costs are shown in the Council's overall supply curve in Volume II, Chapter 10, Table 10-1. These costs include the best available control technologies for air emissions, although such strict controls are not currently required by the Environmental Protection Agency or any state in the region except Montana.

Because these values do not include the 10-percent cost advantage for conservation in the Northwest Power Act, and the appropriate adjustments for transmission and distribution system cost and losses, the criterion for evaluating measures in the conservation supply curves has to be adjusted. The adjustments include the 10-percent advantage in the Act--7.5 percent for avoiding transmission and distribution system losses, and 2.5 percent for avoiding transmission and distribution system costs. An additional adjustment to conservation costs is required to account for administrative costs, estimated to be 20 percent of program capital costs. The Council has judged that it is inappropriate to apply the approximately 20-percent administrative cost overhead to individual marginal measures in the conservation supply curves, since overhead does not change with the installation of incremental measures.

Taking these factors into account, the Council had chosen 10 cents, levelized in nominal terms, to cut off the conservation supply curves. Measures were evaluated up to 12 cents, and approximately 255 megawatts of additional conservation is available between 10 and 12 cents. More recently, the Council chose to include some potentially desirable generating resources in the overall regional supply curve that are more expensive than the highest-cost coal plant. These are renewables such as small hydro, wind, biomass and some cogeneration. The Council has included these higher-cost renewable resources in its overall supply curves, based on judgment that these resources are developing and likely to experience lower costs in the future. The Council intends to review the status of the conservation above 10 cents before issuing the final plan. Inclusion of additional high-cost conservation in the regional supply curve would not be expected to change the Council's Action Plan.

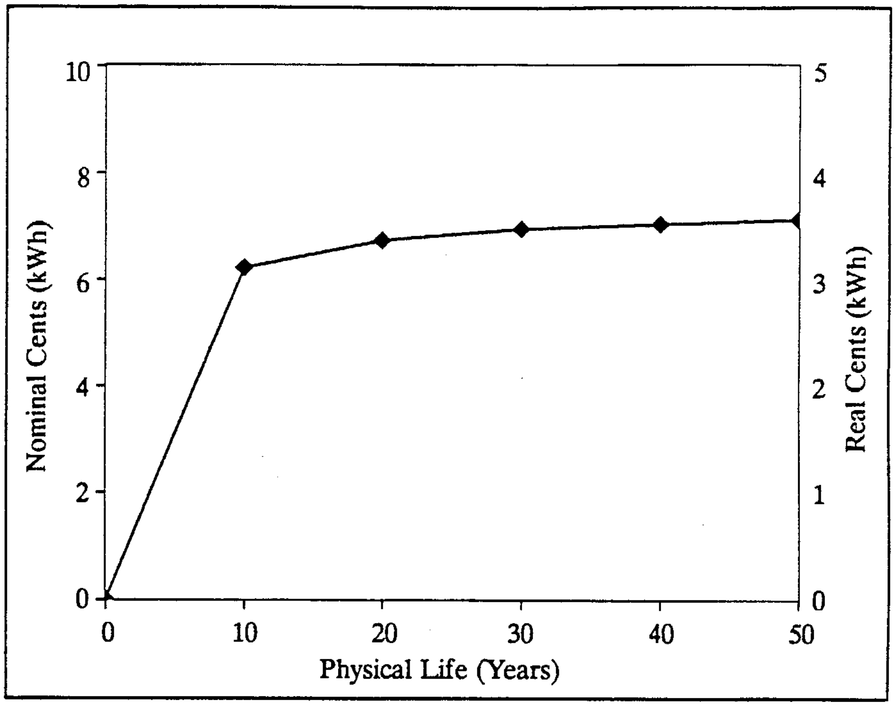
The overall supply curve is shown in Volume II, Chapter 10, Table 10-1. The conservation shown in the supply curve represents programs composed of a set of individual measures. While the programs' average costs shown in that table do not reach the cutoff level based on coal plant costs, the marginal measures do go as high as that cost level.

Cost-Effectiveness of Near-Term Acquisitions

The evaluation of the cost-effectiveness of near-term acquisitions begins with an analysis, using ISAAC, of the value of resources to be acquired over the next several years. Figure 14-1 illustrates the value of resources with lifetimes from zero to 50 years, if they are acquired in 1995. These resources are assumed to have a flat seasonal shape over the year.

Avoided Costs

Figure 14-1
Regional Avoided Costs—1995 Energy



The curve in Figure 14-1 shows that a resource acquired in 1995, with an expected lifetime of 30 years, has an expected value to the region's power system of approximately 7 cents per kilowatt-hour. The Council will use these avoided cost estimates to determine the value of resources to be acquired during the next five years. The Council also has used this criterion to limit the average cost of the conservation programs that are being called for in the Action Plan. The average cost includes the effect of the credits that accrue to conservation, but also includes approximately 20 percent for the administrative cost of the programs. However, taking into consideration the additional non-quantifiable environmental benefits of conservation, the Council has judged that it is appropriate to include individual measures in the programs called for in the Action Plan in Volume I up to the 10-cent cost-effectiveness point. That point is based on coal plant costs and was described above.

To apply this regional avoided cost estimate to specific resources proposed by specific utilities or developers, adjustments would need to be made to take account of the individual utility's situation. All resources will need to be adjusted for seasonal shape and load following ability. Special local situations, such as the transmission constraint facing the Puget Sound region, would call for additional credits for resources that could help to mitigate the constraints. Several of these factors are described further below.

Resource Evaluation Methodology

Introduction

The computer models used by the Council for this type of analysis tend to be large and complex, and the algorithms used are not widely understood. They also require significant computer resources to operate.

Outside parties, such as resource developers and regulatory agencies, have an interest in resource cost-effectiveness issues. However, the methods used by these groups for resource evaluation tend to be significantly different than those used by the Council. Such discrepancies can easily lead to different results and conclusions about resource cost-effectiveness.

The purpose of this section is to propose a method that allows outside parties to estimate resource cost-effectiveness in a manner that is consistent with the Council's methodology, but without needing access to the Council's computer models. The goal is to develop a process that can be easily applied to an individual resource. Such a process should take the important characteristics of the resource into account, and yield cost estimates similar to those of the full Council methodology. If successful, the methodology should provide a means for more consistent perspectives between the Council and other parties in evaluation of resource cost-effectiveness. It should be noted that the results presented in this section are limited in scope. Not all resource traits or possible combinations of important characteristics are addressed here.

Background

Most resource developers and regulatory agencies use a "stand-alone" approach for evaluation of resources. That is, the costs of a generation project are evaluated as if that resource were operating in isolation. Assumptions are made about project operating levels, and estimated costs for capital and operating expenses are projected through time. Engineering economy techniques are used to translate these cost streams into levelized costs. The project's levelized costs then are compared to those of other projects or to avoided cost estimates for a determination of cost-effectiveness. Only the costs associated with a particular resource are considered in the analysis.

The Council's methods for determination of cost-effectiveness differ significantly from this stand-alone approach by reliance on a system perspective. The objective is to capture the cost impacts that would occur over the entire regional power system due to the addition of a new resource. When a resource is added to the system, it is likely to produce effects that extend beyond that individual project. For example, it may affect the operating levels and costs of other resources, such as combustion turbines or coal plants. It also might affect the amount of energy sold on the secondary market, impacting secondary revenues. Depending on the load/resource balance conditions, it could have an effect on the level of load served. In addition, the nature of the energy produced by an individual project can have cost or value consequences. For instance, variations in seasonal output can affect the value of the resource. The Northwest load shape and nature of the hydro system constraints combine to convey more value to projects which produce more of their energy in the fall and winter.

The Council captures these effects by modeling the entire Northwest power system as well as secondary energy markets in the Pacific Southwest and Canada. This makes it possible to simulate the way a new resource would operate in the system, its impact on the operation of other resources, and estimate all changes in system costs due to that resource. By testing different resources or sets of resources, conclusions can be made about relative cost-effectiveness. Bonneville, the Pacific Northwest Utilities Conference Committee (PNUCC), and several utilities in the region use similar methods. In fact, several of the models used for regional planning were developed jointly by staff from the Council, Bonneville, the InterCompany Pool, PNUCC and the utilities. However, because of the size and complexity of the models, the user group generally is limited to the above organizations.

This gap in methodology can easily lead to differences in conclusions about resource value. It is possible for two projects which have similar stand-alone costs to have very different cost effects, when viewed from a system perspective.

In the Council's 1986 Northwest Power Plan and again in the 1989 supplement to that plan, the Council attempted to bridge this gap by publishing estimates of regional avoided costs. Avoided costs represent an amount the region could afford to pay for new resources and still have system costs equal to those obtained through the plan's resource portfolio. The intent was to provide a benchmark against which project sponsors could test levelized costs. If a project's estimated levelized costs were less than avoided costs, the resource would save the region money over the resource portfolio, and therefore would be cost-effective. However, to be directly comparable to the avoided cost estimates, the project being evaluated would need to have traits identical to those of the resources used in development of the avoided cost numbers. This would rarely be true, and therefore the avoided costs in the 1986 plan and the 1989 supplement were of limited use.

Methodology

The resource evaluation methodology consists of three steps. The first step is the calculation of project stand-alone levelized cost. The levelized cost calculation should incorporate all direct and indirect capital costs, associated finance rates, taxes, fixed and variable fuel costs, fixed and variable operating and maintenance costs, escalation rates, financial life and physical life. For comparability, the levelized costs should be expressed in nominal terms using a nominal discount rate of 8.15 percent (a 5 percent inflation rate and a 3 percent real discount rate). Costs should be expressed in January 1988 dollars. If year-to-year variation in energy output is expected, the average generation should be used in the levelizing calculation.

The second step is to apply a series of adjustments to the stand-alone levelized cost. The magnitude of adjustment is based on a set of selected resource attributes. These are characteristics of resources which would be moot in a stand-alone cost analysis, but which would have an effect in a system oriented analysis. Depending on the nature of the attribute, the adjustment could have a positive or negative effect. The net effect of these adjustments would be to translate the stand-alone levelized costs into an estimated levelized cost from a system perspective.

The final step is to compare the adjusted levelized cost to avoided cost estimates. The adjusted costs should now be on a basis that is comparable to system avoided costs, and direct comparison would be appropriate. A conclusion of cost-effectiveness is warranted if the adjusted costs are lower than avoided costs. It implies that a full system analysis would find that the resource produces net benefits to the region. Obviously, if adjusted costs are higher than avoided costs, the resource is not cost-effective.

Important System Perspective Resource Attributes

A set of resource qualities were investigated and found to have significant effects in a system-oriented analysis. Again, these traits are limited to those that would have no effect in a stand-alone analysis. Obviously, other variables, such as capital or fuel costs, have a major effect on resource cost-effectiveness, but these are already included in both the stand-alone and system analysis and would not lead to differences in conclusions between the methods. The resource attributes addressed and found to have significant effects included:

1. seasonality,
2. ratio of firm to average resource capability,
3. discretionary versus non-discretionary scheduling, and
4. construction lead time.

