Forecasting Electricity Demand Of The Region's Aluminum Plants

Background

Direct Service Industries, or DSIs, refers to a group of industrial plants that have purchased electricity supplies directly from the Bonneville Power Administration. In the past, most of these plants obtained all of their electricity needs from Bonneville. Recently, many of these plants have diversified their electricity supplies, either by choice or because of reduced allocations from Bonneville. This discussion generally addresses the total electricity requirements of these industrial consumers regardless of source.

"DSIs" is often used interchangeably with aluminum smelters because aluminum smelters account for the vast bulk of this categories' electricity consumption. If all of the region's ten aluminum smelters were operating at capacity, they could consume about 3,150 average megawatts of electricity. Table 1 shows the smelters, their locations, their aluminum production capacity and the amount of electricity they are capable of consuming at full operation.

Table 1: Pacific Northwest Aluminum Plants

Owner	Plants	County	Capacity	Electricity Demand
			(M tons/yr.)	(MW)
Alcoa	Bellingham WA	Whatcom	282	457
Alcoa	Troutdale OR	Multnomah	130	279
Alcoa	Wenatchee WA	Chelan	229	428
Glencore	Vacouver WA	Clark	119	228
Glencore	Columbia Falls MT	Flathead	163	324
Longview Aluminum	Longview WA	Cowlitz	210	417
Kaiser	Mead WA	Spokane	209	390
Kaiser	Tacoma WA	Pierce	71	140
Golden Northwest	Goldendale WA	Klickitat	166	317
Golden Northwest	The Dalles OR	Wasco	84	167
Total			1663	3145

Source: Metal Strategies, LLC, *The Survivability of the Pacific Northwest Aluminum Smelters*, Redacted Version, February, 2001.

This amount of electricity is significant in the Pacific Northwest power system. The amount of power used by these aluminum plants in full operation could account for 15 percent of total regional electricity use. When operating, the electricity use of these plants tends to be very uniform over the hours of the day and night. However, the aluminum plants have faced difficulty operating consistently over the past 20 years because of increased electricity prices and aluminum market volatility.

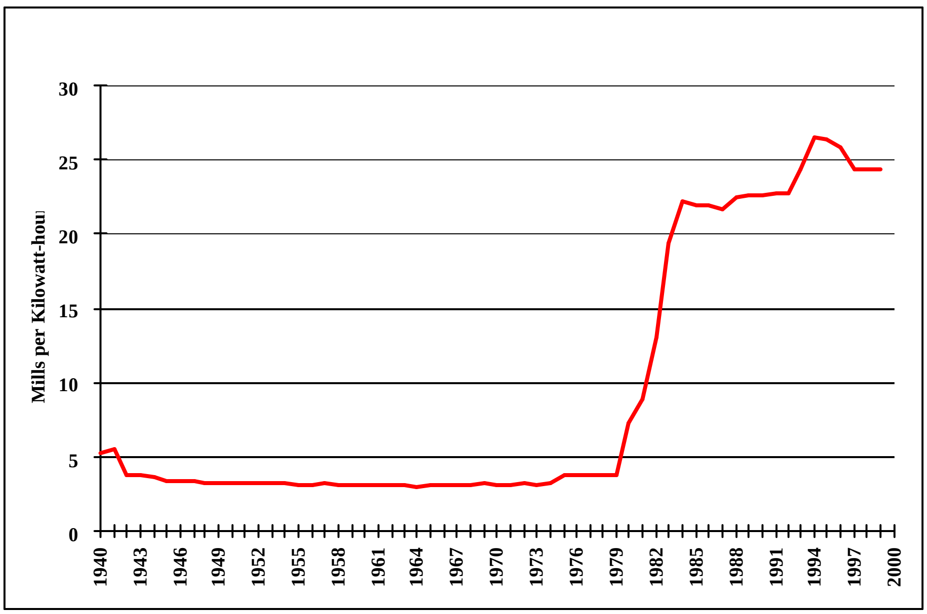
Aluminum smelting in the region started during the early 1940s to help build up for the war effort and to provide a market for the hydroelectric power production in the region. Smelting capacity was expanded throughout the 1960s and 1970s. Since then no new plants have been added, although improvements to the existing plants have resulted in some increases in smelting capacity. The 10 aluminum plants in the Pacific Northwest account for a significant share of the U.S., and even the world, aluminum smelting capacity. The region's smelters account for 40 percent of the U.S. aluminum smelting capacity and about 6 to 7 percent of the world capacity. Their presence in the region is largely due to the historical availability of low priced electricity from the Federal Columbia River Power System. Aluminum smelting is extremely electricity intensive. Electricity accounts for about 20 percent of the total cost of producing aluminum in the region's smelters and is therefore a critical factor in their ability to compete in world aluminum markets.

