Achievable Savings

A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions

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Executive summary

The Northwest Power Act of 1980, the federal law that authorized the states of Idaho, Montana, Oregon, and Washington to form the Northwest Power and Conservation Council, directs the Council and the Bonneville Power Administration to treat energy conservation --improved efficiency of electricity use -- as a resource equal to electricity generation when planning to meet future demand for power. The Act requires Bonneville to acquire all cost-effective conservation first before acquiring new power from generating resources.

The Act also directs the Council to prepare, and to periodically review, a regional electric power plan to assure an adequate, efficient, economical, and reliable electricity supply in the Pacific Northwest. The administrator of Bonneville is required by the Act to make resource acquisition decisions that are consistent with the Council's power plan. Consistent with the Power Act, energy conservation is the highest-priority resource in the Council's power plan.

To assist the Council in determining the cost-effectiveness of generating and conservation resources that are included in the power plan, the Act establishes three criteria. A cost-effective resource or measure is one that is forecast by the Council to be 1) reliable, 2) available when it is needed, and 3) no more expensive than the least-cost alternative resource.

From this instruction, the Council developed a methodology to identify all of the technically feasible potential conservation measures in the region and any timing constraints to their implementation. With this methodology, the Council forecasts the rate of annual deployment of conservation measures and the maximum achievable potential of the measures over the 20-year horizon of the power plan (the Act requires the Council to plan 20 years into the future and to review the plan every five years).

The Council divides conservation measures into two categories: those that can be acquired at any time, such installing low-flow shower heads (these are called non-lost opportunity measures), and those that can only be acquired under specific conditions or at a specific time, such as wall insulation in buildings that are under construction (these are called lost-opportunity measures -- if they aren't implemented, the opportunity is lost). For planning purposes, the Council sets penetration limits, with respect to time, for both types of conservation.

In its planning, the Council assumes that the upper limit of conservation (this is called "penetration") that can reasonably be acquired by all mechanisms available. These mechanisms include more than utility programs alone. The mechanisms include incentive payments from utility and system benefit charge programs, improved state and local building codes, federal and state appliance standards, market transformation programs, marketing efforts, voluntary programs, electricity pricing mechanisms and other tools. The Council's assumptions estimate achievable penetration rates without respect to what fraction will be acquired by utility programs versus other mechanisms such as market transformation, codes, standards, or electricity price effects.

Over the twenty-year planning horizon the long-term cumulative upper limit of market penetration in the region is 85 percent of the economically (i.e., cost-effective) and technically achievable potential for non-lost opportunity measures and about 65 percent for lost-opportunity measures over a 20 year period. In addition to long-term penetration limits, the Council sets annual near-term limits on how much conservation can reasonably be developed. These annual limits are a more critical assumption for regional planning and implementation than the long-term penetration limits.

The annual limit for non-lost-opportunity measures is 120 average megawatts per year. The annual limit for lost-opportunity measures gradually increase from 15 percent to 85 percent of annually available and cost-effective lost-opportunity measures over the first twelve years of plan implementation. These annual limits have the effect of reducing the near-term achievable potential significantly. For example, in the first ten years of plan implementation, the resultant cumulative limit of achievable potential is 62 percent of the 20-year economically and technically available potential for non-lost opportunities and 21 percent for lost-opportunity resources. In aggregate, across both non-lost opportunity and lost-opportunity resources, the Council's 5th Plan limits achievable potential to about 44 percent of the 20-year technical and economic potential over the first ten years.

There is ample historic evidence to support retaining these near-term and long-term planning assumptions, as both are supported by actual experience during the last 20 years. There are many examples of better than 85 percent penetration for lost-opportunity measures. For example, before the end of 1992 -- not quite 10 years after the Council issued its first power plan -- Washington and Oregon, the two most populous states in the region, already had met the energy-savings goals in the plan set forth for new residential and commercial construction. By 2002 all four Northwest states had met the goals of the plan for conservation in new residential construction and also exceeded the goals for conservation in new commercial buildings by at least 10 percent.