The results presented here were determined through use of the Council's decision analysis modeling system, except for the results on seasonality, which were determined using the System Analysis Model. A base case was first developed for each variable. Structured changes were made to the variables, and new model runs were made to determine the change in the present value of system costs. System costs include fuel and operating costs for all generating resources, revenue from secondary sales, emergency purchase costs, and capital costs for all new generating resources and conservation programs. The present value changes in system costs were translated into levelized costs adjustments using a discount rate of 8.15 percent and a time period equal to the physical life of the resource, usually forty years. All levelized costs and adjustments referenced in this section are in nominal terms and expressed in January 1988 dollars. A discussion of the results for each variables follows.

Seasonality

The effect of changing seasonality was studied by dividing the year up into six separate two-month periods. The periods chosen were January-February, March-April, and so forth. Seven resources were studied, six of which produced all of their energy in one of these two-month periods. The seventh resource had a flat seasonal distribution, that is, the energy output was constant across the year. The resources were identical in all characteristics except for seasonality variations.

The effects of changes in seasonality are depicted in Figure 14-2. The height of the bars reflects the increase in system cost (or reduction in value) over a project which would have a uniform or flat seasonal distribution. For instance, energy produced only in the January-February time period would be worth about 0.4 cents per kilowatt-hour more than a project which produced the same total annual energy output, but in a uniform fashion across the year. That is, the cost adjustment to the resource would be negative to account for the benefit. Energy in the May-June period only would receive a 2.4 cents per kilowatt-hour penalty. Late spring and summer is the high runoff period, and additional energy in this season is frequently of very limited value. On the other hand, energy produced in the September to December time frame results in a decrease in system cost (or increase in value) over a flat seasonal distribution. Fall and early winter is the season when combustion turbines have a higher probability of operation, because the probability of nonfirm hydro energy being available is relatively low. Energy production in the fall, which displaces high variable cost combustion turbine energy, results in higher project value.

Seasonal Shape

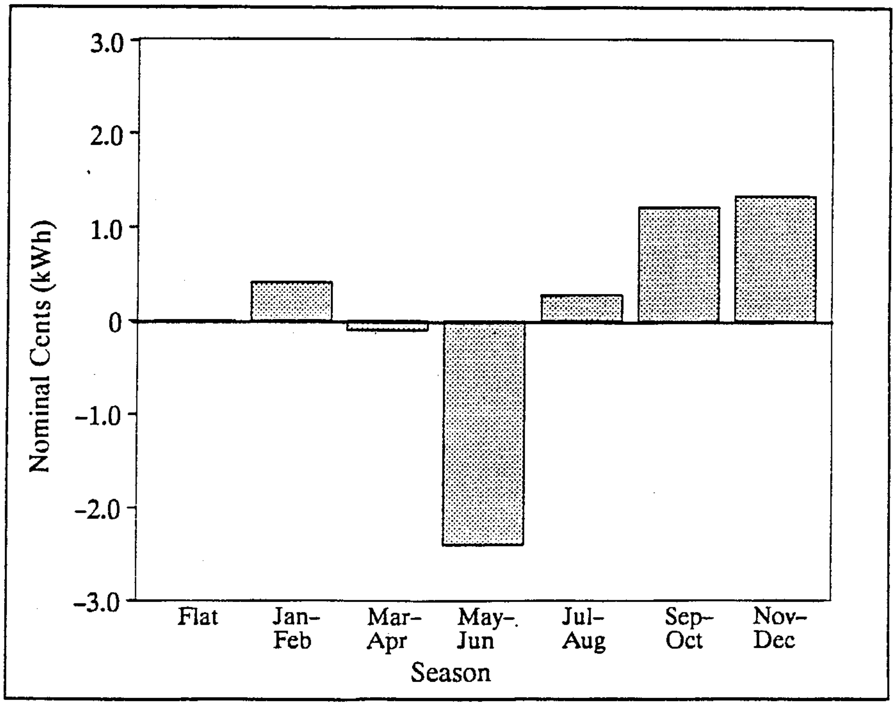


Figure 14-2
Effect of Seasonal Shape

Obviously, no resource will produce 100 percent of its output in any one of these three periods. However, the relative worth of seasonal energy contributions should be similar to that shown in Figure 14-2. Calculating a weighted average using the period cost adjustment weighted by the percentage of energy produced in the period should produce a reasonable estimate of the total seasonal cost adjustment. A sample calculation is included in the example.

Firm versus Average Energy Capability

Some resources will have differences between average or expected energy capability and their firm capability. For instance, a typical hydro project will not be able to generate as much energy in a poor runoff year as it could in a good water year. The region uses critical water capability as the basis for new resource development. A resource that has a reduction in capability that may be coincident with poor water conditions is of lower value than an identical resource with no reduction. Other resources would need to be developed to maintain system reliability. This additional capital expenditure is offset to a degree by reductions in system production costs or increases in secondary revenue under better water conditions, but the net effect is to increase expected system costs.

The effect of a reduction in firm capability is shown in Figure 14-3. The results are expressed as a function of the ratio of firm to average energy capability. The data points shown on the graph are model generated results. Values for the penalties range from zero cents per kilowatt-hour at a ratio of 1.0, to about 1.1 cents per kilowatt-hour at a ratio of zero.

Linear regression provides a good fit to the data and yields the following equation:

Cost Adjustment = 1.08 - 1.08 x (Firm Energy ÷ Average Energy)

Reduced Firm Capability

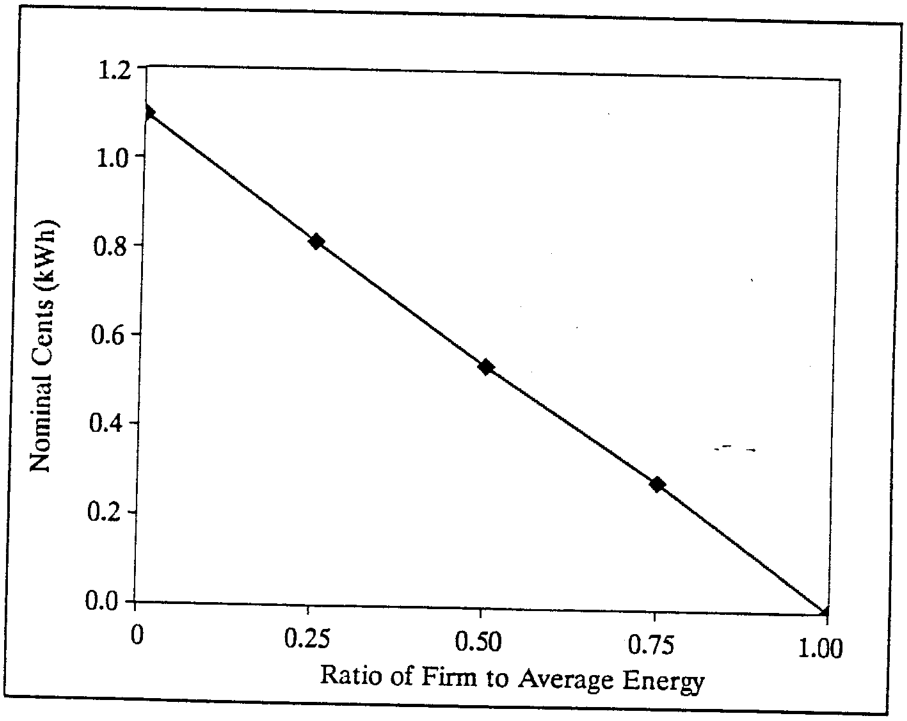


Figure 14-3
Effect of Reduced Firm Capability

Discretionary versus Non-Discretionary Scheduling

A discretionary resource has flexibility in scheduling. A non-discretionary resource has no flexibility in scheduling. A non-discretionary resource forces a construction decision to be made in a particular time period. It would imply a very short window during which the resource could be developed. An example might be a hydro project with a construction license about to expire, and no expectations for relicensing. If the resource is to be acquired, the decision must be made immediately. Even if the resource is cost-effective, the acquisition pattern is likely to be sub-optimal. Depending on the cost of the resource, benefits might be maximized if the resource could be developed at a later date. Forcing immediate acquisition could postpone the development of cheaper resources. The cost penalties associated with non-discretionary resources depend on the cost of the resource. Obviously, forcing a cheap resource into the system ahead of need has less penalty than forcing an expensive one.

The Council's methodology for calculating avoided costs uses a non-discretionary resource as its base. The objective in Council avoided cost analyses to date has been to estimate the value of lost-opportunity resources. Therefore, no additional cost adjustments are needed in cost-effectiveness determinations for a non-discretionary resource. However, rather than penalties for forced acquisition, the adjustments can be interpreted as benefits or decreases in perceived costs due to scheduling flexibility.

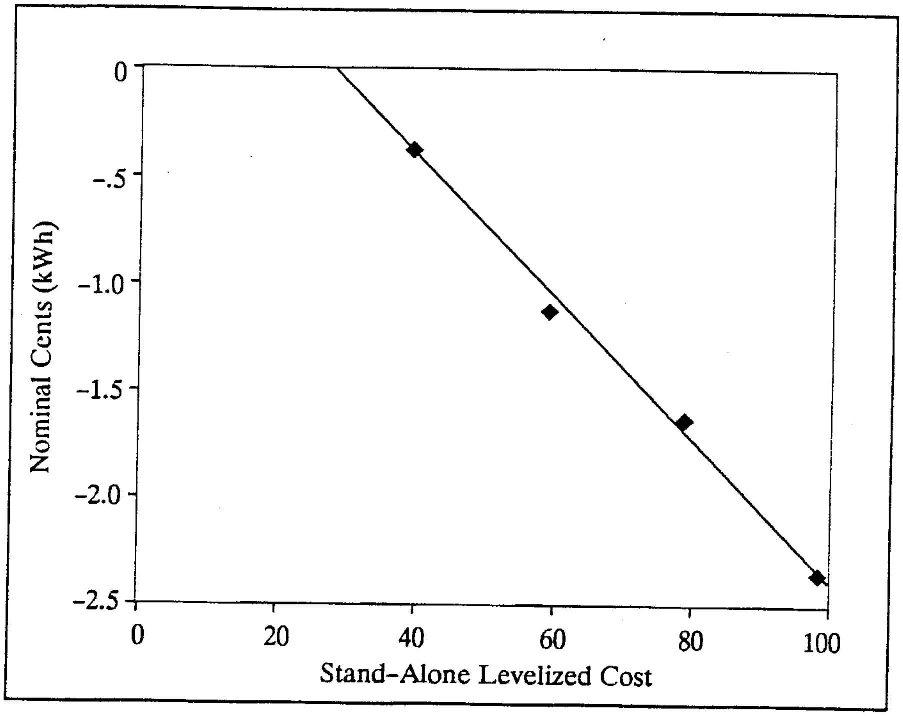
The effect of moving from a non-discretionary to a discretionary basis for a resource is shown in Figure 14-4. The adjustment associated with allowing the construction decision for a resource to float is expressed as a function of stand-alone levelized cost. A resource with a stand-alone levelized cost of 4.0 cents would see an adjustment due to discretionary acquisition of about -0.4 cents. Freeing up a 10-cent resource reduces its perceived system cost by about 2.4 cents. At a levelized cost of about 2.7 cents, the adjustment goes positive, indicating that to minimize system costs, the resource should be acquired immediately, regardless of need.