Deteriorating Position of Northwest Smelters

The position of the region's aluminum smelters in the world market has been deteriorating since 1980. This is due to a combination of increased electricity prices, declining aluminum prices and the addition of more efficient aluminum smelting capacity throughout the world.

Around 1980 the cost and availability of electricity supplies to the Pacific Northwest aluminum plants began to change dramatically. At the time, Bonneville supplied all of the smelters' electricity needs at very competitive prices. However, between 1979 and 1984 Bonneville's electricity prices increased nearly 500 percent. This illustrated in Figure 1, which shows Bonneville preference utility rates for electricity since 1940. The aluminum plants, along with other electricity consumers in the region, suddenly found themselves in a much less advantageous position with regard to electricity costs.

Figure 1: Bonneville Power Administration Preference Rates



As the region's aging smelters have struggled to stay competitive in a world aluminum market, the conditions of their electricity service have also been changing. During the 1970s, the region's electricity demand began to outgrow the capability of the hydroelectric system. The fact that aluminum smelters had no preference access to the Federal hydroelectric energy meant that their electricity supplies were threatened. The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (The Act) extended the DSI access to Federal power in exchange for the

DSIs covering, for a time, the cost of the residential and small farm exchange for investor-owned utility customers. In addition, the DSIs were to provide a portion of Bonneville's reserve requirements through interruptibility provisions in their electricity service.

Over the years since the Act, the DSI service conditions and rates have changed in response to changing conditions. Interruptibility provisions have changed, DSIs gave up their long-term contracts in exchange for increased access to the wholesale power market and for a while DSI electricity rates were related to world aluminum prices in an attempt to help smelters operate more continuously as some had become swing operations. Until 1996, aluminum plants in the region bought all of their electricity from Bonneville, with the exception of one plant that acquire part of its electricity supply from a Mid-Columbia dam. In the 1996 rate case, Bonneville reduced the amount of energy allocated to the DSIs to about 60 percent of their demand. In the 2001 rate case, it was further reduced to about 45 percent of their potential demand, or about 1,425 megawatts. The aluminum smelters are now required to obtain over half of their electricity requirements in the wholesale electricity market or from other non-Bonneville sources.

Most new world aluminum smelting capacity has been added outside of the traditional western economies, often in countries where social agendas may be driving the capacity decisions as much as aluminum market fundamentals. The disintegration of the former Soviet Union and the liberalization of trade in China have had a significant effect on the development of a world aluminum market. The addition of more capacity over time and improving aluminum smelting technology is reflected in declining aluminum price trends. Figure 2 shows aluminum prices from 1960 through 2001. Trends calculated over different time periods all show a consistent downward trend. On average, prices decreased by about 0.8 percent annually from 1960 to 2001. The downward trend is particularly pronounced from 1980 to the present.

Figure 2: Aluminum Price Trends

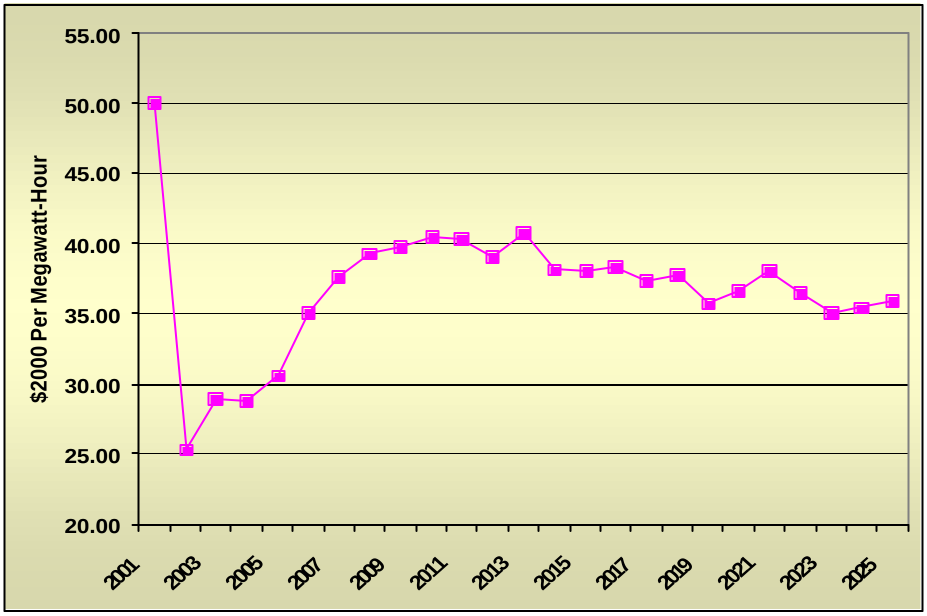
Source: CRU International Ltd., Presentation to Aluminum Association 2002.