Examples of historic penetration rates for non-lost-opportunity measures are more difficult to analyze on a retrospective basis by measure because of data limitations and a lack of sustained efforts for many measures. The Hood River Weatherization Project demonstrated over 85 percent penetration in just two years with a 100 percent incentive and a large marketing effort. Recent data shows over 32 percent penetration in just six years for residential compact fluorescent lighting. Furthermore, there are two episodes of high region-wide acquisition rates in the early 1990s and 2000s that demonstrate the capability to acquire over 100 average megawatts per year through utility programs alone.

It is more relevant today to reliably predict the pace at which conservation programs can be "ramped up" and maintained over the near-term than it is to plan 20 years into the future. The

20-year timeframe stipulated in the Act for the Council's power and conservation planning is less important for conservation than the near-term acquisition rates for two reasons. In 1980, new generating plants took up to 15 years to site, license, and build. Today, new generating facilities and transmission system expansions can be brought on line in three to five years. Second, the Council develops a new power plan every five years or so. Conservation potential is reassessed in each plan which allows a fresh look at accomplishments as well as what exists for future potential.

Background

In 2007 there is a resurgent interest in the Council's approach to integrated resource planning in general, and its methodology for incorporating conservation in its Northwest power plans in particular. There are several reasons. 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 consider their resource choices more systematically. In Washington State, the enactment of HB1010 and the passage of Initiative 937 (I-937) created additional impetus for the state's larger utilities, public and investor-owned. HB1010 requires utilities to prepare resource plans to demonstrate that they have adequate resources to meet their load-serving obligations.[1] I-937 requires utilities to develop all conservation that is cost-effective, reliable, and feasible using methodologies consistent with those used by the Council.[2] Because I-937 specifically references the Council's methodology there is heightened interest in understanding how the Council assesses 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 evidence.

The Council's Conservation Planning Methodology

The Northwest Power Act establishes three criteria for resources included in the Council's power plans: resources must be 1) reliable; 2) available within the time they are needed, and 3) available <u>at an estimated incremental system cost no greater than that of the least-cost similarly reliable and available alternative.</u>[3] Beginning with its first power plan in 1983, the Council interpreted these requirements to mean that conservation resources included in the plans must be:

- technically feasible (reliable)
- economically feasible (lower cost)
- achievable (available)

The first step in the Council's methodology is to identify all of the technically feasible potential conservation savings in the region. This involves the review of a wide array of commercially available technologies and practices for which there is documented evidence of electricity

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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)(i) and (ii) of the Northwest Power Planning and Conservation Act. (http://www.nwcouncil.org/library/poweract/3_definitions.htm or http://www.nwcouncil.org/LIBRARY/poweract/poweract.pdf)

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.

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 its 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, 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 savings on detergent costs.[4] While not all of these costs and benefits are either paid by or accrue to the region's power system, they are included in the evaluation because ultimately they are paid by or benefit the region's consumers.

Once the *net cost* (present value of all cost minus the present value of all benefits) of each of the conservation technologies or practices is determined, the technologies are ranked by cost in two "supply curves" that depict the amount of conservation resource potential available in the region. One "supply curve" represents all of the retrofit or "non-lost opportunity" resources. The other 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. Lost-opportunity resources are only available during specific periods. For example, savings from improved wall insulation in new buildings are 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's process is to establish any timing constraints on the availability of the conservation contained in these supply curves. These constraints are needed in the Council's portfolio modeling process. The portfolio model selects the quantity and timing of all resource development. Because significant quantities of conservation are available at costs 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.