A linear relationship fits the data points well. The following equation can be used to calculate the adjustment for allowing discretionary decisions on a resource:

Cost Adjustment = 8.8 - 0.33 Stand-alone Levelized Cost

Force versus Float

Figure 14-4
Effect of Force versus Float



It should be noted that the scheduling window used for this analysis was the full 20-year planning period. For shorter scheduling windows (i.e., less flexibility), the benefits will be reduced. Conceptually, there is a family of curves, related both to the cost and the scheduling window for a resource. The levels of adjustments appropriate for shorter windows have not been studied to date.

In addition, once discretionary decisions are allowed on a resource, the probability of acquisition becomes less than 1. Obviously, the more expensive the resource, the lower the likelihood of acquisition. This is the primary reason for the significant levels of adjustments seen for expensive resources. Giving the system an option on high-cost resources, without forcing acquisition, allows significant reductions in expected system cost over a forced acquisition scenario. This implies that the use of options in the resource acquisition process could provide significant system benefits.

Construction Lead Time

The effects due to construction lead are only relevant if discretionary decisions are allowed on a resource. They do not apply to forced acquisition decisions. The consequences of lead time are derived largely through load uncertainty and flexibility. Because the degree of error in forecasting loads increases with the forecast period, there is a high degree of scheduling inaccuracy for long lead time resources. This leads to systems that have a high probability of being out of load/resource balance. Missing on either side of the mark can be expensive. If surplus, capital will have been expended or energy produced when it is not needed. If deficit, high cost emergency purchases may be needed to meet load. On the other hand, shorter lead time resources can be scheduled closer to need and can allow more efficient management of resources and capital.

The impact of lead time on resource cost is shown in Figure 14-5. These are penalties with respect to zero lead time or overnight construction. Cost penalties for lead times of one to three years are under 0.1 cents. However, after five years, penalties begin to increase rapidly, up to about 0.95 cents for a resource with a 10-year lead time.

The relationship can be estimated with the following quadratic equation:

$$\text{Adjustment} = 0.16 \times (\text{Lead Time}) + 0.078 \times (\text{Lead Time})^2$$

Construction Lead Time

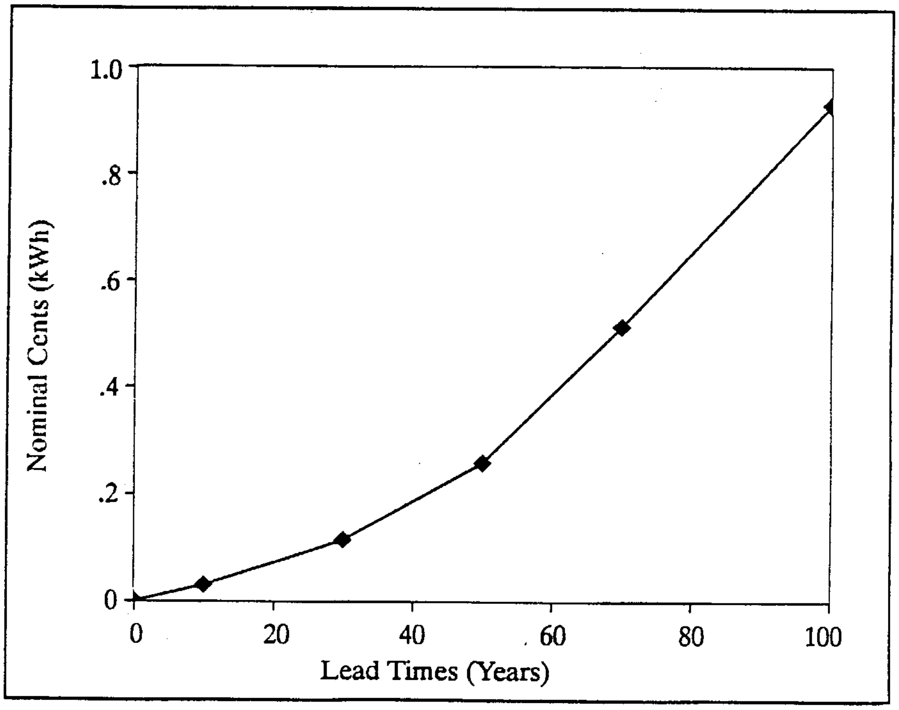


Figure 14-5
Effect of Construction Lead Time

Example

The following is a simple illustration of the application of this methodology. Suppose a small-scale hydro project has the following attributes:

Expected seasonal generation:

January-February:	10 percent
March-April:	15 percent
May-June:	40 percent
July-August:	15 percent
September-October:	10 percent
November-December:	10 percent

Ratio of firm to average output:	.75
Stand-alone levelized costs:	6.8 cents per kilowatt-hour
Physical life:	40 years

The cost adjustment for seasonality would be calculated using the values shown in the example, as follows. Figure 14-2 shows seasonal benefits, which are weighted by the generation seasonal shapes shown above:

$$0.41(0.10) - 0.10(0.15) - 2.40(0.40) + 0.28(0.15) + 1.22(0.10) + 1.34(0.10) = -0.636 \text{ cents per kilowatt-hour}$$

The negative benefit calculated above is a cost, so it will be added to the stand-alone cost.

The cost adjustment for the ratio of firm to average output would be calculated using the equation for Figure 14-3 as:

$$1.08 - 1.08(.75) = 0.27 \text{ cents per kilowatt-hour}$$

The adjusted levelized cost would equal:

$$6.8 + 0.64 + 0.27 = 7.71 \text{ cents per kilowatt hour}$$

Figure 14-1 showed the Council's regional avoided cost estimates. For a resource with a physical life of 40 years, the avoided cost is approximately 7 cents per kilowatt-hour. The project has an adjusted levelized cost that is more than avoided cost, and thus the resource would not be cost-effective.

Other Considerations

As previously mentioned, this analysis has been limited in scope. The objective was to begin to define the important variables left out of a stand-alone cost analysis and estimate their impact when viewed from a system perspective. The results are based on an assumption of independence between the variables addressed in this study. For example, the study assumed differing seasonal distributions would have no effect on the adjustments for the ratio of firm to average capability. In reality, there probably is some effect. Additionally, it was assumed that all of the impacts of physical life could be captured in the stand-alone levelized cost analysis. In reality, the magnitude of the variables addressed here will depend to some degree on physical life. Forty-year physical lives were assumed in this study.

The target resources represented in this study are those believed most likely to be sponsored by independent power producers, with acquisition through purchase contracts. The analysis was targeted toward resources small in unit size (under 50 average megawatts) and would include primarily new hydro, cogeneration, wind and geothermal. An important assumption in this study is non-dispatchability. The resources of interest here were modeled as if both costs and energy were non-displaceable. Hence, these results would not apply to economically dispatched resources, such as combustion turbines or displaceable contracts. Additional analysis would need to be done investigating the impact of fixed/variable cost ratios at several different total cost levels to address dispatchable resources.

Intended Use

This methodology is intended to provide a means for utilities, regulators and resource developers to compare a proposed resource with other possible resources and to determine the value of the resource in serving the regional load. The methodology is based on the Council's resource portfolio and is intended to provide a regional perspective on the resource's cost-effectiveness.

The methodology is not intended to determine whether a particular resource is needed or cost-effective for an individual utility or whether the resource might be cost-effective to serve load outside the region. The perspective of each utility differs somewhat from the regional perspective. For example, avoided cost estimates are highly specific to individual utilities.

The methodology, however, also should be a useful starting point for determining the value of a resource from the perspective of a particular utility. Some adjustments described in this paper, such as seasonality adjustments, should be representative for any Northwest utility with significant hydro resources and firm combustion turbine capability. Other adjustments, such as avoided costs, can be adapted readily to reflect the unique circumstances of particular utilities.

Moreover, this methodology is not intended to give a final answer about the desirability of or need for a particular resource. The cost-effectiveness of a particular resource is an important consideration, but other factors, which are not included in this methodology, must be considered as well.

In particular, there are significant non-quantified attributes that the Council uses in making a judgment about the resources that are included in the power plan. For example, the Council considers environmental concerns, such as the effect of the resource on fish and wildlife, indoor air quality, acid rain, mining impacts, transportation, employment, etc. The Council is required by the Northwest Power Act to give a 10-percent cost advantage to conservation measures, reflecting the environmental desirability of such resources.

The Council also considers the effect of a resource on reducing future load growth uncertainty. The Council gives credit to resources that are flexible and will assist the region in adapting to the wide range of uncertainty it is facing. The

Council also must decide whether sufficient valid cost and performance information is available on which to make an informed judgment.

The location of a resource also is important. Remote resources may require substantial expenditures for transmission. Resources located near large load centers may have positive effects on system stability and reliability.

Because of these additional considerations, the methodology in this section will not, by itself, give a final answer on the value to the region of a particular resource. Nor will this methodology exactly replicate the method by which the Council would evaluate a resource. It offers, however, a useful preliminary estimate of how a proposed resource compares with other resources in the resource portfolio.

Resource developers sometimes are required to determine whether a proposed resource is consistent with the Council's power plan. In the past, the only way in which to determine consistency with the Council's plan has been to request the Council to run computer simulations using their planning models. (Use of the Council's computer models for this purpose is made available at a nominal cost.) The Council's computer models will continue to be available for those seeking a more sophisticated and detailed analysis of regional cost-effectiveness.

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CHAPTER 15

RISK ASSESSMENT AND DECISION ANALYSIS

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Introduction

The recognition and treatment of uncertainty is one of the cornerstones of the Council's planning efforts. While all planning disciplines are subject to the effects of uncertainty, power planning is especially so. Committing to acquistion levels for conservation programs or to construction of generating resources can be multi-billion dollar decisions. Typically, these decisions have to be made with large question marks attached to some of the critical variables in power planning. With the lead times associated with conservation and generating resource development, decisions may need to be made up to 10 years in advance of need. That far into the future, forecasts simply cannot be very precise for important variables such as the level of demand, supply of resource alternatives, status of technological development, environmental factors affecting resource development, capital costs, etc.

In addition to long lead times, energy resources typically have physical or operating lifetimes of 30 to 50 years or more. Over the resource's operating life, variables such as fuel costs and output of the region's hydropower system will further affect the cost-effectiveness of resource decisions.