The steady improvement in aluminum smelting technologies over time has meant that the region's smelters have tended to grow relatively less competitive in terms of their operating costs as new more efficient capacity has been added throughout the world. By investing in improved technology some of the region's smelters have been able to partially offset the effects of these declining cost trends. In addition, the worsening position of the region's aluminum smelters relative to other aluminum plants is partly offset by the decreasing capital costs and debt as older plants and equipment depreciate. Nevertheless, a growing share of the regional smelting capacity has become swing capacity. That is, it can operate profitably during times of strong aluminum prices, but tends to be shut down during periods of weak aluminum markets or high electricity prices.

Caught in the pinchers of decreasing aluminum prices and increasing electricity price trends, many of the region's smelters have reached a critical point. Events since the spring of 2000, in both the electricity and aluminum markets, have had a dramatic effect of the region's aluminum plants. By mid-summer of 2001, all of the region's aluminum smelters had been shut down for normal production, either because of high electricity prices and poor aluminum market conditions or because Bonneville bought back the electricity to help meet an expected shortfall of electricity supplies. The elimination of aluminum electricity load played a key role in avoiding electricity shortages in the summer of 2001 and the following winter. Payments from Bonneville have helped ease the financial strain on aluminum companies and their employees of a long shut down. Electricity prices in the wholesale market have returned to normal ranges for spot electricity, but Bonneville's rates are still higher as a result of the recent electricity crisis. And although wholesale electricity prices have returned to more normal levels, aluminum prices have remained depressed. As a result, only a small fraction of the region's aluminum capacity has resumed operation. There does not appear to be much optimism for a quick recovery of aluminum prices. Some analysts expect the Global aluminum market to remain in surplus until 2005.

With aluminum market recovery uncertain, and electricity prices hovering near a critical point for aluminum plant profitability, future aluminum electricity use is highly uncertain. However, it is clear that the long-term outlook has deteriorated significantly since the Council's last power plan. The ability of aluminum plants to operate may depend critically on the level of electricity prices. With the medium natural gas price assumptions, the Council currently is seeing draft spot market electricity price forecasts moving up to the $35 to $40 per megawatt-hour range (see Figure 3). Few smelters would be able to operate with electricity prices at that level. It is unclear how much of the aluminum load Bonneville might serve in the future, but Bonneville's future electricity prices may also be higher than most aluminum plants can afford except when aluminum prices are especially high.

Figure 3: Draft Medium Case Wholesale Price Forecasts for Mid-Columbia Electricity



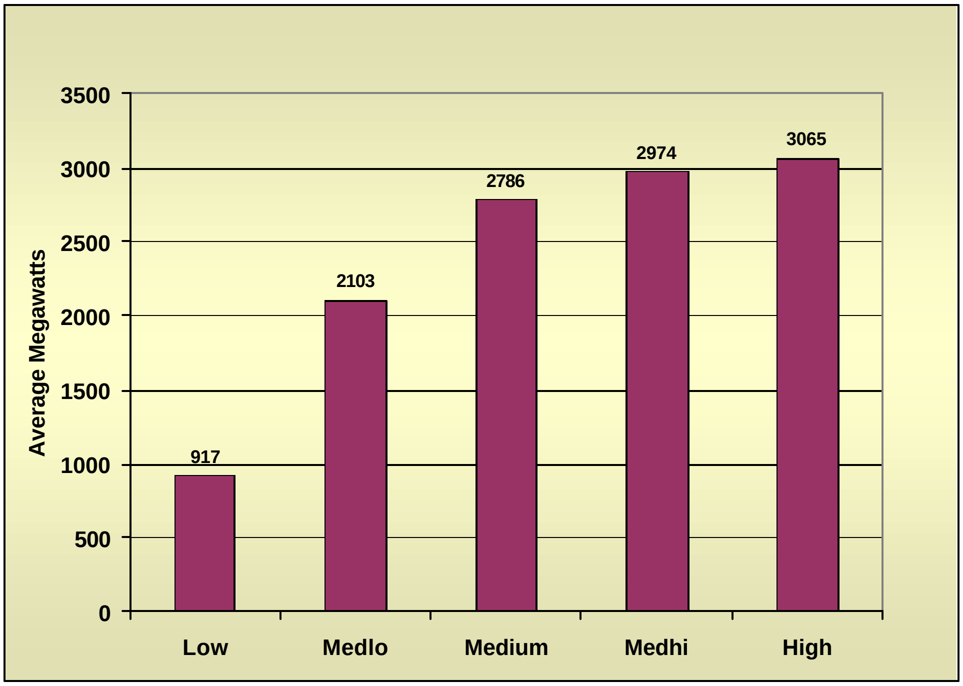
Aluminum Electricity Demand

Background

In all previous power plans, the Council has assumed a range of DSI demands. The high DSI demand assumption was paired with the high economic assumptions and demand forecast. This pairing of aluminum and other forecasting assumptions was based on the theory that aluminum prices would be the key variable and that aluminum prices were likely to be positively correlated with rates of economic growth. Figure 4 shows the aluminum demand assumptions included in each forecast case for the Council's 4th power plan. Only in the low forecast was there a large reduction of aluminum demand. It was assumed that Bonneville or other relatively affordable power would be available to the aluminum plants. Thus most of the plants were assumed to remain competitive, or at least operate as swing plants, in the medium case.

