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May 2, 2007

MEMORANDUM

TO: Power Committee

FROM: Tom Eckman and Charlie Grist

SUBJECT: Achievable Conservation Penetration Rates

We have prepared a staff white paper that provides an overview of the Council's conservation planning methodology and an assessment of its current planning assumptions regarding the level of savings that are "achievable". We have prepared the paper now because we think it will be useful in ongoing regional debates. The paper is attached. We will summarize it at the May meeting.

Several factors have lead to a resurgence of interest in the Council's approach to integrated resource planning in general, and its methodology for incorporating conservation in its plans in particular. Bonneville's pending Long-Term Regional Dialogue proposal will encourage public utilities to more systematically consider their resource choices. In Washington State, the enactment of HB1010 requires large utilities to prepare resource plans including conservation. Washington's Initiative 937 (I-937) requires utilities to develop all conservation that is cost-effective, reliable and feasible using methodologies consistent with those used by the Council. The Council's methodology is specifically referenced in I-937. Because that law is now in rulemaking, there has been heightened interest in the Council's methodology for assessing conservation potential. Of particular interest at the moment, are the Council's assumptions on how much of identified conservation potential is "achievable".

The Council assumes that 85 percent of the cost-effective technical potential is achievable, over twenty years, for non-lost opportunity, or retrofit, measures. For lost-opportunity measures we assume that approximately 65 percent of the potential is achievable over twenty years. The paper presents empirical evidence to support retaining the Council's assumptions for achievable conservation potential. The paper compares the Council's 1983 Plan expectations with what has actually happened over the twenty years since that plan was prepared. Furthermore, the Council's assumed near-term achievable acquisition assumptions, which are more relevant and critical than the twenty-year estimates, are well supported by empirical evidence and may be conservative when compared to what has occurred historically.

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Achievable Savings - A Retrospective Look At The Council's Conservation Planning Assumptions

Several factors have lead to a resurgence of interest in the Council's approach to integrated resource planning in general, and its methodology for incorporating conservation in its plans in particular. For the region's public utilities, Bonneville's pending proposal to serve the load growth of its preference customers at "market-based" rates rather than embedded costs encourages them to more systematically consider their resource choices. In Washington State, the enactment of HB1010 and the passage of Initiative 937 (I-937) created additional impetus for the states larger utilities. HB1010 requires utilities to prepare resource plans to demonstrate that they have adequate resources to meet their load serving obligations.[1] Initiative 937 requires utilities to develop all conservation that is cost-effective, reliable and feasible using methodologies consistent with those used by the Council.[2] Since the Council's approach is specifically referenced in I-937 there has been heightened interest in its methodology for assessing achievable conservation potential. The purpose of this paper is to provide an overview of the Council's methodology and an assessment of whether its current planning assumptions regarding "achievable" savings are supported by empirical evidence.

The Council Conservation Planning Methodology

The Northwest Power Act's sets forth three criteria for all resources that are including in the Council's plans. Resources are included in the plan if they are available _at an estimated incremental system cost no greater than that of the least-cost similarly reliable and available alternative._[3] Therefore, starting with its first Plan in 1983 the Council has interpreted these requirements to mean that conservation resources must pass three screens:

- technically feasible (i.e., reliable)
- economically feasible (i.e., lower cost)
- achievable (i.e., available)

The first step in the Council's methodology is to identify all of the technically feasible potential conservation savings in the region. This process involves the review of a wide array of commercially available technologies and practices for which there is documented evidence of electricity savings. This step also involves determining the number of potential applications in the region for each of these technologies or practices. For example, electricity savings from higher efficiency water heaters are only "technically feasible" in homes that have or are forecast to have electric water heaters. Similarly, increasing attic insulation in homes can only produce electricity savings in electrically heated homes that do not already have fully insulated attics.

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[1] http://www.cted.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=4039&MId=863&wversion=Staging

[2] Energy Independence Act. RCW 19.285.040(1)(a) (http://apps.leg.wa.gov/RCW/default.aspx?cite=19.285.040)

[3] See Section 839a(4)(A)(ii) of the Northwest Power Planning and Conservation Act. (http://www.nwcouncil.org/library/poweract/3_definitions.htm)

The second step in the Council's process is to determine the total resource cost of the energy savings from all of those measures that are technically feasible. This process requires the comparison of the all of the costs of a measure with all of the benefits, regardless of who pays those costs or receives the benefits. In the case of a more efficient clothes washer, cost includes the difference (if any) in retail price between the Energy Star model and the "standard efficiency" model normally purchased by consumer, plus any utility program administrative and marketing cost. On the other side of the equation, benefits include the energy (kilowatt-hour) and capacity (kilowatt) savings, water and wastewater treatment savings and saving on detergent costs.[4] While not all of these costs and benefits are either borne by or accrue to the region's power system, they are included in the evaluation because they are ultimately paid for or benefit the region's consumers.

Once the Council has determined the *net cost* (present value of all cost minus the present value of all benefits) of each of the conservation technologies or practices it rank orders them into two "supply curves" which depict the amount of conservation resource potential available in the region at various costs. One "supply curve" represents all of the retrofit or "non-lost opportunity" resources. The second supply curve represents all of the "lost-opportunity" conservation resources.[5] The Council divides conservation resources into these two categories because their patterns of potential deployment are different. Non-lost opportunity conservation resources can be captured at any time. On the other hand lost-opportunity resources are only available during specific periods. For example, savings from improved wall insulation in new buildings is only available when the building is constructed. Savings from most appliances are available only as appliance stock turns over. If the savings from these lost-opportunity resources are not acquired within this limited window of opportunity, they are treated as lost and no longer available to be deployed.

The third step in the Council process is to establish any timing constraints on the availability of the conservation contained in these supply curves. These constraints on the timing and availability are needed in the Council's portfolio modeling process. The portfolio model selects the quantity and timing of all resource development. Since significant quantities of conservation are available at a cost below most forecasts of future market prices, the portfolio model will "dispatch" all of the low-cost conservation immediately unless the pace of conservation deployment is constrained. Therefore, the Council establishes two types of constraints on the amount of conservation that is available.

The first constraint is on the rate of annual deployment. These constraints represent the upper limit on annual conservation resource development. In the Council's Fifth Plan, non-lost opportunity resource development was limited to 120 average megawatts per year. On the other hand, lost-opportunity resources are more difficult to capture because of the limited window of opportunity. So lost-opportunity deployment was based on penetration rates of 15 percent achievable in 2005 and increasing to 85 percent achievable over twelve years.

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[4] More energy efficiency clothes washers use water and hence require less detergent.
[5] Lost-opportunity resources are those that can only be technically or economically captured during a limited window of opportunity, such as when a building is built or industrial process upgraded.

The second constraint placed on the deployment of conservation is the maximum achievable potential over the 20-year period covered by the Council's plans. In the case of non-lost opportunity resources, the Council has set an upper limit of 85 percent of the technically feasible and cost-effective savings. Since lost-opportunity resources are phased in to an upper limit of 85 percent market penetration over 12 years the cumulative 20-year penetration of lost-opportunity conservation equates to 65 percent of the technically feasible and cost-effective savings.

Figures 1 and 2 show the conservation supply curves for non-lost opportunity and lost-opportunity resources used in the Council's 5th Power Plan.