Nevertheless, even though the stakes are high, and information about the future is poor, decisions have to be made. The worst course of action would be to become paralyzed by future uncertainty and do nothing. The challenge of planning is to use the best information available, assess the benefits and risks associated with various alternatives, and take the course of action that is believed to best balance the costs and risks of energy decisions.

Incorporating uncertainty into the planning process has both quantitative and qualitative components. The analytical process tends to focus on the quantifiable issues. However, there clearly are limitations on the variables for which quantitative values and probability distributions can be defined. These typically are limited to economic and physical variables, such as fuel price forecasts or hydro condition probabilities, things economists and engineers like to argue about. Qualitative variables, such as the political feasibility of particular resources or the environmental benefits and costs associated with a resource strategy, generally must be incorporated into the process through decision-maker judgment.

The objective of this chapter is to describe the computer model the Council uses for the quantitative treatment of uncertainty. This model is called ISAAC, which is an acronym for the Integrated System for Analysis of Acquisitions. ISAAC was developed jointly by staff from Bonneville, the Intercompany Pool and the Council, with support from the Pacific Northwest Utilities Conference Committee. It is maintained jointly by the Council and Bonneville, and is used by both organizations for resource planning studies. The rest of this chapter will provide an overview of ISAAC, discuss some of the major features within the model and briefly describe the major algorithms used in the modeling process.

Background

One of the hallmarks of the Council's plans has been the recognition and treatment of long-term load uncertainty. Ever since the first plan in 1983, the Council has characterized future demand through a range of load forecasts, and has emphasized that future load could be anywhere in that range. The forecast range acknowledges the highly uncertain nature of the assumptions underlying the forecast, and abandons the idea of point forecasting and planning resources to a specific load level with little consideration of other possible load outcomes. It recognizes the possibility of alternative futures and the large impact those futures will have on the types and amounts of resources that will need to be developed.

The Council's plans also have placed an emphasis on flexible, short lead time resources. Shorter lead time resources reduce the period over which the need for new resources must be forecast, and allow resource sponsors to move closer to the point of actual need before committing large amounts of capital for construction. The less lead time needed for resource development, the better that development can be matched with load, and the lower the chance for the system to be either surplus or deficit.

However, quantitative estimates of the economic value of flexibility are difficult to obtain with the analytical methods traditionally used in utility planning. Traditional planning models typically are designed to schedule or evaluate a set of future resources under one specific load condition or forecast. Loads are treated deterministically, and resource plans are formulated as if a utility has perfect knowledge of future loads, leading to systems where supply and demand are in close balance over the planning horizon. This type of study structure reflects none of the benefits inherent in short lead time resources. A study that assumes perfect information on load will show no economic difference between two resources that have the same total cost, regardless of any differences in lead time.

It is difficult to evaluate the effects of load uncertainty and its impact on cost effectiveness with single load path models. The important effects to capture are the consequences of forecasting errors. It would be possible to manually set up studies that reflect errors in the resource planning process, resulting in systems that are out of load/resource balance. However, it would be very time consuming to set up and run enough studies to be sure of a representative set of wrong outcomes. Most of the planning studies performed before the advent of the Council were done under an assumption of perfect knowledge of future load. With single load path models, it is possible to model the single way of being right. It is virtually impossible to model all the different ways of being wrong. However, there is little doubt that the prediction of future conditions used to justify today's planning decisions will turn out to have some degree of error.

Perhaps the feature that most sets ISAAC apart from other utility planning models is its treatment of long-term load uncertainty. The model uses the entire forecast range as an input. A single study may examine hundreds of different load paths spread throughout the forecast range. The cost impacts and risks inherent in following a particular resource strategy can easily be tested across the entire load range. Because of imperfect forecasts, errors in resource planning are made, and the consequences are evaluated in terms of their magnitude and likelihood. If there are benefits associated with increasing the flexibility of a resource portfolio, they are captured and explicitly evaluated. This approach provides planners with the ability to assess the risks associated with different resource strategies and explore alternatives to balance cost with the risk imposed by load uncertainty. The approach can provide decision-makers with information in an area where they previously had to rely largely on intuition and judgment.

ISAAC uses a modeling approach that combines features of "Monte Carlo simulation" and decision analysis. Monte Carlo simulation is a technique for exploring uncertainty by using a mathematical model of a system with uncertain elements to make repeated experiments on that system. It can be used to build quite complex models of real world systems. Decision analysis is a branch of operations research involving the evaluation of decisions in light of uncertain future events. It can provide insights into the range of consequences for a decision, and can be particularly helpful in trying to find decisions that balance the sometimes-conflicting objectives of reducing both cost and risk. This is the focus of the quantitative problem addressed with ISAAC. Given the complexities and future uncertainties surrounding the Northwest power system, what set of policies and resource actions can provide the best trade-off between cost and risk.

It should be pointed out that ISAAC is not an optimizer. It does not attempt independently to find the best resource decision or decision strategy. The decisions or strategies for resource development are user-defined inputs to the model, and the model is simply a tool to allow the evaluation of alternative actions. By comparing the results produced by one set of decisions versus another, it is possible to discern the advantages of one course of action over another.

Model Overview

An overview of ISAAC and the general modeling process is shown schematically in Figure 15-1. As discussed previously, an important set of inputs are the load forecast scenarios that define the load range and the probability distribution for that range. Other important inputs include the resource alternatives available (both conservation and generating resources), their supply distributions and constraints on rates of development, physical and economic characteristics of both new and existing resources, data characterizing the variability of the Northwest hydro system, and the nature of out of region energy markets. Also, instead of specifying a fixed resource schedule, the user specifies a "resource strategy" that, in general terms, defines the types of resources preferred.

The model randomly generates future load paths, which in aggregate will have a probability distribution consistent with that specified in the input. It then moves through the future along one of these random load paths, forecasting and making resource decisions as consistently as possible with the resource strategy. It has very limited knowledge of the future and internally develops its own forecasts based on the characteristics of the original input load forecast range. Resource decisions are made concerning the management of individual conservation programs, preconstruction or option decisions for generating resources, and construction decisions for generating resources.

As the future within the model unfolds, random selections are made for uncertain variables. These can include such things as direct service industrial loads and loads that are not direct service, resource supply, hydro conditions, fuel prices, status of out-of-region markets and successful completion of resource options. As in the "real world," the observed values for these variables frequently turn out to be different than the predictions used when decisions were made.

Costing routines are used to keep track of the capital and production costs associated with the observed load and resource schedule, as well as secondary sales and need for purchases. Retail rates are calculated, and the load path is adjusted for price effects.

The model repeats the entire process for each year of the planning horizon. After one pass is completed, it will have simulated the effect of the resource strategy under one set of future conditions. Because of the large number of possible alternative futures, it is usually necessary to make many passes through the future to ensure statistical reliability for the results. The outcomes of all the passes are compiled into a variety of reports describing the economic and physical results for selected variables. Reports are generated that describe not only the expected value or mean outcomes, but also describe the distribution of outcomes for important variables.

Model Overview

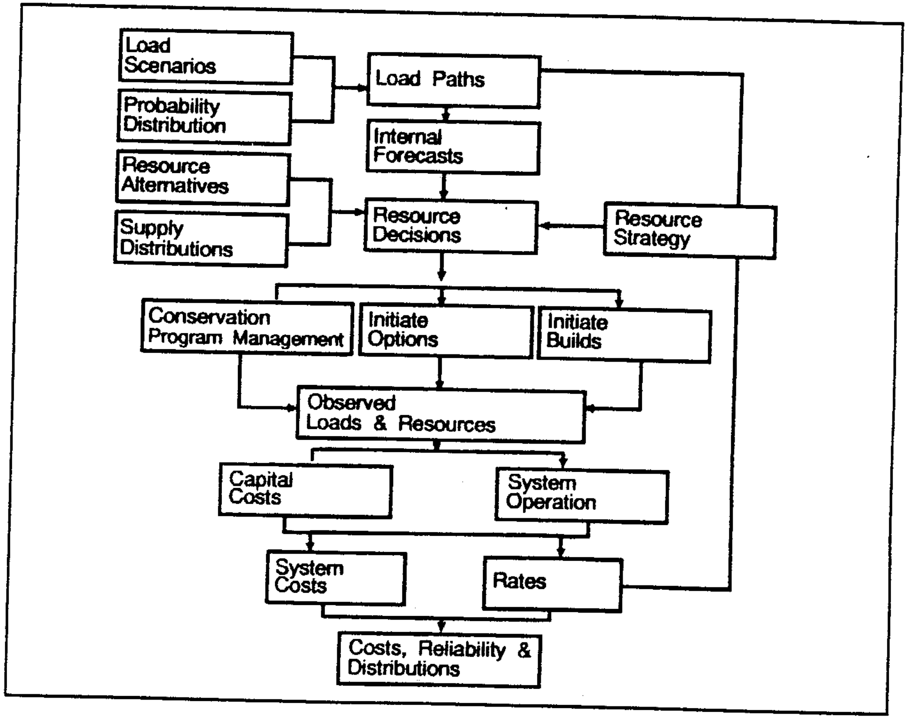


Figure 15-1
Flow of Information in ISAAC

The following sections describe some of the major features of ISAAC.

Multiple Planning and Dispatch Parties

To accommodate the institutional relationships and interests of the various organizations involved in electrical energy planning in the Northwest, ISAAC uses the institutional structure illustrated in Figure 15-2. There are three major categories used within ISAAC for utility organizations. The first of these is referred to as a "planning party." A planning party is defined as any utility or group of utilities for which planning activities are modeled separately. Within a study, each separate planning party can pursue its own resource strategy, independent of what others in the region do. The loads, resources and investment decisions for each planning party are tracked separately. A planning party does its own load forecasting, can have a reserved set of conservation and generating resources, and has its own priority order for resource development. One of the options available for planning parties is to place a user-defined portion of its load growth on Bonneville, through the power sales contract provisions of the Northwest Power Act. There is no limit on the number of planning parties allowed in a study. It would be possible to treat each utility in the Northwest as a separate planning party, however, the data development for such a configuration would not be trivial.