Thus the Council establishes two types of constraints on the amount of available conservation. The first is on the rate of annual deployment. This constraint represents the upper limit of annual conservation resource development. In the Council's Fifth Northwest Power 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

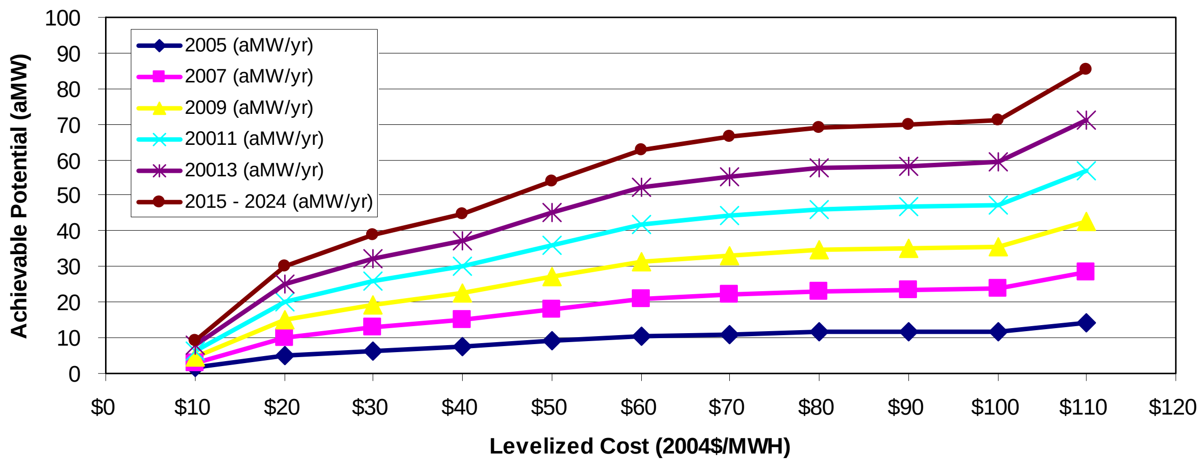
[4] More energy efficiency clothes washers use less water and hence require less detergent.
[5] Lost-opportunity resources are those that can only be technically or economically captured during a limited window of opportunity, such as when a building is built or industrial process is upgraded.

opportunity. So lost-opportunity deployment was based on penetration rates of 15 percent achievable in 2005 and increasing to 85 percent achievable over 12 years.

The second constraint is the maximum achievable potential over the 20-year period covered by the Council's power plans. In the case of non-lost opportunity resources, the Council set an upper limit of 85 percent of the technically feasible and cost-effective savings. Because 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 lost-opportunity and non-lost-opportunity resources used in the Council's Fifth 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 considered 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 the total achievable potential of non-lost opportunity resources.

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

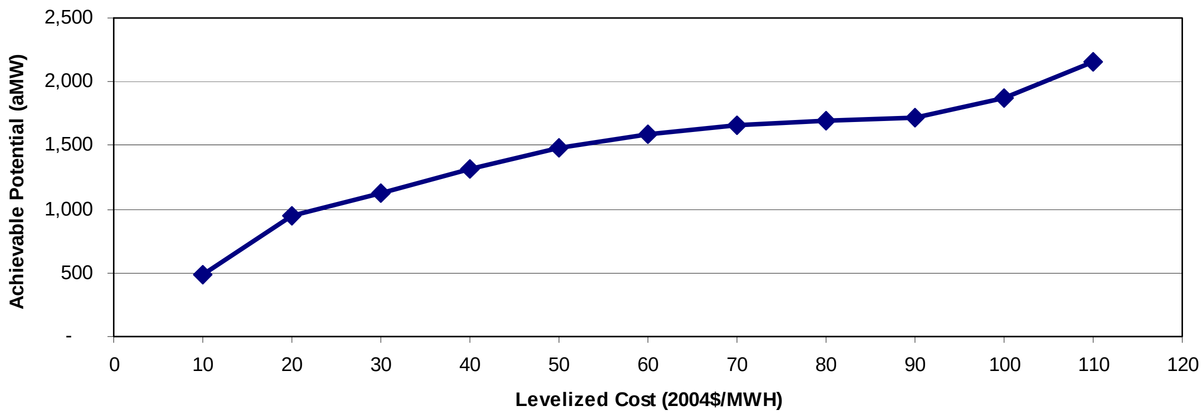


Figure 3 shows the expected value and annual deployment rate of those resources from 2005 through 2024 as well as the annual deployment rate of lost-opportunity resources over this same time period. As can be seen from Figure 3, the maximum amount of non-lost opportunity resource development remains 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 1,600 average megawatts of non-lost opportunity conservation resources are deployed over 20 years. But most of it, about 1,400 average megawatts, is deployed in the first 12 years. Figure 3 also shows that the 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 the annual technical and cost-effective lost-opportunity potential. However, in the first 10 years, the Council assumes a gradual ramp up of achievable lost-opportunity conservation resources.