Figure 1 - Annual Lost-Opportunity Achievable Potential Supply Curve
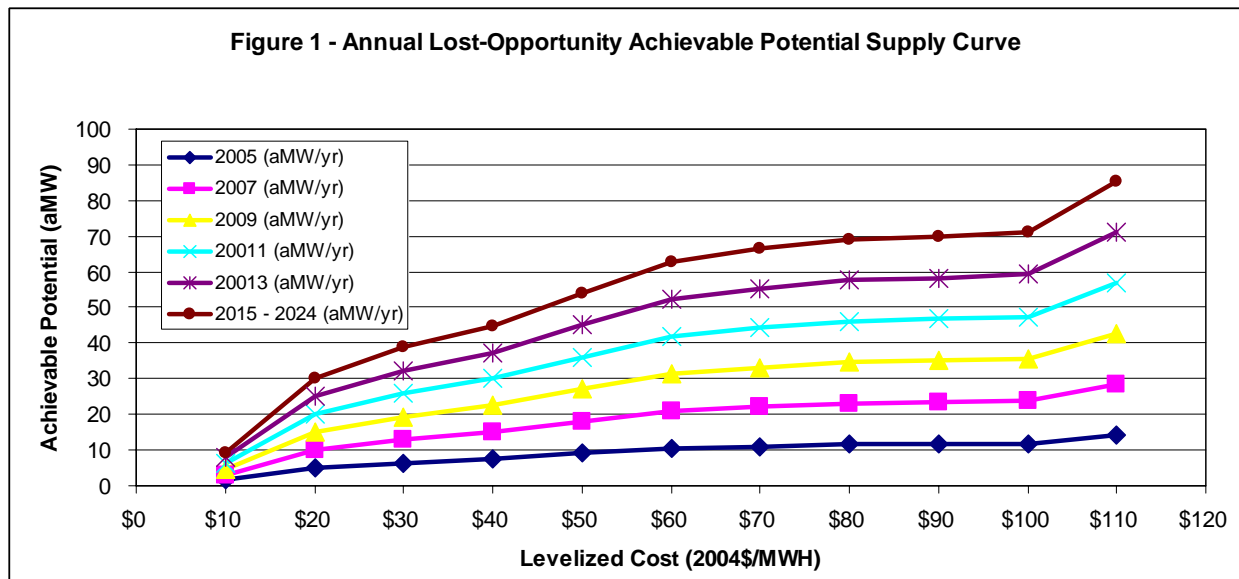
As shown in Figure 1, the Council's planning methodology anticipates that the share of lost-opportunity resources that is achievable at a given cost increases over time. For example, at up to a levelized cost of $60 per megawatt-hour only 10 average megawatts of the lost opportunity resources are deemed achievable in 2005. However, for the years 2015 and beyond, just over 60 average megawatts of savings are available each year at this same levelized cost. Figure 2 shows that total achievable potential of non-lost opportunity resources.

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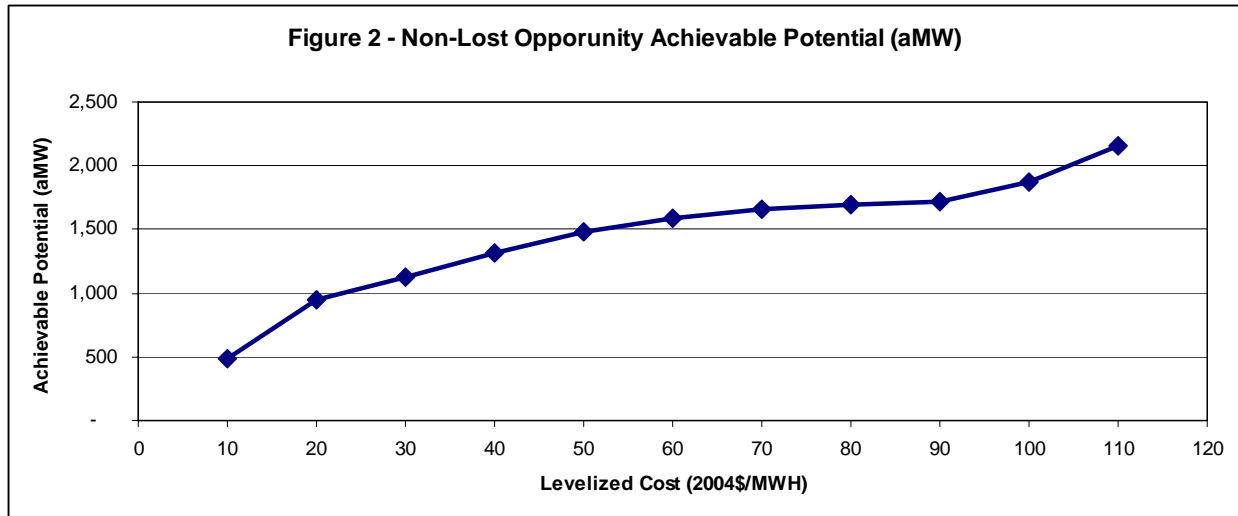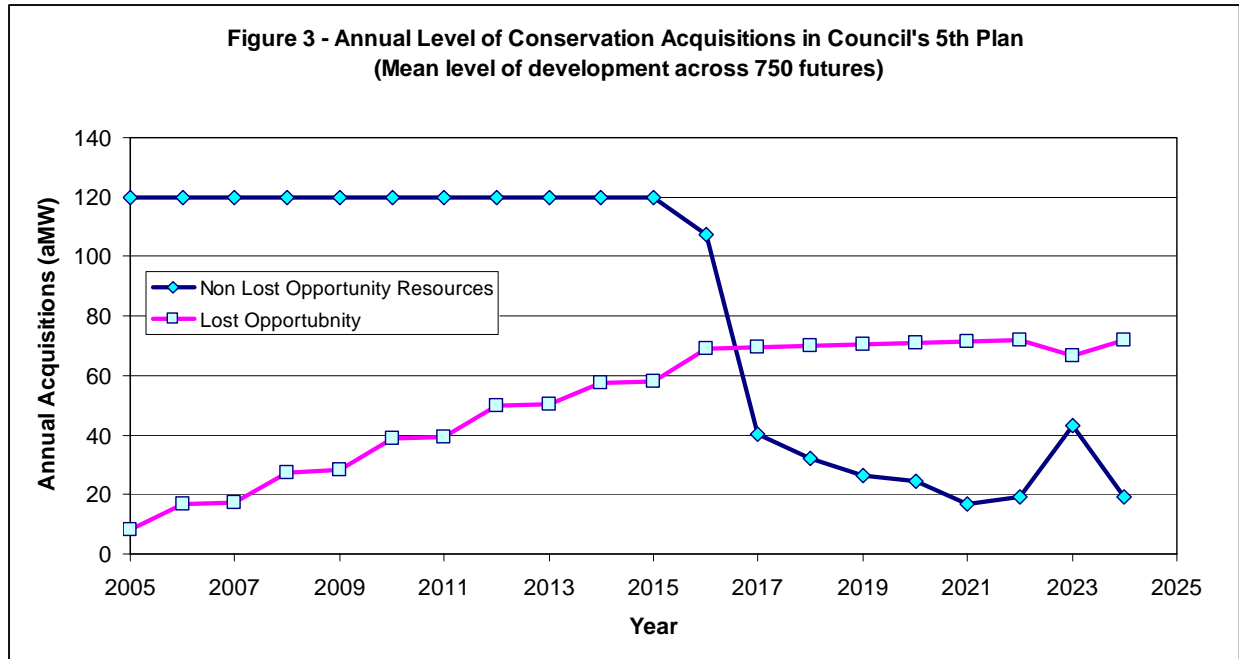**Figure 2 - Non-Lost Opporunity Achievable Potential (aMW)**