Institutional Structure

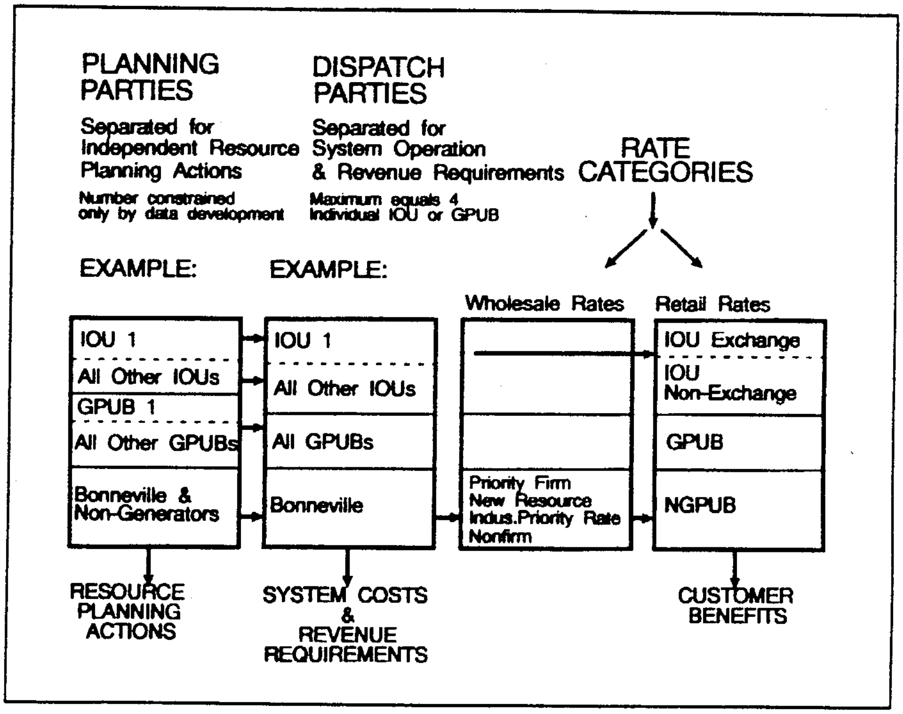


Figure 15-2
Treatment of Various Types of Northwest Utilities

The second major organizational category is that of "dispatch party." A dispatch party is defined as a utility or group of utilities for which system operations and production costing are modeled separately. Because of the complexity of Northwest hydro-thermal operations and the system interactions of utilities, the number of dispatch parties in a study is limited to either three or four. A three-party study will have Bonneville, the aggregated generating publics and the aggregated investor-owned utilities as the three dispatch parties. A four-party study allows either the generating public group or the investor-owned utility group to be broken down into two groups. In studies where more than three *planning* parties are defined for a study, the user can specify a planning party to keep separate in the system operation routines as the fourth dispatch party. This new group will typically represent an individual utility and will have been defined as an individual planning party. All other planning parties will have their loads and resources aggregated into either the Bonneville, generating public or investor-owned utility groups for the system operation simulation. The ability to isolate a planning party as the fourth party in the dispatch party allows the model to track all of the costs associated with the expansion plans of an individual utility.

The final major category for organizations is that of electrical rates. Rates are calculated at both the wholesale and retail level. At the wholesale level, Bonneville's priority firm, new resource, nonfirm and industrial power rates are calculated. At the retail level, rates are differentiated according to average investor-owned utility domestic and rural rates, investor-owned utility commercial and industrial rates, average generating public rates, and average non-generating public rates.

Treatment of Load Uncertainty

ISAAC currently has two alternative methods for treatment of non-aluminum industry loads. The method described here is the method used by the Council for characterization of load uncertainty. An alternative method is used primarily by Bonneville. The differences in the alternatives are largely methodological and are not believed to produce substantively different results. Efforts are under way to merge the two methods into a single approach.

One of the first steps taken by the model in a pass through the future is the creation of a load path for non-aluminum industry loads. This process is shown on Figure 15-3. The four detailed load forecasts are used to define a trapezoidal probability distribution for long-term load growth. A random selection is made from this distribution and is used to calculate the observed load at the end of the planning horizon. Because the input load forecasts do not have constant load growth rates over the entire planning horizon, a trend growth pattern is determined to reflect the general time series structure of the forecast. Once this load growth trend has been developed, the trend growth rates are modified with a series of random shocks to introduce volatility into the load path. The parameters influencing the amount of volatility in the load paths are controllable by the user.

Random Loads

Figure 15-3
Load Path Development Process for Non–Direct Service Industry Loads

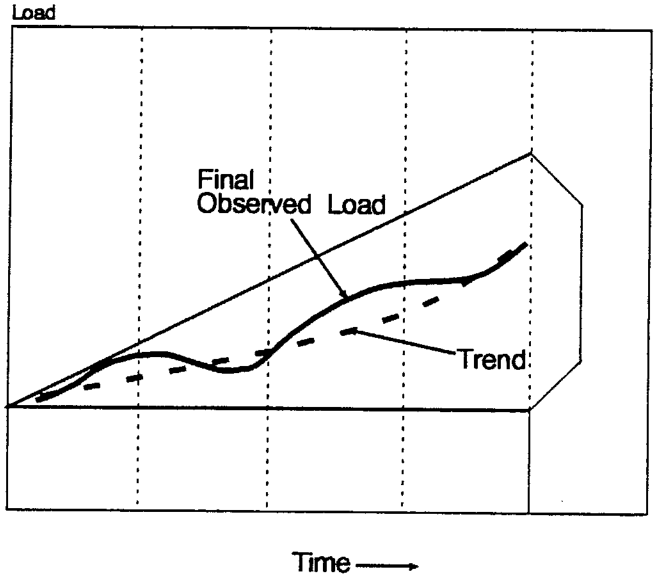
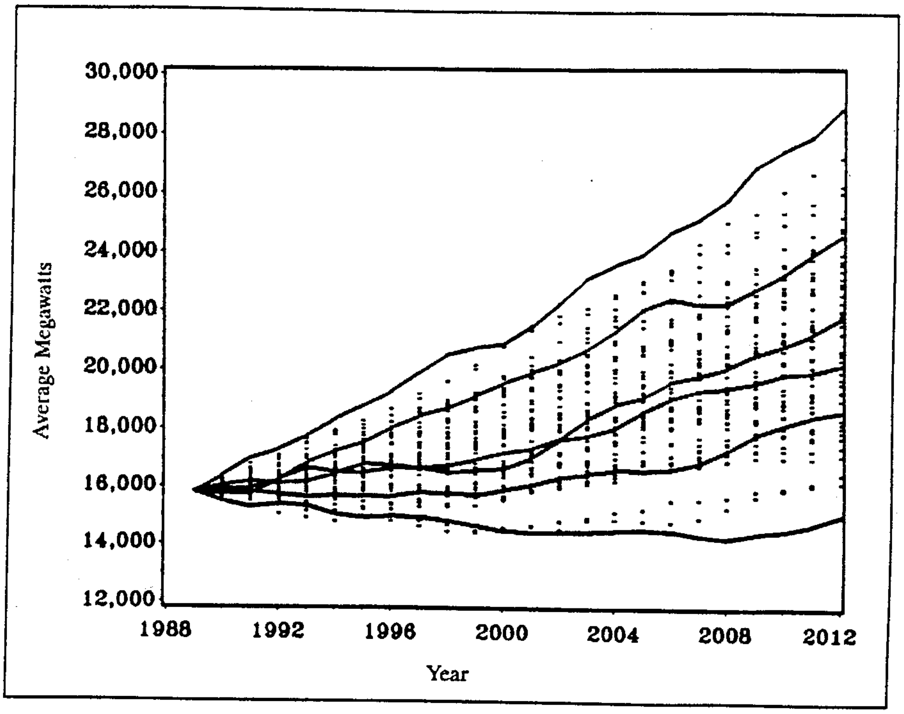


Figure 15-4 is an illustration of the observed load paths generated by the model. It is a scatter diagram of regional non-aluminum industry load against time for a study in which only 50 load paths were generated. The Council uses at least 100 paths in an actual study. Each dash represents a load level that the model will observe as it moves through the future. The solid lines represent a set of continuous load paths that would be followed by the model. Alternative load paths all start at a particular load level in a particular year, but may end up at any point between the low and high forecasts. The user has control over the size of the load range, the shape of the distribution of ending load values, and the amount of volatility present in the individual load paths. However, the model has only internal forecasts of where a load path eventually will lead. It has limited forecasting ability and continually updates forecasts as it moves through time, but it is blind to the future load within the limits of the forecast range. Forecast and observed loads are broken down into the loads required for utility planning activities, system dispatch and rate calculations, through a set of ownership and allocation matrices.

Load Outcomes

Figure 15-4
Example
Load Distribution



Aluminum Industry Model

The other component of load uncertainty is that associated with the direct service industry aluminum smelter loads. ISAAC contains an aluminum industry submodel that generates forecast and observed values for direct service industry loads. This submodel uses an aggregate picture of the aluminum industry in the Northwest, rather than focusing on individual smelters. The market price for aluminum is treated as a random variable. It is assumed to be normally distributed, with a user-specified, long-term mean and standard deviation. The level of aluminum load is driven principally by forecast and observed prices for aluminum.

Loads are determined through two major components. The first is a long-run smelter capacity decision. It is made through a function that describes smelter capacity as a function of estimated present value of aluminum production profits. The upper and lower bounds for capacity and the parameters defining capacity as a function of net present value are user defined. The actual amount of aluminum load is driven by a function that describes how much of the smelter capacity will be used based on costs of production and the price of aluminum. Aluminum load forecasts are done annually and are based on forecasts of aluminum price. These forecasts are used in the system expansion routines for acquisition of resources. Observed load levels are determined quarterly, and are based on observed prices for aluminum. The observed load levels are used in the system operation routines. The direct service industry variable rate is modeled and is assumed to be in effect through 1996. Improved aluminum plant efficiency through the conservation modernization (Con-Mod) program is modeled and is controlled externally through user inputs.

One thing to note about the aluminum load logic is that it produces loads that are largely independent of the level of regional non-direct service industry load. This is a departure from the assumption in the detailed load forecasts, where high direct service industry loads accompany the high forecast, low loads accompany the low forecast, etc. In ISAAC, the assumption is that long-run aluminum prices are driven by world markets, and will be determined independently from regional economic conditions. While the pattern of correlation between direct service industry and non-direct service industry loads differs from the detailed demand forecasts, the range of loads should not. ISAAC's aluminum submodel is usually calibrated to result in approximately the same range of aluminum industry loads as contained in the detailed demand forecasts.

Option and Build Requirements

Two of the input parameters defining the resource strategy are the option level and build level. The option level governs the amount of resource for which options would be acquired and held in inventory. The build level governs the amount of resource moved out of inventory and into actual construction as well as the acquisition efforts for conservation programs. The option and build levels represent levels within the range of load uncertainty to use as guides for making resource decisions.

An example is shown in Figure 15-5. In this example, the region has moved out along a somewhat random load path and finds itself at load level "L" in time period "T." The future load path is still unknown, and decisions must be made in the face of this uncertainty. To do this, a range forecast is first made from period "T" and a probability distribution is applied to the forecast range. The length of the forecast corresponds to the longest lead time of available resources. The range of this new forecast range is likely to be narrower than the original range in the same time period. The high growth rate still is achievable, but since the model is now at a middle point in the range, it is very unlikely that it will ever reach the original high load path. Within this range, further forecasts must be made to use as a guide in making option decisions and build decisions.