The expectation of higher electricity prices and rapid expansion of aluminum smelting capacity in China have changed the outlook for the region's smelters substantially. Aluminum prices are still important, but the cost of electricity has become a critical element for Northwest smelters. Since electricity prices are related to natural gas prices in the long-term, and high natural gas prices are associated with the high economic growth case, it may now make more sense to assume lower aluminum demand in the higher economic growth cases. However, if high aluminum prices are still associated with higher economic growth, then it is possible that the high economic growth cases will favor aluminum plant operation given that electricity prices are not too high. In short, it is not clear how aluminum demand will be related to the economic growth conditions.

Figure 4: Aluminum Electricity Demand Assumptions Compared to the Council's 4th Power Plan



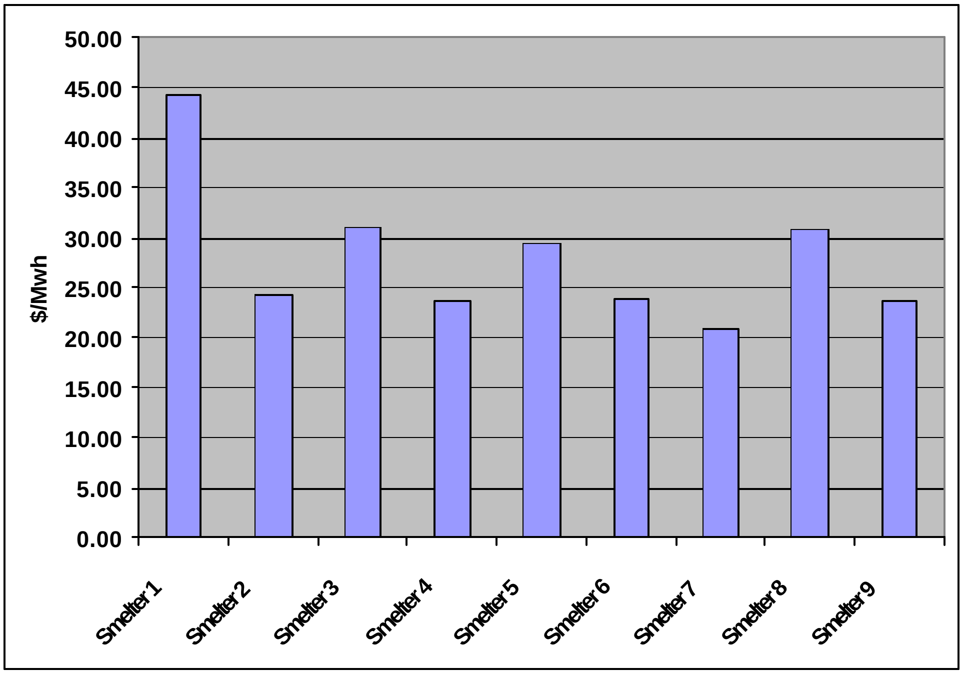
The proposed solution to this dilemma is to forecast aluminum electricity demand separately from other demands for electricity. Since aluminum demands are very significant in the future electricity demands of the region, they are an important source of uncertainty that should be modeled and addressed directly in the Council's resource planning process. Therefore, the Council proposes to model the aluminum industry demands explicitly in its portfolio model. To that end, a simple model of aluminum electricity demand was developed.

A Simple Model of Aluminum Electricity Demand

A simple model of Pacific Northwest aluminum plants was developed to relate the likelihood of existing aluminum plants operating to different levels of aluminum prices and electricity prices. Given an aluminum price, the model estimates what each aluminum plant in the northwest could afford to pay for electricity given its other costs. Then for a given electricity price, the electricity demand of the plants that can afford to operate make up the aluminum electricity demand in the region. Basic data for the model came from the July 2000 study cited as the source for Table 1 and advice from the Council's Demand Forecasting Advisory Committee.

Figure 5 illustrates the relative competitiveness of nine of the Northwest aluminum plants as represented in the model. It is assumed that the 10th smelter in Troutdale Oregon will not operate in the future. Figure 5 shows the amount that each plant could afford to pay for electricity given an assumed aluminum price of $1500 per tonne (about 67 cents a pound), which is about the average aluminum price over the past several years.