Figure 3 shows the expected value annual deployment rate of those resources from 2005 through 2024 as well as the annual deployment rate of lost-opportunity resources over this same time period. As can be seen from Figure 3, the maximum amount of non-lost opportunity resource development remains constant at 120 average megawatts per year until 2015 and then declines significantly. This is a result of the fact that by 2015 all of the lower cost (<$50 /MWH) non-lost opportunity resources have been acquired and only in futures where prices are higher are the more costly conservation resources developed. A total of about 1600 average megawatts of non-lost opportunity conservation is deployed over twenty years. But most of it, about 1400 average megawatts, is deployed in the first twelve years. Figure 3 also shows that amount of lost-opportunity resources developed annually increases over time until it reaches a "steady state" of around 70 average megawatts per year. That level represents 85 percent of annual technical and cost-effective lost-opportunity potential. However, in the first ten years, the Council assumes a gradual ramp up of achievable lost-opportunity conservation. In fact, over the first ten years, the achievable penetration rate is only about 50% on average for lost-opportunity measures.

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Figure 3 - Annual Level of Conservation Acquisitions in Council's 5th Plan
(Mean level of development across 750 futures)

Legend:
- Non Lost Opportunity Resources
- Lost Opportubnity

(Y-axis: Annual Acquisitions (aMW), X-axis: Year)

The first two filters in the Council screening processes, technical feasibility and cost involve less "subjective" assessments than does the application of the "achievability" filter. Therefore, it is important to understand the basis on which the Council established its constraints for achievable conservation. The Council established the 85 percent upper limit for achievable non-lost opportunity resource development in its first Plan in 1983 and has used this value in all subsequent plans. It is based in the actual achievements in the Hood River Conservation Project, sponsored by Bonneville and operated by PacifiCorp (then called Pacific Power and Light). The Hood River Conservation Project made weatherization measures available to all county residents with electric heat at no cost over a period of two years. In this project 85 percent of technically feasible weatherization measures in the electrically heated residences in Hood River County were installed within a period of two years.[6]

While the Hood River sets one mark for how much conservation is achievable, the Council also adopted the 85 percent value because, in its judgment, the region had access to multiple "tools" that could be used to achieve this goal. First, the region had _20 years_ to achieve the 85 percent goal.[7] Second, Bonneville and utilities can offer significant financial incentives to encourage consumers to adopt the more energy efficient technologies and practices called for in its Plans. Indeed, by definition, Bonneville and utilities can offer to pay up to the full incremental cost of any cost-effective energy efficient technology or practice to encourage consumers to install them. In the Council's judgment, it seems realistic to assume that the combined ability to offer the more energy efficient technologies and practices at no additional cost to consumers over a 20-year period would result in an 85 percent market penetration of those measures. Finally, in

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[6] "Cooperation and Community Conservation," report on Hood River Conservation Project, 1987, by Oak Ridge National Laboratory for Bonneville Power Administration and Pacific Power & Light.

[7] The Council also viewed its 85 percent goal and having limited risk, since it's Plans are updated every five years, if progress toward the goal is slow, then adjustments to the timing of the development of other resources can be made.

addition to financial "carrots," that Bonneville and utilities could offer, they also had the ability to work at both the state and federal level to enact standards and improve codes that would require the use of more energy efficient technologies and practices by law.

In addition to the Hood River project, the Council is aware of only one other empirical test of comparable scale that addresses the question of how much of the technically and economically feasible conservation potential in the region is actually "achievable." The Council's 1983 Plan covered the period from 1983 through 2003. In that Plan the Council set forth its expectations for the level of efficiency that could and should be "achieved" between 1983 and 2003. The following section of this paper compares the 1983 Plan's forecast of the level of efficiency that could be achieved with the region's actual conservation achievements over that same time period.

1983 Council Plan Achievable Potential - Goals and Actual Achievements

The 1983 Council Plan set forth a range of future load growth forecasts and resource plans to meet them. In the "high forecast" case the 1983 Plan targeted over 4900 average-megawatts of conservation savings by 2002. In the "low forecast" cast the Plan's target was less than 700 average-megawatts. According the Council's recent analysis of historic activity, by the end of 2002 the region had acquired just over 2300 average-megawatts of savings. It is not possible to directly compare this value with the "achievable potential" set forth in the 1983 Plan. First, the "actual" load growth experienced between 1983 and 2002 does not correspond with any of the 1983 Plan's four forecasts. Thus, the amount of potentially achievable "lost-opportunity" resources that could have been developed does not match the 1983 Plan's resource assessment. Second, Bonneville and utility conservation acquisition programs did not operate in a sustained manner over this period. In fact, during the mid-1980s and late 1990s Bonneville and utility conservation programs were significantly curtailed. Therefore, any comparison between the 1983 Plan's goals which called for a 20-year sustained conservation acquisition effort and the actual results which did not attempt to achieve those goals would be misleading.

However, it is possible to compare many of the 1983 Plan's specific estimates of achievable potential with what actual occurred. In particular, the 1983 Plan contained detailed forecast of achievable conservation potential for residential and commercial buildings, appliances and equipment.[8] What follows is a comparison of those forecast of achievable savings with the actual efficiency levels achieved by 2002.

Residential Sector
The 1983 Plan set forth estimated achievable conservation potential for new and existing space heating, appliances, lighting and water heating end uses. With respect to new space heating the Plan called upon the region to adopt energy codes that were equivalent to the Council's Model Conservation Standards (MCS). The MCS represented a 40 percent savings over the construction practices and codes of 1983. Table 1 below compares the "prescriptive requirements" of 1983 Model Conservation Standards with the 1992 energy code requirements in Oregon and Washington. A review of Table 1 reveals that by 1992 energy code requirements in Oregon and

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[8] 1983 Northwest Power and Conservation and Electric Power Plan, Volume II, Appendix K. Northwest Power Planning Council. Portland, OR.

Washington were nearly identical to the Council's 1983 MCS. These energy code requirements were adopted in Oregon in 1992 and in Washington in 1991, less than 10 years after the Council established the MCS.
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Table 1 1983 Plan Model Conservation Standards versus 1992 Oregon and Washington Energy Code Requirements					
Component	MCS - Zone 1	MCS - Zone 2	MCS - Zone 3	WA Code - Zone 1	WA Code - Zone 2	OR Code All Zones
Ceiling/Attic	R-38	R-38	R-38	R-38	R-38	R-38
Wall	R-19	R-25	R-25	R-19	R-19	R-21
Floor	R-30	R-30	R-30	R-30	R-30	R-25
Window	U-0.37	U-0.37	U-0.37	U-0.40	U-0.35	U-0.40
Door	R-5	R-5	R-5	R-5	R-5	R-5
Slab	R-10	R-12	R-15	R-10	R-10	R-15

The Council's 1983 Plan anticipated that it would take until 2002 for the region to achieve 85 percent of MCS savings potential. Table 2 shows the estimated regional (all four states) average electric space heating requirements, normalized to kilowatt-hours per square foot, for new homes built under various "vintages" of energy codes. This table shows that by 1992 the entire region had already achieved that goal (85% of 40% is 34%) and that by 2006 the region had slightly exceeded the Council's original MCS efficiency levels