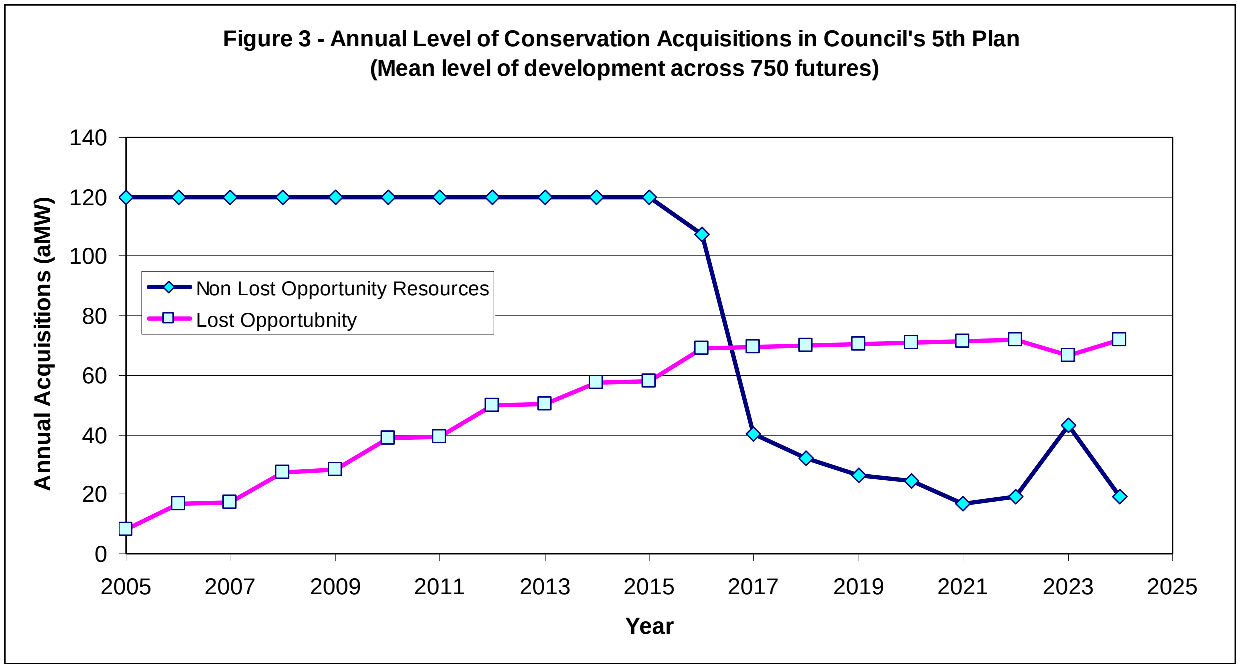


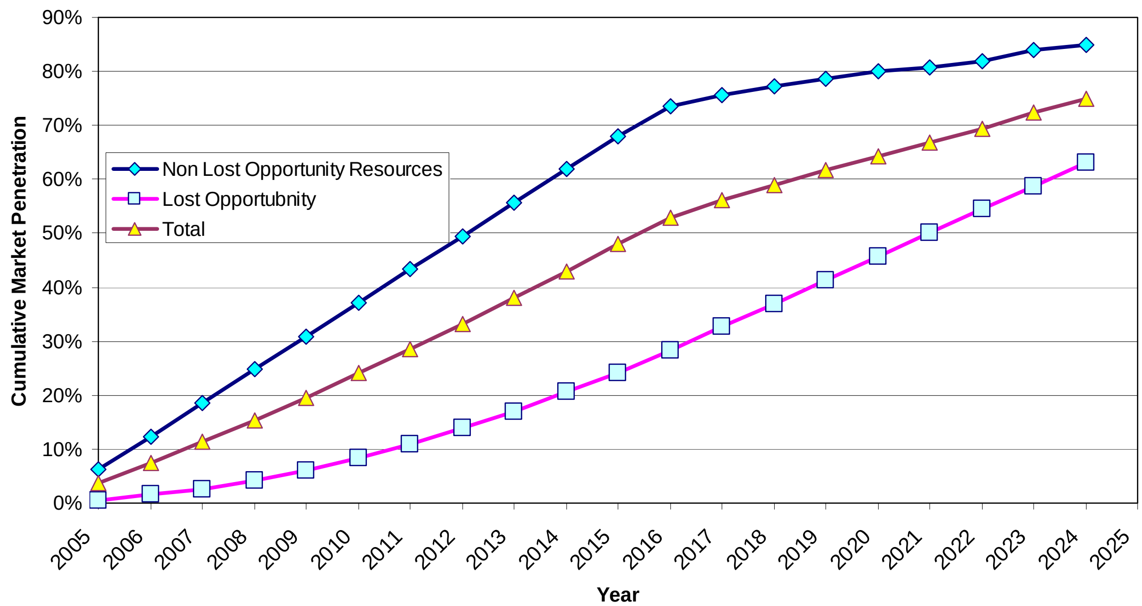
Figure 4 shows the cumulative maximum market penetration rate for lost-opportunity, non-lost opportunity and the total for conservation resources used in the Council's 5th Plan for each year covered by that plan. As can be seen from this figure, ten years into the plan (2014) the cumulative maximum market share of lost opportunity resources is 21 percent of their 20-year technical and economic potential. Also by this year, the cumulative maximum market penetration rate for non-lost opportunity resources is 62% of their of their 20-year technical and economic potential. In aggregate, across both non-lost opportunity and lost-opportunity resources the Council's 5th Plan limits cumulative achievable potential to about 43 percent of their 20-year technical and economic potential.

Basis of "Achievable Potential" Constraints

The first two filters in the Council's screening process, technical feasibility and cost, involve less "subjective" assessments than does the application of the "achievability" filter. Therefore, it is important to understand the basis of the Council's constraint on achievable conservation. The Council established the 85-percent upper limit in its first power plan in 1983 and has used this limit in all subsequent plans. The limit is based on the actual achievements in the Hood River Conservation Project sponsored by the Bonneville Power Administration and operated by PacifiCorp (then called Pacific Power and Light Company). The Hood River Conservation Project made weatherization measures available to all Hood River County residents with electric heat at no cost over a period of two years. In this project 83 percent of technically feasible (i.e. audit recommended) weatherization measures, representing 93% of the potential savings in the electrically heated residences were installed within a period of two years.[6]