Figure 5: Affordable Electricity Price Limits of PNW Aluminum Smelters At $1500 Per Tonne Aluminum Prices



One aluminum plant in the region is very efficient and likely to operate under a wide range of electricity and aluminum prices. Three other smelters could pay around $30 a megawatt-hour for electricity if aluminum prices were $1500 a tonne, which is higher than aluminum prices have been in several months. The other smelters could only afford to operate at electricity prices less than $25 per megawatt-hour.

There are some important limitations to this simple model. It is intended to represent whether aluminum plants would be willing to operate for an intermediate time period. The costs used in the model include an amount above the pure short-term operating costs to allow sufficient ongoing capital investments to maintain the plants capability to produce. But the costs do not include sufficient returns on capital to justify the long-term operation of the plant.

Thus, the model does not address the question of when a plant would be likely to be permanently closed. In order to remain in operation, a plant would have to be able to recover sufficient funds during periods of high aluminum prices and low electricity prices to recover an adequate return on investment. However, as plants depreciate, or as they are sold at discounted prices, capital recovery becomes a smaller part of the decision, and strategic positioning in global markets may enable some plants to remain available for operation when conditions are attractive enough. The implicit assumption in the model is that, if a plant can operate for the intermediate term under expected electricity and aluminum prices, then it will be able to recover sufficient returns during favorable cyclical market conditions to survive in the long term.

The model does not address the dynamics of temporary closures of aluminum plants or their return to operation. The dynamics of aluminum smelter operations are important considerations for assessing their potential value as demand-side reserves. The potential demand-side reserves that might be provided by aluminum plants include; very short-duration interruptions for system stability purposes, interruptions of up to four hours during extreme peak electricity price spikes, and long-term shut downs of several months to a year or more to address periods of poor hydroelectric conditions or other periods of significant generation capacity shortages. These issues will be addressed outside of the simple aluminum model described here.

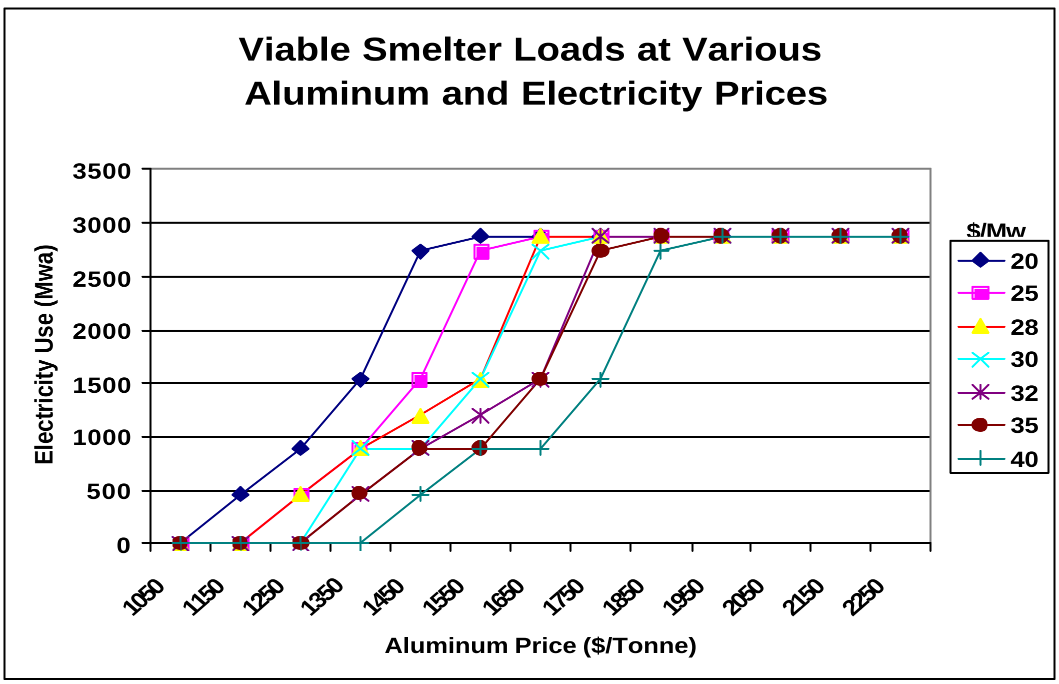
Model Results

By varying the aluminum and electricity prices over a range of possible values, the model can be used to simulate expected aluminum electricity demands under varying conditions. Aluminum prices were varied between $1050 and $2250 per tonne in $100 increments. For each aluminum price, electricity prices were varied between $20 and $40 per megawatt-hour. This generated 91 different estimates of aluminum plant electricity demand under the varying aluminum and electricity combinations. Figure 6 shows the results of this exercise.