The approach shown here is to develop a 50-percent cumulative probability (median) forecast and add or subtract constant energy amounts to develop the option and build forecast. In this example, 1,500 average megawatts is added to the median forecast to generate the option forecast. The build level adjustment is zero, and the build forecast is identical to the median forecast. Another alternative for specification of the option and build levels is to use only cumulative probabilities within the conditional forecast range. For example a 90-percent option level would correspond to a forecast level that 90 percent of conditional load paths would be below. Once these forecasts have been made, a set of resource priorities is used to guide resource decisions. Conservation acquisition and generating resource build decisions are guided by the build-level forecast. Generating resource option decisions use the option-level forecast as a target.

Load Targets

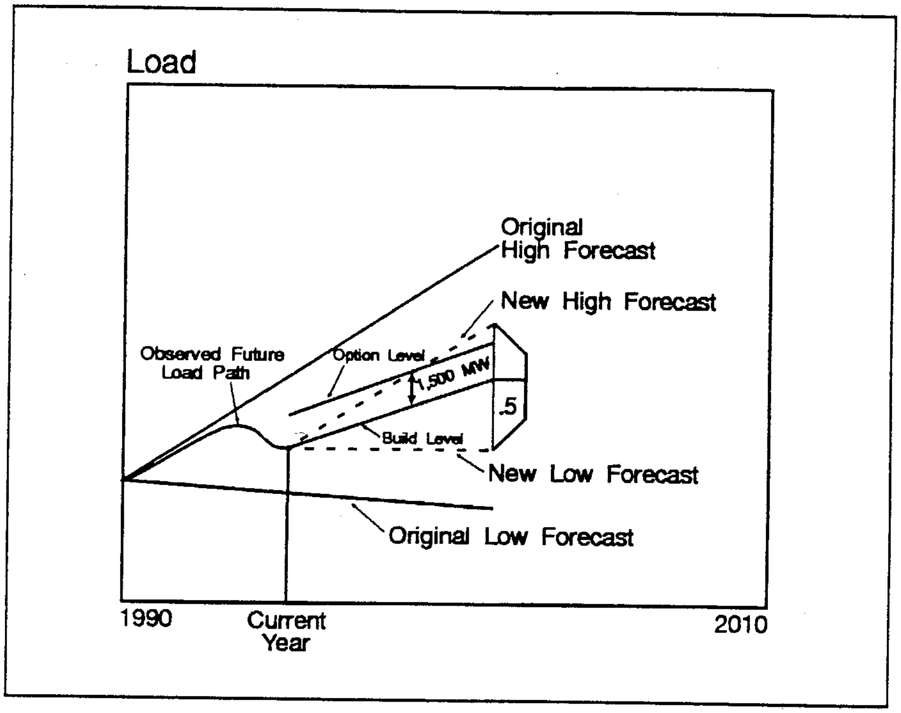


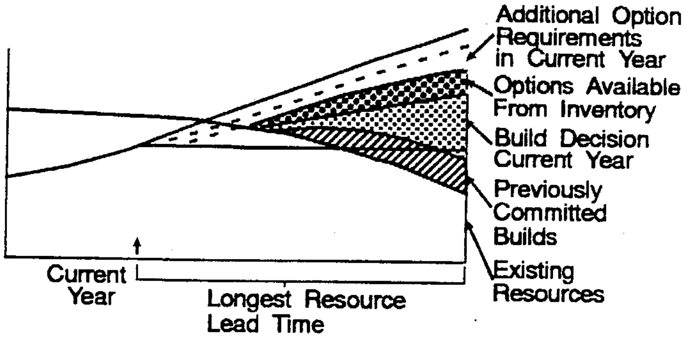
Figure 15-5
Example of Option and Build Levels

Resource Scheduling Decisions

The level of need for resource decisions is determined by subtracting existing system resources and the energy associated with previous decisions from the option-level and build-level target forecasts. Figure 15-6 shows an example of this calculation. This diagram shows the energy of existing resources, plus the energy resulting from a set of conservation acquisition and generating resource build decisions that were made in previous years. Note that not all of this new resource is likely to be online in the model's current year, but will come online as resources complete construction. The difference between these resources and the build forecast represents the amount of energy the model will attempt to secure from additional conservation and generating resource build decisions. The need for additional resource options is determined by comparing the target option forecast to the sum of existing resources, energy from previous conservation and build decisions, and potential energy from previous option decisions if fast-tracked into construction.

Need for Decisions

Figure 15-6
Determination of Option and Build Requirements



Conceptually, the process of making decisions concerning resource development in ISAAC is straightforward. The objective of the model's system expansion logic is to make decisions as consistently as possible with the user-defined resource strategy. As just discussed, the option and build levels are two components of a resource strategy. The other elements include a specified priority order for resource development, a set of constraints on resource availability and, potentially, a set of forced decisions to be made regardless of need. Note that the conservation programs and generating resources are freely mixed in the resource priority order. Also, the priority order is externally defined by the user. It is not determined internally on the basis of forecast resource economics. The Council ultimately develops a priority order by first screening resources based on levelized costs. It then makes multiple trials of priority orders using ISAAC to capture the system-cost impacts of unit size, lead time, seasonal shape, secondary energy markets, integration into the existing system and uncertain variables. Finally the Council makes modifications to the priority order based on judgment, to account for the qualitative factors excluded from the analysis.

Resource decisions are made by stacking the remaining energy available from conservation programs and generating resources under the build and option requirements in accordance with the priority order. Forced decisions specified by the user are made regardless of need as are acquisitions of non-discretionary conservation programs. For discretionary decisions, recognition is taken of lead times and development rate constraints. If energy from a resource is needed at a point in time that is equal to or less than its lead time, an action is taken on the resource. If the resource is expected to be needed at a point beyond its lead time, the action is deferred. Build decisions on generating resources consider only the construction lead time and can only be made on generating resources that have completed pre-construction activities and are currently in the option inventory. Option decisions consider the total generating resource lead time. Conservation programs use a user-defined scheduling window for determination of program management actions.

There can be occurrences where the resource priority order is not followed explicitly. Constrained development rates can cause parallel development of many resources. The model's highest priority is to maintain the reliability targets specified. Events, such as sudden spurts in load growth may require scheduling resources with lower priority, but shorter lead time, in order to maintain balance with respect to the option and build levels specified. It is also possible that reductions in observed load growth may cause options to expire before they can be used and may lead to choosing resources out of order.

Conservation Program Modeling

The conservation modeling capability within ISAAC is fairly extensive. A program is described through specifying a number of physical, economic and program management characteristics. Supply curves are defined through specifying program units available as a function of time and load level, in combination with values for savings per unit. As many different conservation programs as are needed can be specified. The Council typically uses 12 to 15 different programs in its resource portfolio modeling.

Conservation program types in ISAAC fall into four categories. The first type, typically referred to as a non-discretionary program, will have units automatically secured regardless of need for the program's energy. This is exemplified by programs that would be implemented by building code, such as the residential model conservation standards or new appliance efficiency standards. The units for this program type represent new purchases (e.g., new refrigerators purchased). Use of this program type forces acquisition of all new units and avoids the creation of lost opportunities. If the savings are not secured at the point of purchase, the opportunity will not arise again until the end of the lifetime of the newly purchased less-efficient unit. The number of units acquired for a non-discretionary program will usually be linked to the observed load path. The higher levels of economic activity associated with the higher load growth paths will provide more conservation savings potential than at lower paths.

The second program type is similar to the first in that the units for potential acquisition represent new purchases. However, this is a discretionary program. That is, the units are not automatically acquired, but are secured through program management decisions. If the energy savings for a type-two program are not needed, they probably will not be acquired. Use of this program could simulate the creation of lost-opportunity resources.

The third program type is a discretionary program used to acquire savings from existing end uses. An example of this type would be existing residential weatherization. The principal differentiation between this program type and the previous one is that lack of action is assumed not to create lost opportunities for conservation acquisition. If a house is not weatherized this year, it is still likely to be available for weatherization next year.

The final program type available is a two-stage program and is really a combination of the first and third program types. The first stage is designed to capture the effect of customer actions in a particular sector due to price response in the absence of an active program. When it is determined that the system needs energy from this program, it transitions to an actively managed discretionary program, and program management actions are taken to secure the remaining energy.

Conservation has historically been thought of as a very flexible, short lead time resource. The perception has been that it comes in small amounts and its acquisition could be easily managed to adapt to changing load growth patterns. The experience of the 1980's has shown that, while conservation is an attractive resource, there are limits on its flexibility. This can be caused by any number of factors, but is primarily due to the time it takes to develop conservation delivery mechanisms and to the resistance encountered when changing program design characteristics or utility funding levels.

As discussed earlier, flexibility can affect system economics and cost-effectiveness. The flexibility of discretionary conservation in ISAAC is controlled through a set of program management parameters referred to as acceleration and velocity constraints. These are user defined and specified separately for each discretionary program. These parameters are used to define upper and lower limits for the program activity levels and how quickly they can be changed. They are somewhat analogous to lead times for generating resources. These acceleration and velocity parameters are shown graphically in Figure 15-7. They allow program development to be modeled much as the movement of a car would be, with the activity level of a program analogous to the velocity of the car. Each program has an upper limit to its activity level (maximum velocity) and constraints on how quickly the activity level can change (maximum acceleration and deceleration). A minimum activity level (minimum velocity) required to keep the program viable also is specified. High accelerations and velocities would mean a program is quite flexible and energy could be acquired quickly. Low values would indicate slow acquistion rates and difficulty in changing program activity levels. The modeling of these program constraints provides the ability to value the flexibility or constraints of conservation program development in assessing its cost-effectiveness.