[6] Hirst, E. 1987. Cooperation and Community Conservation: The Hood River Conservation Project, ORNL/CON-235, pp. 36-37.

Figure 4 - Cumulative Market Penetration in Council's 5th Plan (Mean level of development across 750 futures)



While the Hood River project set 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, even though it was accomplished in just two years in Hood River.[7] Second, Bonneville and utilities can offer significant financial incentives to encourage consumers to adopt energy-efficient technologies and practices called for in the Council's power plans. Indeed, by definition, Bonneville and utilities can offer to pay up to the full incremental cost of all cost-effective energy-efficient technologies or practices 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 addition to offering financial incentives, that Bonneville and utilities 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."

[7] The Council also viewed its 85-percent goal as having limited risk because its power 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.

1983 Power Plan Achievable Conservation Potential: Goals and Actual Achievements

The 1983 Plan included a range of future load growth forecasts and resource scenarios to meet them. In the "high forecast" case, the 1983 Plan targeted over 4,900 average-megawatts of conservation savings by 2002. In the "low forecast" case, the plan's target was less than 700 average-megawatts. According the Council's recent analysis, by the end of 2002 the region had acquired just over 2,300 average-megawatts of savings. It is not possible to directly compare this value with the "achievable potential" in the 1983 Plan, for two reasons. 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 conservation goals, which were forecast to be achievable through stable and aggressive programs over 20 years, and the actual results would be misleading.