A couple of bracketing points are evident. First, at aluminum prices below $1050 per tonne, none of the Northwest aluminum plants can operate profitably at any electricity price between $20 and $40 per megawatt-hour. Aluminum prices have seldom been below $1200 a ton (in 2002 prices) in the past 20 years. On the other extreme, all nine smelters could operate at aluminum prices above $1900 per tonne for electricity prices up to $40 per megawatt-hour.

If past trends in aluminum prices continue, aluminum prices might decline at about 1 percent a year. That would mean that average aluminum prices might average less than $1500 over the next 20 years. Of course there will be considerable volatility around that trend. At this point in the Council's planning process, we do not have a range of future electricity prices that match the range of natural gas prices we are assuming for our analysis. Preliminary analysis with the medium natural gas price forecast shows that wholesale electricity prices (see Figure 3) could be between $35 and $40 per megawatt-hour over the long term. In those ranges of electricity and aluminum prices, aluminum electricity demands may be less than 880 megawatts.

Figure 6: Spectrum of Potential Aluminum Smelter Electricity Demands

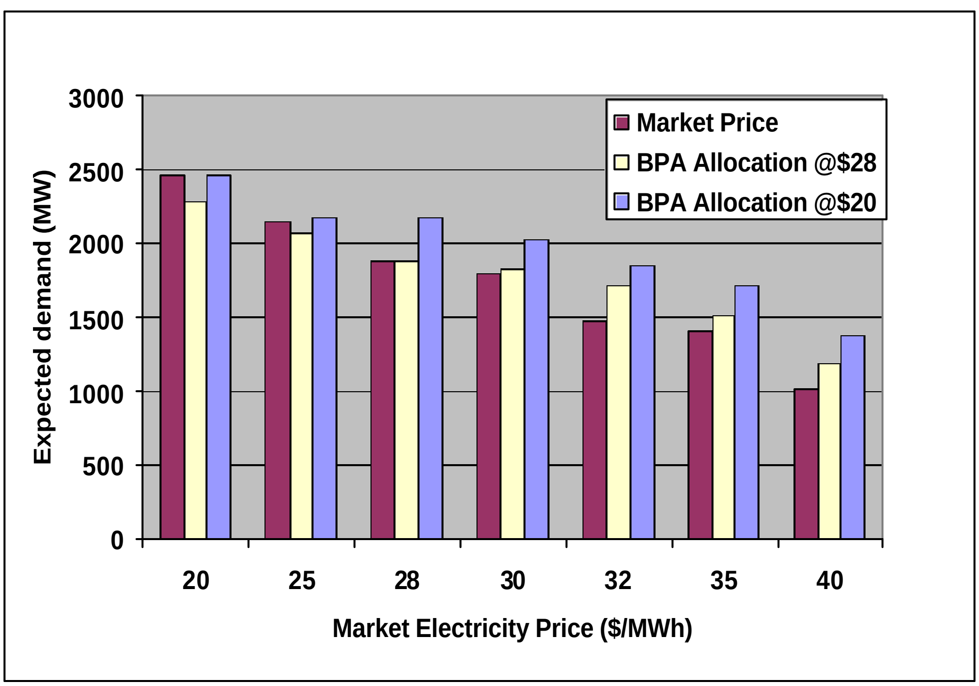


The results in Figure 6 include an assumption that one smelter will continue to have access to low cost mid-Columbia dam power for part of its electricity demand. Access to some lower cost allocations of Bonneville electricity and further investments in smelter efficiency may improve the ability of some smelters to stay in operation. The simple aluminum model was used to see what effect an offer of 100 megawatts of Bonneville electricity priced at $28 per megawatt-hour would have on smelter operations. Assuming an availability of electricity from Bonneville changes the model results for the 91 combinations of aluminum and electricity prices. In order to more easily illustrate these effects, an expected value of electricity demand was calculated for each assumed electricity market price. This was done by weighting electricity demand simulated at different aluminum prices by the percent of days in the last ten years that actual aluminum prices fell into that range.

Using just market electricity prices and the one mid-Columbia supply contract, expected smelter electricity demands ranged from 1,000 megawatts at $40 per megawatt-hour electricity prices to 2,468 megawatts at $20 electricity prices. This is shown in the left-most bar for each electricity price group in Figure 7. Another way of characterizing an individual bar in Figure 7 is that it is a weighted average of the electricity use in a individual line from Figure 6.

If Bonneville offered 100 megawatts of power priced at $28 per megawatt-hour to each smelter, it is estimated to have a relatively small effect on expected aluminum operations (See the middle bars in Figure 7). At market prices below $28 the expected electricity demand of aluminum smelters is actually reduced by the higher priced Bonneville power. If market power prices were $40, the availability of Bonneville supplied power at $28 per megawatt-hour is estimated to increase the expected value of aluminum smelters' electricity demand of from 1,013 to 1,187 megawatts, a relatively small effect. If Bonneville could offer power at $20 (illustrated by the right-most bars in Figure 7) the estimated increase in electricity demand at the $40 market price would be 357 megawatts. That increase is roughly the electricity demand of one additional smelter.