Table 2 Regional Average Annual Space Heating Use of New Single Family Homes Constructed Between 1983 and 2006			
Vintage	Annual Use (kWh/SF/yr.)	Percent of 1983 Use	Improvement over 1983
1983	6.3	100%	0%
1986	5.5	88%	12%
1989	5.4	86%	14%
1992	4.0	64%	36%
Current Practice - 2006	3.7	59%	41%

Further evidence of the pace of efficiency improvement in new homes is shown in Table 3. This table shows the average heat loss rate derived from field audits of a random sample of homes across the region collected as part of a regional heat pump performance evaluation. As can be seen from Table 3, the average heat loss rate of the homes in the 2001 vintage is 35% lower than for the homes built in 1983, clearly reflecting the improvements in energy codes and construction practices across the region. For site built homes, regulation via state energy codes was critical to achieving high rates of market penetration. Furthermore, improvements in the

state's energy codes and federal standards remain to an excellent tool for capturing further energy efficiency savings.

Table 3 - Average Heat Loss Rate for New Single Family Homes Built Between 1980 - 2003		
Vintage	Heat Loss Rate (BTU/hr/sq.ft. floor area	Improvement over 1983 Code/Practice
1980-1984	0.260	0%
1985-1988	0.247	5%
1989-1991	0.194	25%
1992-1999	0.182	30%
2000-2003	0.170	35%

Manufactured housing provides an example of similar achievable penetration rates, but without reliance on the regulatory approach used to achieve the savings from site built housing. The 1983 Plan assumed that the MCS did not apply to new manufactured homes since federal law pre-empted the state regulation of energy efficiency aspects of these homes. Consequently, no savings from this market segment was included in that Plan's forecast of achievable potential. However, beginning in the mid-1980's the region's manufactured housing industry began working with Bonneville and the state energy offices to develop options for improving the efficiency of these homes -- over 80 percent of which use electric space heating. Early in 1992, just as the new "MCS equivalent" energy codes for site built homes were adopted, all of the region's manufactured home plants agreed to build all of their new electrically heated homes to "MCS levels." From 1992 through mid-1995, 100 percent of the electrically heated manufactured homes generated savings that were not envisioned as "achievable" in the 1983 Plan.

Table 4 shows the annual penetration rate achieved for "MCS level" efficiency manufactured homes between 1988 and 2005. Two periods shown in this table are noteworthy. The first period of interest is the period between 1988 and 1994 which indicates the rapid increase in market penetration of these more efficient homes. This period demonstrates that with a concerted effort and program design, the region achieved almost 90 percent of the technically feasible and cost-effective potential of this lost-opportunity resource without regulation. It is also worthy of note that this far exceeds the pace of market share increase assumed over 12 years as the upper limit of achievability for lost-opportunity resources used in the Council's 5th Plan.

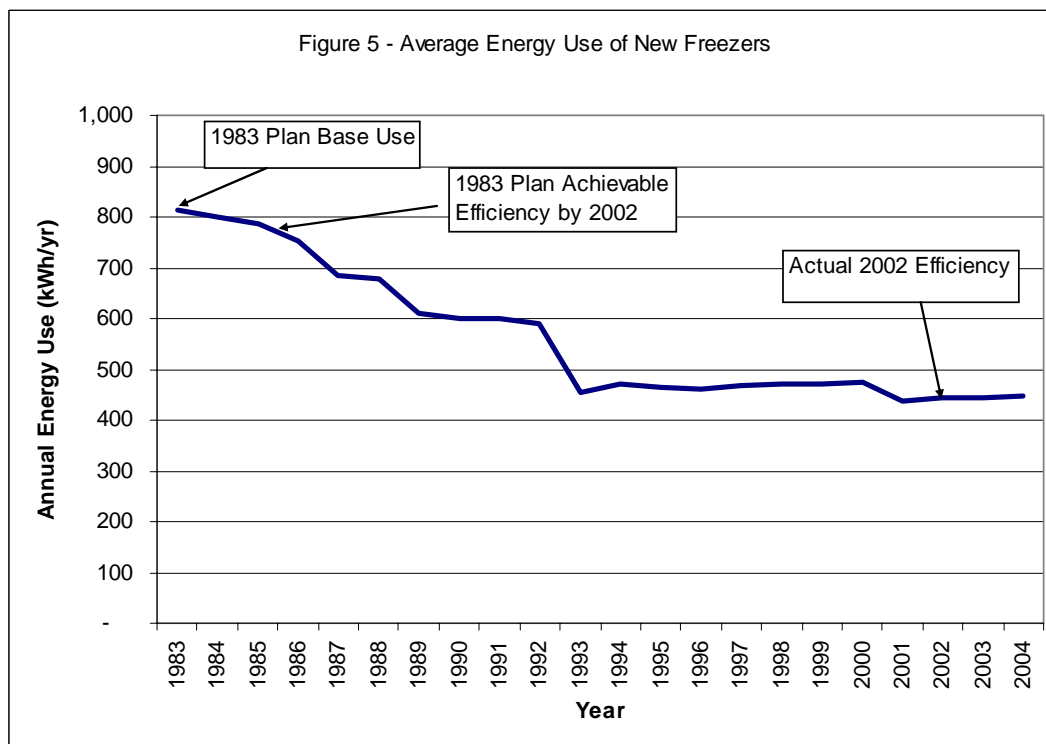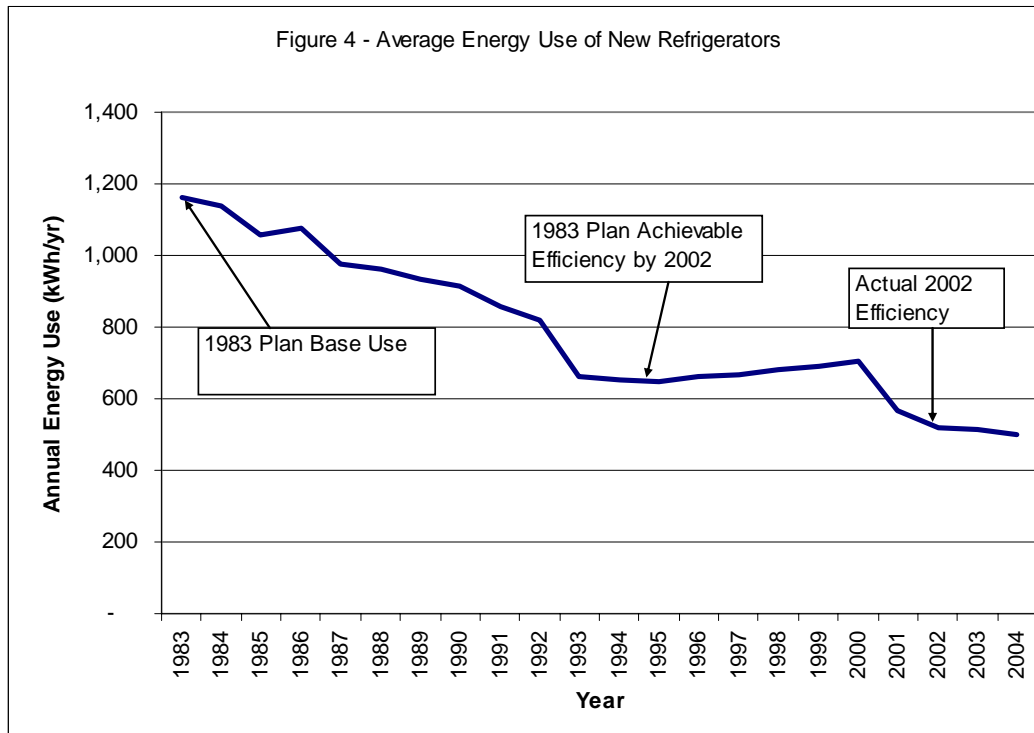| Table 4 - Model Conservation Standard Equivalent Manufactured Home Shipments and Market Share 1988 - 2006			
Year	SGC/NC Shipments	Total Shipments	SGC/NC Market Share
1988	29	9,049	0%
1989	135	9,967	1%
1990	684	11,875	6%
1991	2,081	11,815	18%
1992	11,000	13,784	80%
1993	15,094	17,535	86%
1994	18,356	20,512	89%
1995	15,710	19,641	80%
1996	11,503	17,125	67%
1997	9,231	17,301	53%
1998	7,677	17,996	43%
1999	5,366	14,620	37%
2000	3,475	9,564	36%
2001	3,828	7,437	51%
2002	4,887	8,029	61%
2003	4,669	7,384	63%
2004	4,654	7,601	61%
2005	4,754	7,834	61%