However, it is possible to compare many of the 1983 Plan's specific estimates of achievable potential with what actually occurred. In particular, the 1983 Plan contained a detailed forecast of achievable conservation potential for residential and commercial buildings, appliances, and equipment.[8]

Residential Sector

The 1983 Plan estimated achievable conservation potential for space heating in new and existing residences, appliances, lighting, and water heating. With respect to space heating new residences, 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. The table shows that by 1992 energy code requirements in Oregon and 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.

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 percent of 40 percent is 34 percent) and that by 2006 the region had slightly exceeded the Council's original MCS efficiency levels.

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

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

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 percent 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 an excellent tool for capturing further energy efficiency savings.

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 because 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-1980s 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 builders agreed

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%

to build all of their new electrically heated homes to MCS levels. Since 1988 over half (54%) of new 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 Fifth Power 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%
1988 - 2005	123,133	229,069	54%

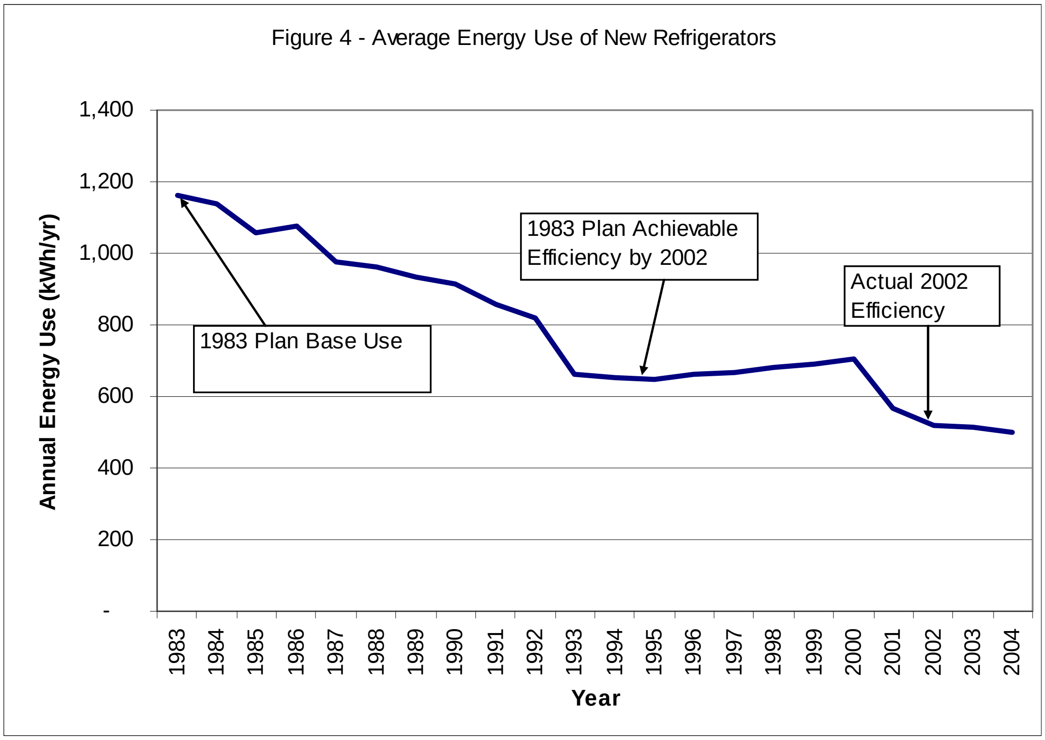
The second period of note is between 1996 and 2002 when the region's manufacturers first abandoned the production of energy-efficient homes and then returned to building these homes after discovering that the market did not want the less-efficient products they were trying to sell. While not specifically 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.