Conservation Constraints

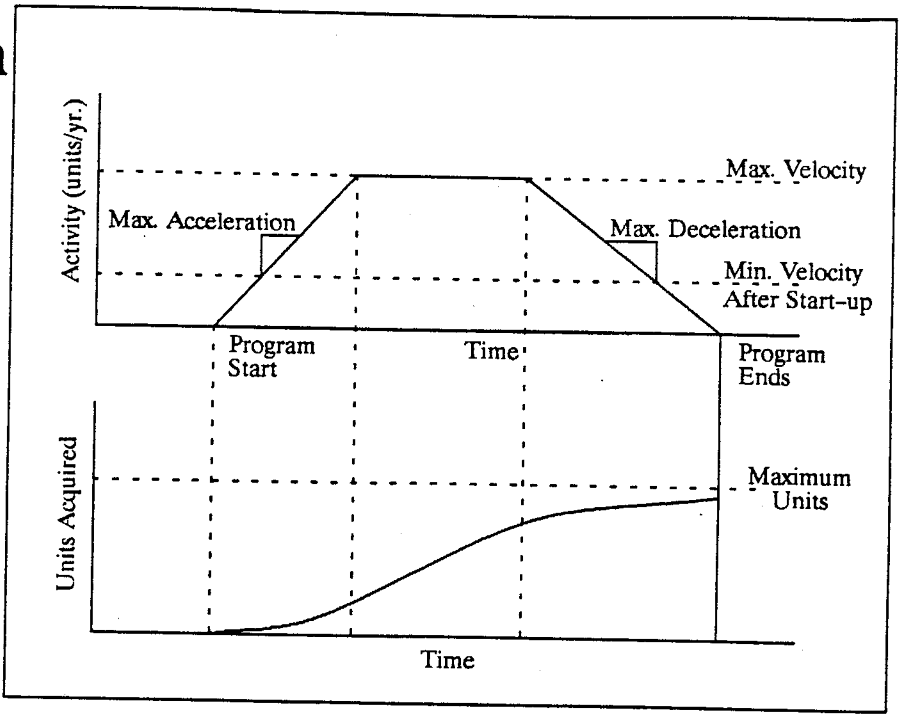


Figure 15-7
Conservation Development Controlled Through Accelerations and Velocities

Generating Resource Modeling

Like conservation programs, new generating resources are described through a number of physical and economic characteristics. Some resources, such as WNP-1 and WNP-3, are modeled individually, while others will require some amount of aggregation for computational efficiency. For instance, dispersed resources, such as small hydro and cogeneration, are typically aggregated into several generic blocks, and the input parameters describe the average values for the entire block. Supply curves for generating resources are defined by specifying the number of individual units available as a function of both time and load level. If there is more potential available for a resource under high than low load conditions, or if a user wanted to constrain the resource strategy to acquire a resource only under certain load conditions, these constraints can be modeled. While the supply curves for generating resources generally have some level of aggregation, the resource decisions are made on an individual unit basis.

For all generating resources, decisions are made in two steps. The first is a decision to option or start pre-construction activities on a unit; that is, to enter the siting, licensing and design stage. The second decision is to move a unit into the actual construction phase. Once an option decision on a unit is made, the resource moves into a period of pre-construction activity. If the unit successfully completes this stage it moves into the option inventory. Once an optioned unit is in inventory, it becomes available for a decision to move it into the actual construction phase. Depending on need, it may be held in inventory for several years. Each generating resource has a user-defined inventory shelf life, and if a unit is not built before the end of its shelf life, it either expires and is no longer available as a regional resource, or again becomes a candidate to enter the siting, licensing and design stage. Once a build decision has been made on a generating resource unit, it moves through the construction phase and enters commercial operation where it will be available for dispatch through the end of its physical life. The process is summarized in Figure 15-8.

Resource Milestones

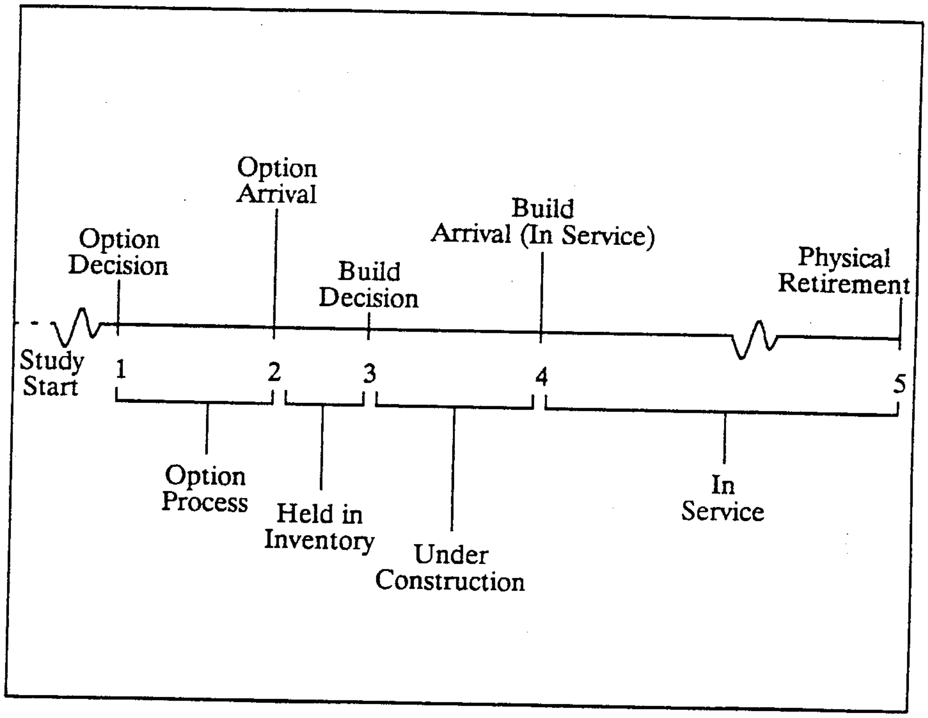


Figure 15-8
Timing of Events for Generating Resources

The timing of generating resource decisions is driven by the option and construction lead times for a resource. Unless forced resource decisions are specified by the user, decisions are delayed for as long as is possible and still meet the option and build level targets. The user also can specify constraints on the number of units for which option or construction decisions can be made in any given year.

Another of the random variables modeled in ISAAC is the uncertainty associated with the successful completion of the pre-construction phase for a resource, and if successful, whether it will remain a viable option over the maximum length of time it can be held in inventory. The user specifies values for the probability that an option will fail during the siting, licensing and design stage, and for the chance of an option failing over the period it is held in inventory. These input values are used to define the probability density functions for option failure during both the option and hold period. These are shown in Figure 15-9. The option failure distribution is treated as uniform over the option period, that is, if the attempt to gain the option fails, it has an equally likely chance of failing at any point during the pre-construction period. If the option is successful and moves into inventory, the probability of failure starts at zero and increases linearly to the end of its shelf life. This represents a condition where the longer an option is held on the shelf, the higher the probability is that it will be lost before a decision is made to construct. The model takes random samples from these distributions, first to determine if and when the option fails during the pre-construction period. If the unit successfully completes this phase, a sample is taken from the hold period density function to determine if and when it fails during its stay in inventory. As option failures happen, information on the occurrence flows into the decision-making routines so corrective actions can be taken.

Option Uncertainty

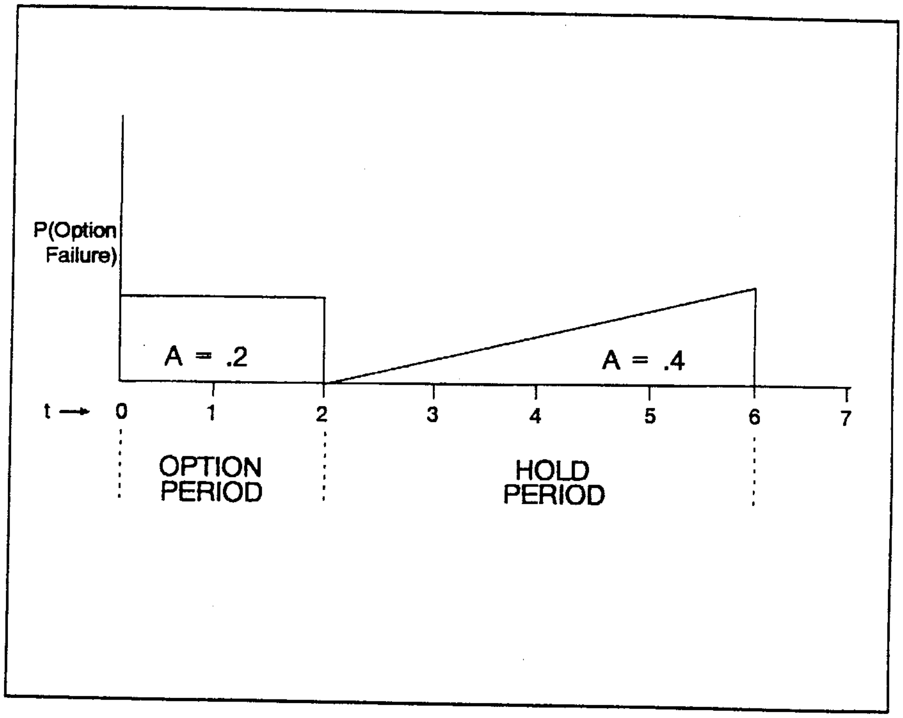


Figure 15-9 Options Can Fail During Pre-Construction or While in Inventory

If a generating resource unit makes it all the way through the option or pre-construction stage and is moved into construction before an option failure occurs, it moves into commercial operation at the end of its construction period with certainty. In ISAAC, all of the uncertainty regarding the completion of a generating unit is resolved in the siting, licensing and design stage and during the period it is in inventory. Once a resource has negotiated the hurdles required to move into construction, it is assumed that it can be completed successfully.

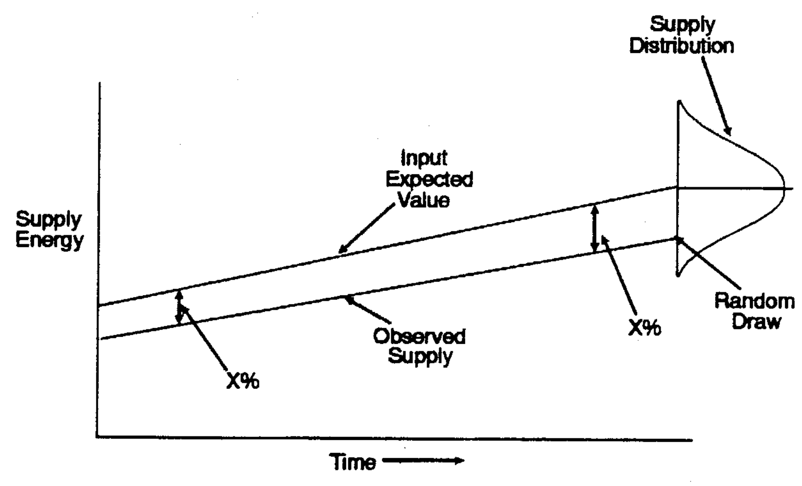
Resource Supply Uncertainty

One thing many conservation programs and generating resources have in common is uncertainty about future supply. While the Council believes that its data development process produces reasonable and balanced supply estimates, there is no question that today's forecasts of cost and availability for future resource alternatives are highly uncertain. This is especially true of emerging technologies, such as solar photovoltaics, or of resources, such as geothermal, where the ultimate cost-effective energy potential depends on the future confirmation of the size and quality of an uncertain heat source.

ISAAC has algorithms that allow for the modeling of uncertainty in future resource supply and the examination of its impact on today's resource decisions. The methodology used to treat supply uncertainty is illustrated in Figures 15-10 and 15-11. Expected resource supply estimates and the long-term coefficient of variation for the supply distribution are added by the user. The expected supply can be a function of time and load. The supply distribution is assumed to be normally distributed. At the beginning of a pass through the study period, a random sample is taken from the supply distribution. This defines the amount of resource supply that will be observed to be available at the end of the planning period. The percentage difference between the mean and the observed supply is applied uniformly across the planning period to generate the observed supply through time.