The second period of note is between 1996 and 2002 when the region's manufacturer's first abandoned the production of energy efficient homes and then returned to building these homes after discovering that the market did not want the less efficient products they were trying to sell. While not specifically germane to the issue of "achievable potential", this market trend clearly demonstrates that even without regulation, higher levels of efficiency for manufactured housing sold in this region has become the market norm.

The 1983 Plan anticipated that by 2002 the region would have weatherized approximately 1.27 million existing electrically heated homes. Unfortunately, data collection processes that permit a direct comparison with this forecast were not in place during the period prior to 1991. However, current utility residential weatherization programs continue to produce savings, so it is clear that not all homes in the region have been fully weatherized. It is also clear that the pace of residential weatherization has slowed considerably since the early 1980's. For example, less than 7 average megawatts of residential weatherization savings were reported by the utilities participating in Bonneville's Conservation and Renewable Resources Rate Discount Program for the fiscal years 2001 through 2006. In comparison Bonneville reported over 50 average megawatts of residential savings from 1991 through 1996, primarily from residential weatherization measures. While this may or may not be an indication of whether the 85 percent market saturation rate of technically and economically feasible measures has been reached, it does appear that this market is reaching saturation.

Residential appliances offer another window into the viability of achievable conservation assumptions. Data on the energy savings from major residential appliances, water heating and lighting are available. The 1983 Plan assumed that by 2003 average residential water heating use could be reduced by about 12 percent from roughly 5,150 kilowatt-hours per home per year to 4,530 kilowatt-hours per home per year. Three measures were identified to achieve this; increasing tank insulation, use of lower flow showerheads and lowering the water tank temperature from 140 F to 130 F. As of 1991 the minimum federal standard for electric water heaters required that the average 50 gallon tank use less than 4220 kilowatt-hours per year. This surpasses the Council's forecast of achievable potential with just one of these three measures (tank insulation) in less than ten years. In 1994 federal standards mandated that showerheads not exceed flow rates of 2.5 gallons per minute and that temperature on all water heaters be set at the factory at 120 F for safety reasons. The 1994 federal standard was below the 2.75 gallons per minute showerhead flow rate assumed to be achievable in the 1983 Plan. In combination with the mandated lower water temperature, the achievable energy savings from residential water heating were nearly 50% higher than anticipated in the 1983 Plan.[9] Furthermore, the Council's 20-year target for improving water heating efficiency by 12 percent was exceeded in just ten years.
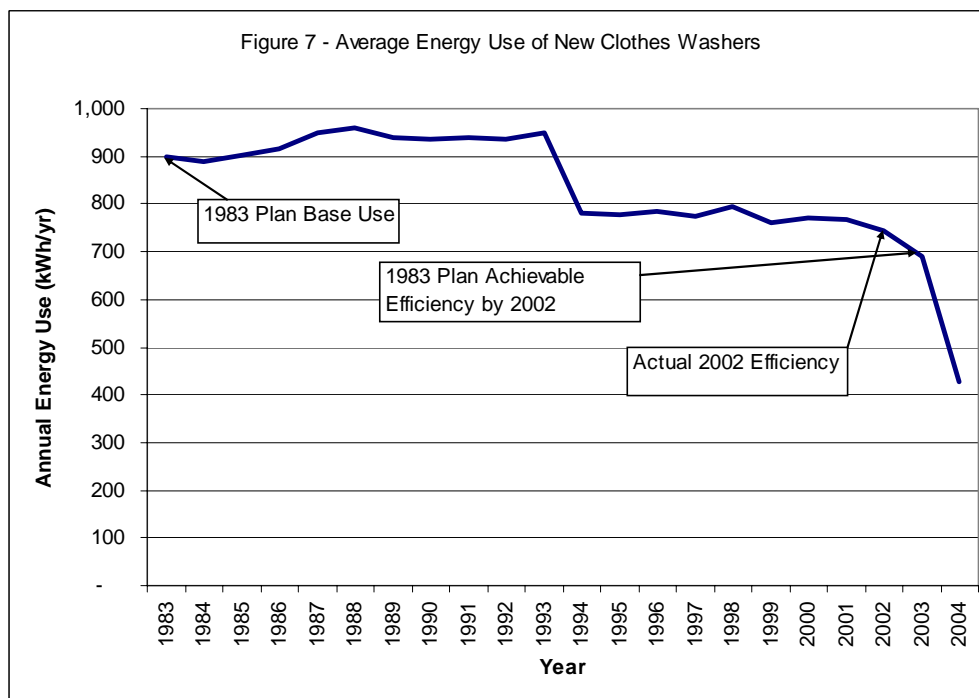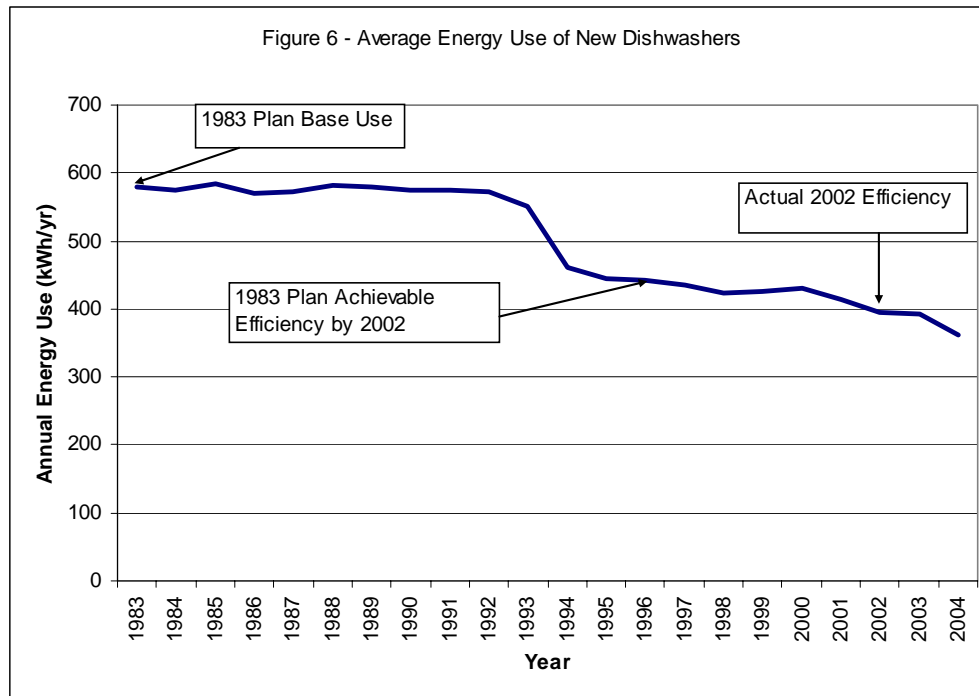
In 1983 the Council forecast that the achievable potential savings between the average consumption of a new refrigerator and the most efficient model on the market would result in a savings of 515 kilowatt-hours per year. For freezers the savings potential was just 35 kilowatt-hours per year. The Council did not break out its specific assumptions for clothes washers and dishwashers, but it did indicate that between these two appliances it anticipated that an annual savings of 340 kilowatt-hours should be achievable by 2002. Figures 4 and 5 show the "sales weighted average" energy use of each of these appliance by year of purchase. As can be seen from these figures, the actual efficiency improvements for both refrigerators and freezers not only exceeded the forecast of achievable potential in the 1983 Plan, but they were achieved far earlier than forecast. Figures 4 and 5 are based on data reported by the Association of Home Appliance Manufacturers (AHAM), the appliance manufacturing industry trade association.