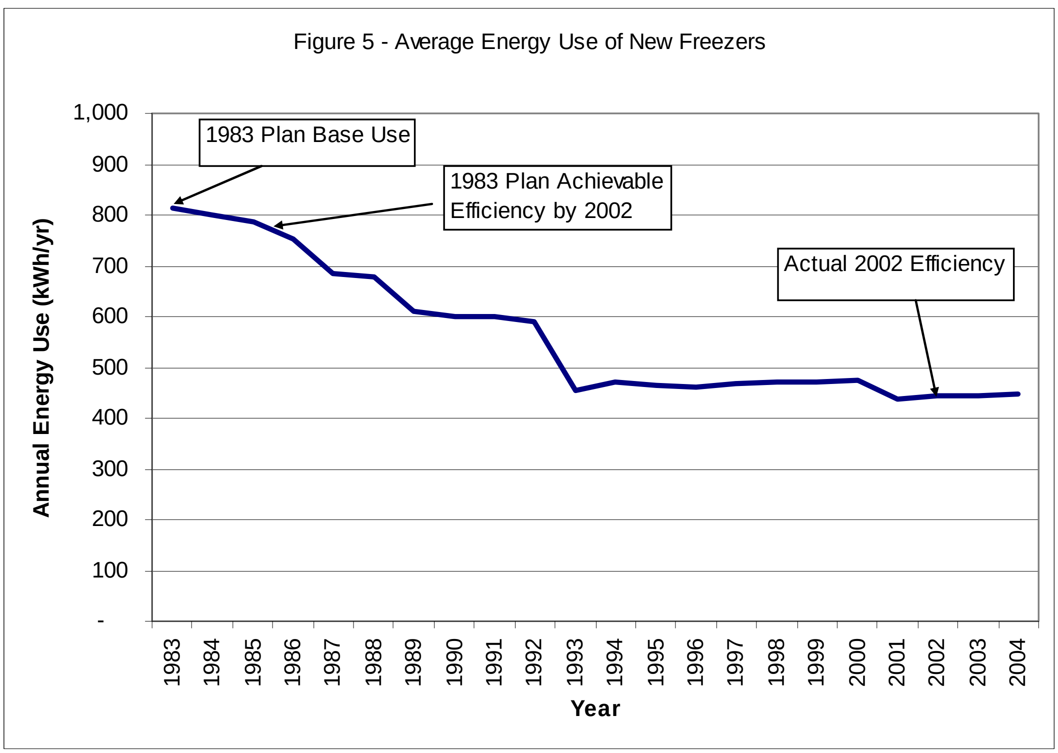
The 1983 Plan anticipated that by 2002 the region would have weatherized approximately 1.27 million existing electrically heated homes. Unfortunately, data collection processes that permit a direct comparison with this forecast were not in place during the period prior to 1991. However, current utility 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: 1) increased tank insulation; 2) lower-flow showerheads, and 3) lower the water tank temperature (from 140 degrees Fahrenheit to 130). As of 1991 the minimum federal standard for electric water heaters required that the average 50 gallon tank use less than 4,220 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 degrees Fahrenheit 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 percent 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.