Figure 7: Expected Aluminum Plant Electricity Demand (Effect of Bonneville Electricity Supplies)



The analysis above addresses the question of whether the existing smelters in the region are likely to operate under different aluminum and electricity market conditions. It does not address the likelihood of permanent closure. Historically, older and less efficient smelters are not frequently closed permanently. Their depreciated capital costs allow them to operate when electricity and aluminum prices are attractive. They may provide an inexpensive option for aluminum supplies in tight aluminum markets. In addition, permanent closure may involve expensive site clean up.

The result is that the region might retain a large, but uncertain, electricity demand. If such a demand is required to be served when they need electricity, it can be very costly for their electricity supplier to maintain generating capacity to serve the potential demand. If serving the demand is optional, however, through either interruption agreements or the smelters purchasing available power in the market, it can have attractive features that may reduce electricity price volatility. The future of aluminum operations in the region may depend on the ability of aluminum plants to find, and get value for, their potential for complementing the power system in a competitive wholesale market.

Aluminum Demand in the Portfolio Analysis

In developing the 5th power plan, the Council proposes is to model aluminum plants as uncertain loads that depend on aluminum prices and electricity prices. This will be done in the Council's portfolio analysis model. As it simulates alternative futures, the portfolio model randomly selects different electricity prices and aluminum prices. These conditions will be used to estimate the aluminum plants' demand for electricity.

The relationship between the aluminum plants' electricity demand and electricity and aluminum prices is derived from the results of aluminum model simulations that were illustrated in Figure 6. The 91 aluminum model simulations were used as the basis for an equation relating aluminum smelter electricity demand to aluminum and electricity prices. Simulated aluminum electricity demands were regressed against the corresponding values of aluminum and electricity prices. The resulting equation is shown below.

$$D_e = -1752.73 + 2.875 P_a - 40.507 P_e$$

Where: D_e is regional aluminum smelter demand for electricity
P_a is the market price of aluminum in 2002$ per tonne
P_e is the market price of electricity in $2002 per megawatt-hour

By including this equation in the electricity portfolio model, strategies that address the risk posed by uncertain aluminum demand can be addressed directly in the power plan.

Mid-Term Aluminum Demand Assumption

The Council is required to include in its power plans a 20-year forecast of demand. The Council is also increasing its focus on the nearer term for purposes of reliability and adequacy analysis. For these purposes, a specific forecast of total electricity demand is useful. And for that a specific assumption about DSI demands is needed. This section presents such a best guess forecast, but it is important to keep the extreme uncertainty regarding this assumption in mind when evaluating reliability, adequacy, or long-term resource strategies.

Figure 8 shows the assumed mid-term pattern of aluminum electricity demand through 2005 compared to the Council's assumption made in the summer of 2001. In the current forecast, electricity demand is assumed to recover to about 1,500 megawatts by 2005. This would be consistent with the 4 best aluminum smelters in the region operating. If the aluminum model is reasonably accurate, and if electricity can be acquired for $30 to $35 per megawatt-hour, this implies that aluminum prices would have to recover to $1,550 to $1,650 per tonne by 2005. That is in the range of average aluminum prices during the past 10 years, but given recent trends and events in world aluminum markets, should be viewed as reasonably optimistic assumption for the region's aluminum plants.

In contrast, the summer of 2001 forecast assumed that there would be a reasonably rapid economic recovery, with a concurrent recovery in aluminum prices and a significant lessening of electricity prices as the effects of the electricity crisis of 2000-2001 were dissipated. Under these assumptions, all but two of the region's aluminum plants were assumed to be able to operate by 2005.

The forecast also is significantly more pessimistic about aluminum plants' ability to operate than the Council's 4th power plan. This is consistent with a prolonged period of low aluminum prices during 2001 through 2004, with higher forecasts of electricity prices. It also is more pessimistic about the ability of some smelters to survive a prolonged period of high electricity prices, poor aluminum prices, and uncertainty about electricity markets and contracts. For the long-term medium forecast, the 2005 forecast level is extended to the end of the forecast in 2025. Although the loads after 2005 are shown as constant, we would actually expect them to be quite volatile around that trend. In addition, since aluminum prices are expected to trend downward over time, and natural gas prices upward, it may become increasingly difficult for regional smelters to operate as the future unfolds.

Figure 9 shows the medium total DSI demand assumptions extended to 2025 compared to the forecasts in the Council's 4th power plan. In this figure non-aluminum DSI loads of 60 average megawatts have been added to the aluminum forecast. Again, this forecast does not imply that Bonneville will serve all of this DSI demand; it has been labeled DSI for convenience. The medium case is 1,260 average megawatts below the forecast in the Council's last power plan.