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[9] In 2004 the federal minimum standard for a typical 50 gallon electric water heater resulted in use of 4060 kilowatt-hours per year.

Figure 4 - Average Energy Use of New Refrigerators

Y-axis: Annual Energy Use (kWh/yr), ranging from - to 1,400

Labels on chart:
- 1983 Plan Base Use
- 1983 Plan Achievable Efficiency by 2002
- Actual 2002 Efficiency

X-axis: Year (1983 to 2004)

Figure 5 - Average Energy Use of New Freezers

Y-axis: Annual Energy Use (kWh/yr), ranging from - to 1,000

Labels on chart:
- 1983 Plan Base Use
- 1983 Plan Achievable Efficiency by 2002
- Actual 2002 Efficiency

X-axis: Year (1983 to 2004)

Figures 6 and 7 show AHAM's sales weighted average energy use for dishwashers and clothes washers for each year between 1983 and 2004. Also shown on these graphs are the 1983 Plan's implied achievable potential savings for new dishwashers and clothes washers. As was the case with refrigerators and freezers it appears that the 1983 Plan's forecast of achievable savings for dishwashers proved to be overly conservative. However, the Council's assessment of achievable

efficiency improvements in clothes washer efficiency roughly correspond to the actual improvement in this appliance's energy use in 2002. However, it should be noted that by 2004, just two years later, the sales weighted average energy use of new clothes washers was *almost half* that anticipated in 1983 for machines sold in 2002.

Figure 6 - Average Energy Use of New Dishwashers

Annotations on chart:
- 1983 Plan Base Use
- Actual 2002 Efficiency
- 1983 Plan Achievable Efficiency by 2002

Y-axis: Annual Energy Use (kWh/yr), 0 to 700
X-axis: Year, 1983 to 2004

Figure 7 - Average Energy Use of New Clothes Washers

Annotations on chart:
- 1983 Plan Base Use
- 1983 Plan Achievable Efficiency by 2002
- Actual 2002 Efficiency

Y-axis: Annual Energy Use (kWh/yr), - to 1,000
X-axis: Year, 1983 to 2004

The 1983 Plan also anticipated efficiency improvements in residential lighting. That plan assumed that by 2002 the average residential dwelling would use approximately 170 kilowatt-hours per year less for lighting than it did in 1983. While the 1983 Plan assumed that linear fluorescent lighting technologies could be employed to achieve these savings it appears that compact fluorescent lamps (CFLs) are actually being used to achieve most of these savings. Based on surveys done for the Northwest Energy Efficiency Alliance it appears that "on average" homes in the region had two to three CFLs installed by the end of 2002[10]. Based on the Council's current savings assumptions this would translate into between 70 and 105 kilowatt-hours per home per year of savings. These savings are approximately half those anticipated as being achievable in 1983.

Commercial Sector

The data we have for new commercial buildings tell a similar story as in the residential sector; today's energy codes far exceed the achievable penetration rates identified by the Council twenty years ago. In the 1983 Plan (as is the case in the 5th Plan) the largest portion of the commercial sectors achievable conservation potential was forecast to come from improvements in lighting. Lighting was estimated to make up about 45 percent of commercial sector electric use in 1983. Lighting power density, as measured by watts per square foot, is one metric that can be used to gauge the progress in lighting efficiency over time. Table 5 compares the lighting power densities for four major building types forecast to be achievable in the Council's 1983 Plan through adoption of its Model Conservation Standards for New Commercial Buildings with the current requirements of the commercial energy codes in the region. A review of Table 5 reveals that for office buildings and schools current code requirements far exceed the levels of efficiency forecast to be achievable in 1983. For retail stores and warehouses the 1983 Plan's assessment of achievable efficiency levels appears to be very near current code requirements. Offices, schools, retail stores and warehouse make up about 60 percent of total commercial sector building floor space.

In addition to lower lighting power densities, the 1983 MCS also made recommendations on several lighting control measures which have largely been adopted, or exceeded in local codes throughout the region. The 1983 MCS included switchable lighting circuits that would allow manual or automatic control to turn off half the lighting circuits in spaces over 400 square feet. Current energy codes in all four states have adopted similar or superior provisions. The 1983 MCS called for automatic controls on outdoor lighting to turn lights off during daylight hours. That measure has been adopted in all local codes in the region. The 1983 MCS also required lighting circuits be designed to accept manual or automatic day lighting controls for areas within 12 feet of windows in office and school spaces. That measure is in code in Washington. In addition, current energy codes go much further in lighting controls than was anticipated in the 1983 MCS. For example, occupancy sensors are required in Oregon and Washington on certain classroom, office and conference spaces. Automatic nighttime control of interior lighting is required in all four states for all but the smallest buildings.

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[10] ECONorthwest, Market Progress Evaluation Report, No. 1 (E02-101), prepared for NEEA June 20, 2002.

Table 5 Commercial Building Maximum Lighting Power Densities in 1983 Commercial Model Conservation Standards and Current Regional Energy Code Requirements					
	Lighting Power Density (watts/sq.ft.)				
Building Type	1983 Commercial MCS	OR 2004	WA 2004	ID & MT	Seattle 2004
Office buildings	1.5	1.0	1.0	1.0	1.0
Retail Stores	1.5	Varies 1.5+	Varies 1.5+	Varies 1.5+	Varies 1.5+
Schools	2.0	1.1	1.35	1.2	1.2
Warehouses	0.7	0.5	0.8	0.8	0.5

Lighting improvements for existing commercial buildings show similar trends of exceeding 1983 estimates of conservation potential. Two extensive surveys have been conducted to assess the energy related characteristics of existing commercial buildings in the region. The first of these surveys was carried out in 1987 about five years after the 1983 Plan was adopted. The second was completed in 2002. Table 6 shows the average lighting power density of the sample of existing buildings in 1987 and these same buildings in 2001. During this time frame the lighting power density was reduced by 20 percent across all buildings and from 13 to 21 percent in office and retail buildings. The 1983 Plan did not estimate lighting conservation potential specifically for existing commercial buildings. But overall electric conservation potential was identified as about 28 percent of electric use in 1982. By 1987, utility programs had already started to take a bite out of the conservation potential identified in 1983. Lighting represented about 45 percent of electricity use in commercial buildings in 1983. So a twenty percent reduction in existing lighting power density in the 14 years between 1987 and 2001 represents at least a 10 percent reduction in overall electric use for older buildings. Since lighting represents 45 percent of all commercial uses of electricity, the 25 percent reduction in lighting power density shown in Table 6 for existing buildings translates into 11 - 12 percent overall building efficiency improvement.