Supply Uncertainty

Figure 15–10
Determination of Long–Term Supply



As shown in Figure 15-11, planning information for resource decision-making at the start of the study period is based on the mean value for resource supply. This represents the current supply forecast, even though it is in error. Resource decisions are made on the basis of the forecast supply. If a supply forecast is too high, the resource may be counted on for more energy than it ultimately can supply. If the forecast for an inexpensive resource is too low, some cost-effective opportunities may be missed. As the model moves through the study period, the forecasts for resource supply are gradually adjusted to be consistent with the observed supply, simulating the process of learning more about the "true" resource potential. The resolution of this uncertainty is proportional to elapsed time, and the updated forecasts as seen from several points in time are shown in Figure 15-11. Any options on generating resources that would exceed the observed supply are forced to fail in the option failure process discussed previously. Observed conservation units are limited to the observed supply, even though program targets may exceed it. The impact of errors that are made because of inaccurate supply forecasts are captured in the simulation and can help identify the risks associated with overdependence or underdependence on uncertain resources.

Supply Forecasts

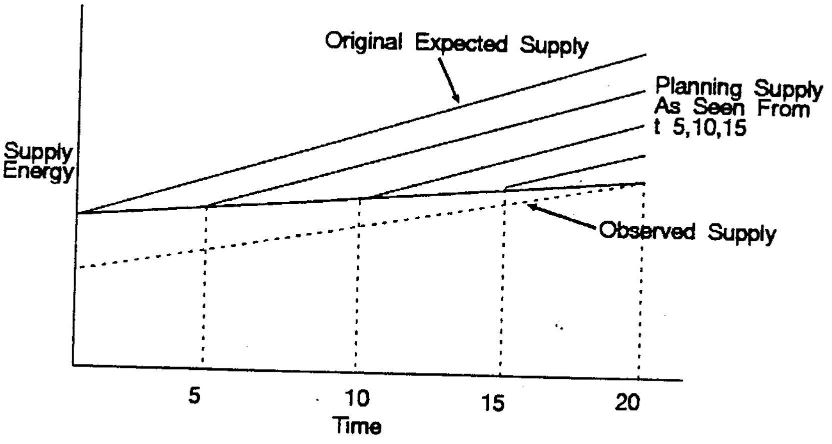


Figure 15-11
Forecasts Improve With Time

Fuel Price Uncertainty

An additional uncertainty treated in ISAAC is that associated with long-term fuel prices for generating resources. This effect is especially important to capture for high variable cost resources such as combustion turbines, gas-fired cogeneration, or rail-haul coal plants. Uncertainty in fuel prices can add significantly to the risk carried by the region, if substantial new commitments are made to these resources.

The algorithm for treatment of fuel price uncertainty is quite similar to that used for long-term load uncertainty. The process is illustrated in Figure 15-12. The inputs for fuel price include an initial price in some reference year and an annual stream of real escalation rates. These are used to develop a time series for fuel prices, which serves as the expected value of price through time. Additionally, a coefficient of variation is specified, which is used to generate a normal distribution for fuel prices at the end of the planning horizon. At the beginning of a load path, a sample is taken from this distribution. This defines the ending fuel price for this pass through the future. The ratio of observed to expected price is used to develop a long-term trend fuel price pattern. The trend growth rates are then modified with a series of random shocks to introduce volatility into the fuel price path. The parameters influencing the amount of volatility produced are controllable by the user.

ISAAC has inputs for both variable-fuel and fixed-fuel price components for all generating resources, and fuel price uncertainty affects both components. It can be applied to any subset of both new and existing resources. Additionally, it is possible to model correlated fuel price groups. For example, if gas prices for combustion turbines are significantly higher than expected, prices for gas-fired cogeneration can be specified to show this same general pattern of escalation. Finally, because of the importance of revenues derived from the Pacific Southwest secondary energy market, dynamic adjustments can be made to the price structure of the Southwest market to reflect random variations in the generating resource fuel prices that would be experienced in the Southwest.

Random Fuel Prices

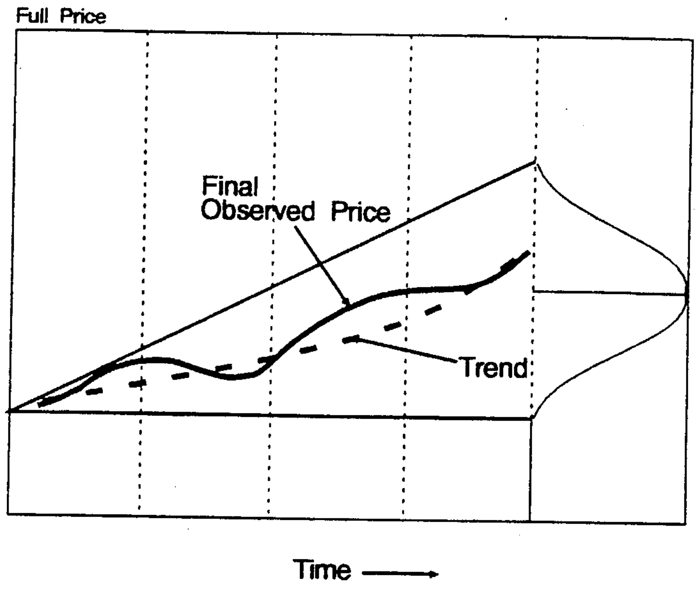


Figure 15-12
Fuel Price Development Process

System Operation

System operation and production costing is based on a composite model of the Northwest's hydroelectric system. Because of the dominance of the Northwest's hydroelectric system, ISAAC is an energy model only; there is currently no treatment of capacity. Simulation of hydropower system operation is based on a one-dam model in which total hydro energy capability, natural streamflow energy, reservoir draft, and limits on draft and refill for the entire system are specified as single values for the various seasons and water conditions. Data for the hydropower model are based on the result of critical period studies and the 40-year hydro regulation studies performed as part of the Northwest Regional Forecast. To capture the impact of streamflow variability, each year the model randomly chooses a water condition based on probabilities associated with the 102-year water record. Four discrete time periods are used for evaluation within each operating year: September through December, January through April, May and June through August. May is modeled separately to provide better resolution on the system impact of the spring fish flows.

Within the dispatch, all resources fall into one of six categories: nuclear, low-operating-cost coal, high-operating-cost coal, simple-cycle combustion turbines, combined-cycle combustion turbines and load-reduction resources. The non-dispatchable resources, principally conservation and renewables, are usually modeled as load-reduction resources, with seasonally shaped energy contributions. Thermal units are modeled with deration through their equivalent availability, and are shaped seasonally according to specified maintenance schedules. Nuclear units are treated as must-run resources. All other thermal operation is modeled with economic dispatch against firm, interruptible and secondary market load blocks, as needed under the various hydro conditions. The secondary market is modeled as a four-tiered market with seasonal prices and seasonally shaped demand blocks changing through time. Transmission access to Northwest parties and BC Hydro is guided by the long-term intertie access policy. If firm regional load cannot be met with regional resources, attempts are made to buy energy from out of region markets in Canada and the Pacific Southwest. The Council currently assumes up to 1,500 megawatts of energy is available from the Southwest at natural gas-fired combustion turbine prices. Any firm load that cannot be met through these emergency purchases is assumed to be curtailed and is costed at a user-specified price. (The Council currently uses 15 cents per kilowatt-hour for firm curtailments.) Curtailments of interruptible load are priced near interruptible rates.

As mentioned previously, the system operation logic accommodates either three or four dispatch parties, depending on user specification. In a three-party dispatch, operations, costs and revenues are tracked separately for Bonneville, the aggregate generating publics and the aggregate investor-owned utilities. In a four-party dispatch, an individual generating public or investor-owned utility can be further isolated. Dispatch parties are modeled with their own loads and resources and have individual rights to firm hydro, secondary energy, intertie access, etc. Rights to interchange are modeled, as are economic transactions between Northwest parties. The four-party dispatch option allows estimates for all of the system costs associated with an individual utility planning strategy to be captured and isolated in the simulation.

Financial Analysis

Financial modeling in ISAAC is performed through a two-step process. At the beginning of a study, a submodel referred to as Microfin performs detailed calculations for capital revenue requirements for each possible resource and sponsor combination. These are translated into a set of factors expressing yearly real capital revenue requirements as a proportion of the cost of the resource and are stored for later use. Then in the simulation, whenever a resource is developed by a sponsor, the appropriate set of factors is used to estimate the stream of nominal capital revenue requirements for that resource.

Microfin treats both conservation programs and generating resources. Annual revenue requirements can be made up of a number of cost components including;

return on debt, return on equity, depreciation, state and federal taxes, deferred state and federal taxes, insurance, property tax and gross revenue tax. Direct capital expenditures for a resource are spread over the construction period according to user-defined cash flow distributions. User options allow the selection of rate-base inclusion of construction work in progress, or to accumulate an allowance for funds used during construction, with no return allowed on either the direct or indirect investment until the resource is placed in-service. A further option to simulate Bonneville financing through treasury borrowing also is allowed. In addition, provisions are made to accommodate the Bonneville acquisition of resources that would be developed by a party placing requirements contracts on Bonneville or by an independent power producer.

Only the capital expenditures associated with construction of a resource are financed. Generating resource option costs are expensed uniformly over the pre-construction period. If a resource fails during the option process, its option expenses are prorated according to how far it had gone through the process before it failed. Option hold costs required to maintain an option on a resource while it is held in the option inventory are expensed, as are the administrative costs associated with conservation programs. For conservation programs, user-defined incentive levels are used to control how much of the conservation investment is funded by utilities and how much by consumers. The financial parameters and accounting methods for utilities and consumers can be defined separately.

Rates and Price Effects

ISAAC includes a rates module that estimates Bonneville wholesale rates and average utility retail rates for a number of rate categories (see Figure 15-2). The rates methodology is fairly complex, and a description here would be overly ambitious. The logic is a somewhat streamlined version of Bonneville's more detailed models (e.g., the Supply Pricing Model), but is considered adequate to capture the general rate effects of differing resource strategies.

Price elasticity of demand can have an effect on the cost-effectiveness and need for resources, and is treated in the model. The detailed demand forecasts that are inputs to ISAAC are developed through detailed end-use and econometric models. These forecasting models calculate changes in price and the resulting response in loads. That is, price effects already have been accounted for at the price levels underlying the detailed forecasts. In ISAAC, further adjustments to demand due to price only are required if the resource strategy produces prices that are inconsistent with those underlying the detailed forecasts. To allow the model to track these differences, a reference price structure is entered, which defines the level of prices associated with the detailed forecasting models as a function of load path. As a random load path within ISAAC unfolds, this reference-price/reference-load structure is used to discern whether the observed prices are consistent with the reference prices associated with the detailed forecasts. If they are consistent, no further adjustment due to price effects is required. If loads and prices are determined to be out of equilibrium, appropriate adjustments to load are made.