Figure 8: Medium Case Assumptions for Aluminum Demand Recovery to 2005 (Comparison to Summer 2001 Assumptions)

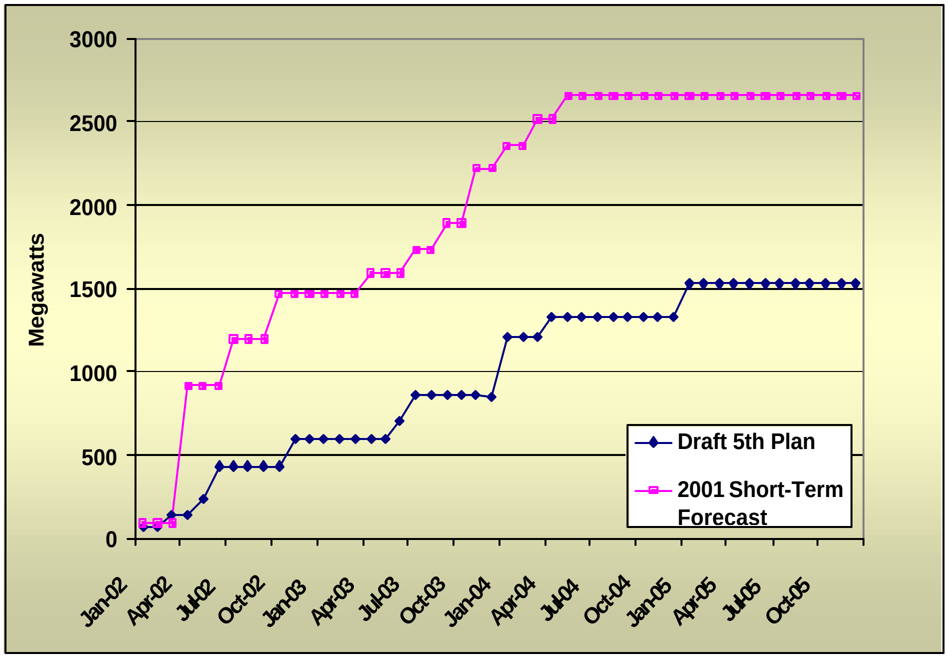
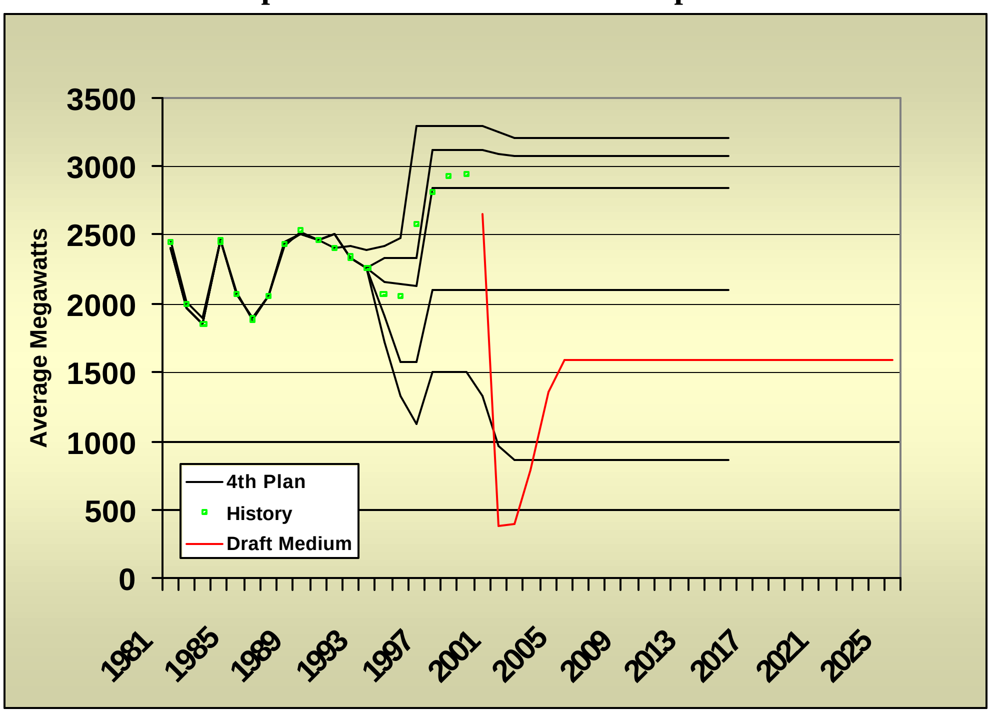


Figure 9: Demand Assumptions for DSI Industries Compared to 4th Plan Assumptions



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