Table 6 - Change in Lighting Power Density for Existing (Pre-1987) Buildings Between 1987 and 2001						
	Lighting Power Density (watts/sq.ft.)			Reduction in Lighting Power Density (%)		
Audit/Survey Date	All Buildings	Offices	Retail	All Buildings	Offices	Retail
As found in 1987	1.5	1.6	1.9			
As found in 2001	1.2	1.4	1.5	20%	13%	21%

Another gauge of lighting improvement is to look at the huge technological improvement in lighting efficacy, particularly fluorescent lighting which accounts for about two thirds of commercial lighting. At the time of the 1983 Plan, improvements in lighting were available through improved fixture design, reduced lighting levels, and conversion from incandescent lighting to fluorescent or other high-efficiency lighting. Only modest improvements, on the

order of 10 percent, were available in the efficacy of lamps and ballasts of fluorescent light sources themselves. But since 1983, improvement in the efficacy of fluorescent light sources has doubled. Figure 8 shows fluorescent source efficacy, as measured by lumens of light output per watt of electric input. Source efficacy for fluorescent lighting, the ability to turn electricity into light, increased from 47 to 94 lumens per watt over the twenty years from 1982 to 2002. In 1987, typical office lighting power density was about 2.0 watts per square foot[11]. If we combine the 50 percent improvement in fluorescent source efficacy, along with additional improvements in fixture design, reduced lighting levels, and conversion from incandescent lighting to fluorescent lighting and other high-efficacy sources, it is easy to see why new office lighting designs can get to 0.7 watts per square foot, about one-third of what they were in 1983 and well below what was thought possible at the time.

Figure 8 - Typical Fluorescent Source Efficacy
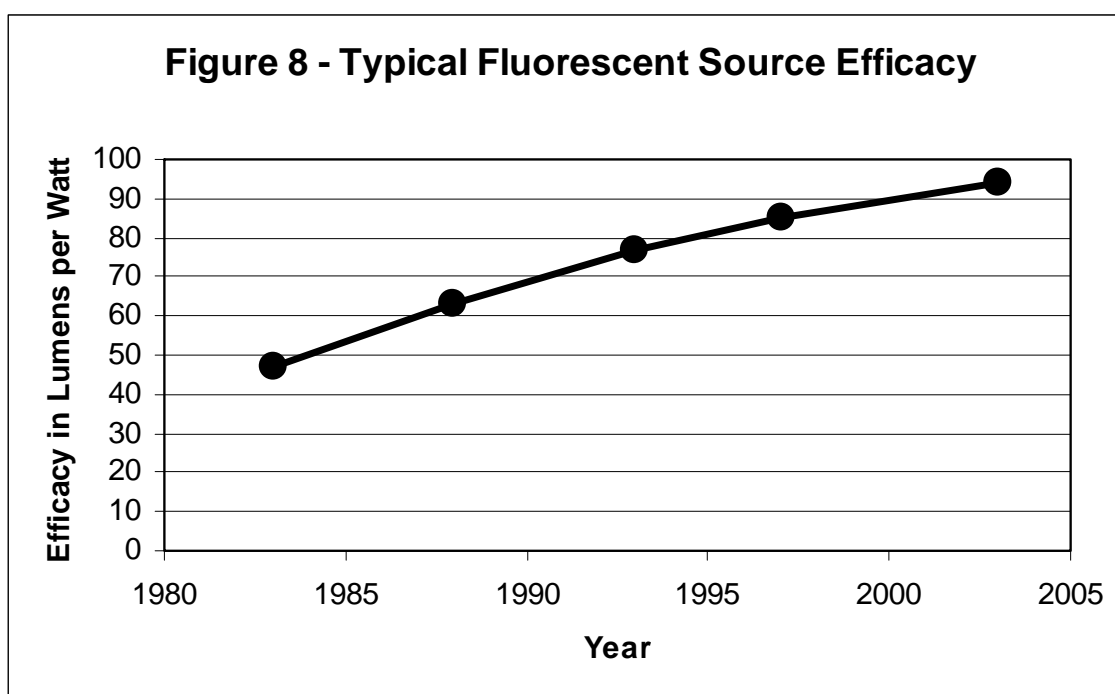
In addition to improvements in lighting efficiency the 1983 Plan forecast achievable savings from increases in the efficiency of heating, ventilating and air conditioning (HVAC) equipment. Table 7 compares the 1983 Plan's expected minimum efficiency requirements for cooling equipment efficiency levels with the minimums have been required by code in all states in the region since 2001. What is clear from an inspection of Table 7 is that current minimum efficiency requirements far exceed those envisioned as achievable in 1983. The minimum efficiency requirements (SEER) for cooling equipment under 65,000 Btu/hr in all Northwest states is 66 percent above that expected in the 1983. Similarly, for larger equipment the minimum efficiency requirement is 22 percent above that anticipated for 2002 in the 1983 commercial MCS.

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[11] PNNonRes Phase II Results, Table 10c

Table 7 - Commercial HVAC Equipment Efficiency Specifications				
System Type	Capacity Under 65,000 Btu/hr		Capacity 65,000 Btu/hr and Larger	
	1983 Achievable SEER[12]	Current Code Minimum SEER	1983 Achievable EER[13]	Current Code Minimum EER
Air Cooled	7.8	13.0	8.2	11.0

Irrigation Sector

In 1982 total irrigated acreage in the region was roughly 8.9 million acres and irrigation electricity use that year was 695 average megawatts or 655 kilowatt-hours per acre per year. In 2002 the irrigated acreage in the region was virtually unchanged from 1982 while electricity used for irrigation had dropped to 595 average megawatts or 579 kilowatt-hours per acre per year. In the 1983 Plan it was assumed that if all achievable efficiency measures (e.g., reduced pressure center pivot systems) and practices (e.g., irrigation water scheduling) were implemented by 2002 electricity use for irrigation would drop to 596 kilowatt-hours per acre per year. Actual irrigation efficiency gains, therefore, slightly exceeded those forecast in the 1983 Plan.

Industrial Sector

Energy efficiency progress is difficult to measure on a broad scale in the industrial sector. Confounding issues include the changing mix of industries, products and feedstocks, the general lack of applicable codes and standards, and the ability to substitute fuel and electricity in some processes. In 1983 the Council's forecast of achievable conservation potential was equivalent to about 6 percent of non-DSI industrial electric loads. Incremental improvements in minimum efficiency levels for electric motors alone have yielded a good share of that potential over the last twenty years. Motors comprise something on the order of 60 percent of industrial energy use. Minimum efficiency standards now in place are a 3 to 10 percent improvement over 1983 efficiency levels for motor sizes covered by federal standards.

Furthermore, motor efficiency is a small part of what has been accomplished in the industrial sector. There are many individual industrial plants and processes that have far exceeded a 6 percent efficiency improvement by improving their processes and facilities. These include documented improvements of 20 to 30 percent in cold-storage facilities, savings of 15 to 30 percent in compressed air systems for many plants across different industries, lighting improvements of about 50 percent in manufacturing spaces with high ceilings and many industry-specific process changes in the range of 20 percent improvement. In addition, NEEA has operated several successful industrial market transformation projects. For example, the NEEA and Siemens project on silicon crystal growing facilities reduced electric power

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[12] SEER = Seasonal Energy Efficiency Ratio. This is the annual ratio of electricity used per unit of cooling energy provided. A SEER of 6.826 equals an annual coefficient of performance of 2.0. (6826 Btu of cooling for each kilowatt-hour (3413 Btu) of electricity use)

[13] EER = Energy Efficiency Ratio. This is the instantaneous ratio of electricity used per unit of cooling energy provided.

consumption requirements for producing silicon crystals by 50 percent[14].   Savings from this project occurred in an industry that barely existed in 1983.

Summary and Conclusions

There is ample empirical evidence to support retaining the Council's assumptions for achievable conservation potential. Both the 85 percent achievable potential for non-lost opportunity resources and the approximately 65 percent achievable potential for lost-opportunity resources over a twenty-year period are supported by experience of the last twenty years.   Furthermore, the Council's assumed near-term achievable acquisition rates are well supported and may be conservative when compared to what has occurred in practice.

In its 1983 Plan the Council forecast that significant improvements in the energy efficiency of a wide array of residential and commercial appliances, equipment and buildings could achieve an 85 percent market share by 2002. With some exceptions, nearly all of the actual improvements in residential appliances and water heating have far exceeded the 1983 Plan's expectations. In its 1983 Plan the Council called upon the states in the region to improve their residential energy codes by approximately 40 percent and their commercial energy codes by 10 percent. Before the end of 1992 the two most populous states in the region, representing over 80 percent of new home construction and nearly 85 percent of new commercial floorspace had met the savings goals. By 2002 all of the states in the region had met the Council's original residential MCS and exceeded its original commercial MCS by at least 10 percent.

The 1983 Plan forecast that a 43 percent efficiency improvement in new residential refrigerators was achievable by 2002. This level of efficiency gain was not only achieved 10 years early (1992), but by 2002 new refrigerators used only 55 percent of the energy they did in 1983, even though they were both larger and more of them were frost-free. Freezer and dishwasher efficiency improvements also far exceed the 1983 Plan's assessment of achievable potential. Freezers met the first Plan's efficiency target in 1984 and by 2002 these appliances were using 45 percent less energy that was viewed as "achievable" in 1983. Dishwashers in 2002 used 32 percent less than they did in 1983, far exceeding the first Plan's goal of a 24 percent savings.

There were a few conservation measures included in the 1983 Plan, such as residential heat pump water heaters, that have not yet realized the penetration envisioned in the 1983 Plan. However, savings from measures not envisioned in the 1983 Plan, such as low-flow showerhead savings and energy efficient new manufactured housing, more than offset these unrealized savings.

While the Council staff believes there is ample empirical evidence to support existing assumptions on 20-year achievable penetration rates, it is important to note that the twenty-year forecast window for achievable conservation is less important today than it was in 1983 when

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[14] Market Progress Evaluation Report, Silicon Crystal Growing Facilities,No. 2, Report #E01-090, prepared by Research Into Action, Inc., for NEEA, November 2001.

generating resource lead times were long[15]. New generating facilities and transmission system expansions can now be brought on line in three to five years. Therefore, the need to accurately predict the achievable market penetration rate of an energy efficiency measure 20 years hence is greatly reduced. Much more relevant to present-day resource planning decisions is what is achievable in the near term. The pace at which conservation programs can be "ramped up" and maintained over the near-term period is critical and of more practical importance than 20-year forecasts. There is solid evidence, presented here, that near-term achievable conservation rates have been higher than the Council's planning assumptions for both lost-opportunity and non-lost opportunity measures.

As we have seen above, the historic effect of codes and standards in comparison to the Council's 1983 Model Conservation Standards reveals that in most cases, Council forecasts of 20-year achievable potential for lost-opportunity measures were met or exceeded in ten years or less. In fact several exceed 100 percent penetration in ten years, far exceeding the Council's near-term assumption of approximately 50 percent penetration in ten years for lost-opportunity measures.

There is also ample evidence from utility programs that indicate conservation acquisition programs for non-lost opportunity measures can be scaled up rapidly. Figure 9 shows annual regional utility program conservation savings from 1980 through 2005. As can be seen from an inspection of this chart, program savings have more than doubled over the course of one or two years. These increases were driven almost entirely by acceleration of programs for non-lost opportunity measures. In the last five years the region has maintained acquisition levels of 130-150 average megawatts per year. Retrofit conservation comprises 110-120 average megawatts per year of that total. If that pace were maintained, it would take 12 to 14 years, not 20, to reach the 85 percent penetration rate for the 1500 average megawatts of cost-effective non-lost opportunity conservation identified in the Fifth Power Plan.

Figure 9 - Annual Utility Program Conservation Savings 1980 - 2005

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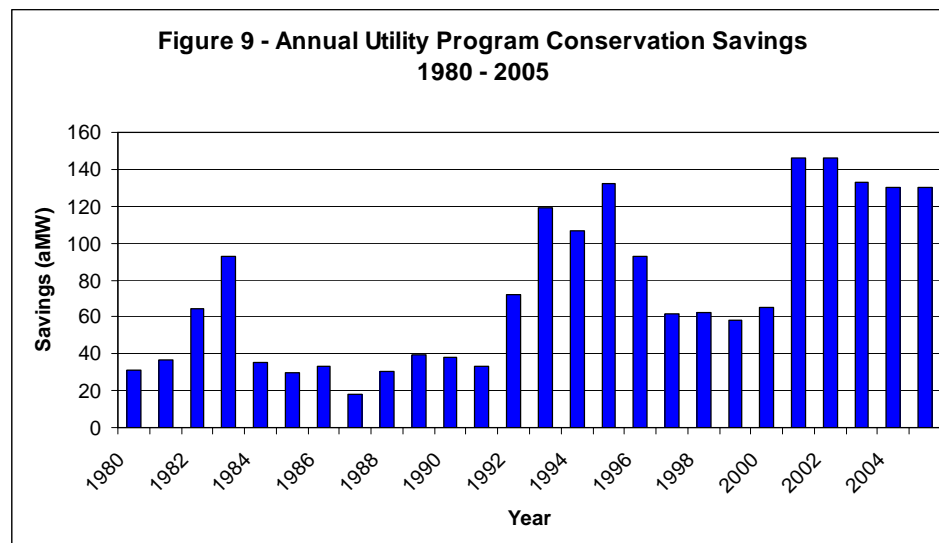
[15] The rationale for selecting a 20-year perspective for realistically achievable conservation in the 1983 Plan stemmed from the fact that at that time it took as much as 15 years to construct major central station generating facilities. Therefore, both load forecasts and resources plans had to predict when construction should start far in advance of actual need.

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