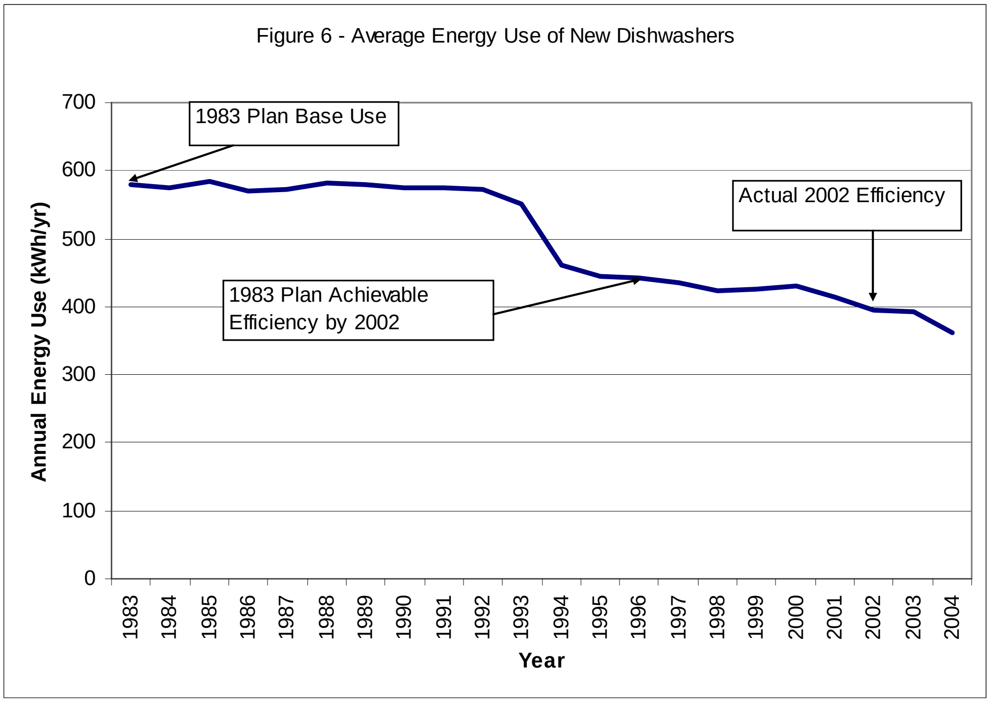
In 1983 the Council forecast that the achievable potential savings between the average electricity consumption of a new refrigerator and the most efficient model on the market would result in a savings of 515 kilowatt-hours per year. For freezers, the savings potential was just 35 kilowatt-hours per 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 appliances 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 early 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.

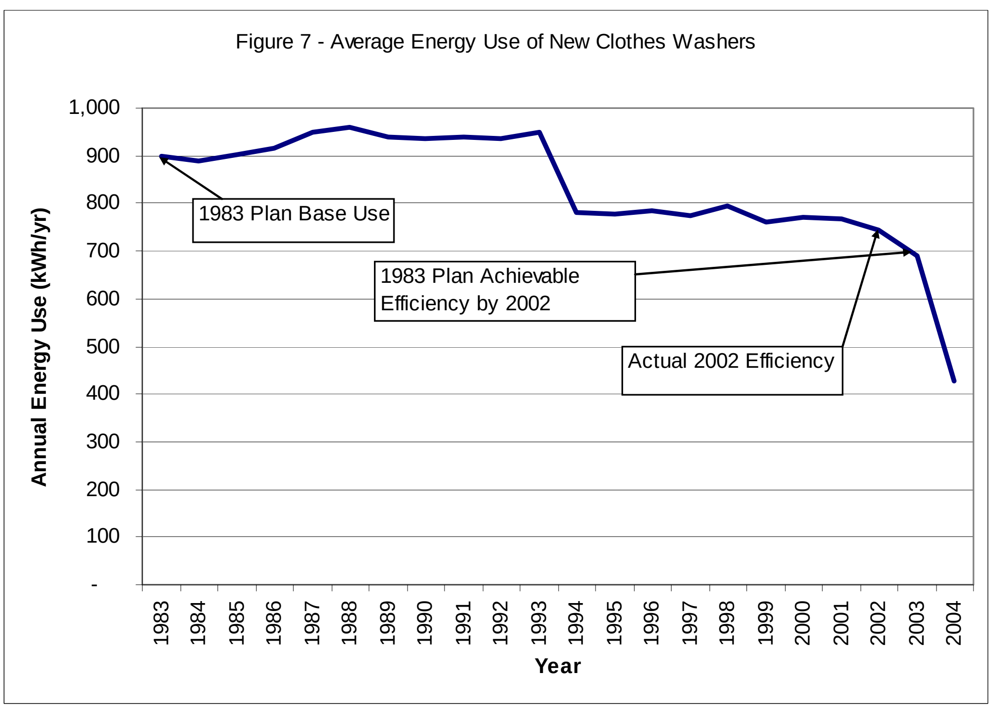
[9] In 2004, the federal minimum standard for a typical 50 gallon electric water heater resulted in electricity use of 4,060 kilowatt-hours per year.





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 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. On the other hand, 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.

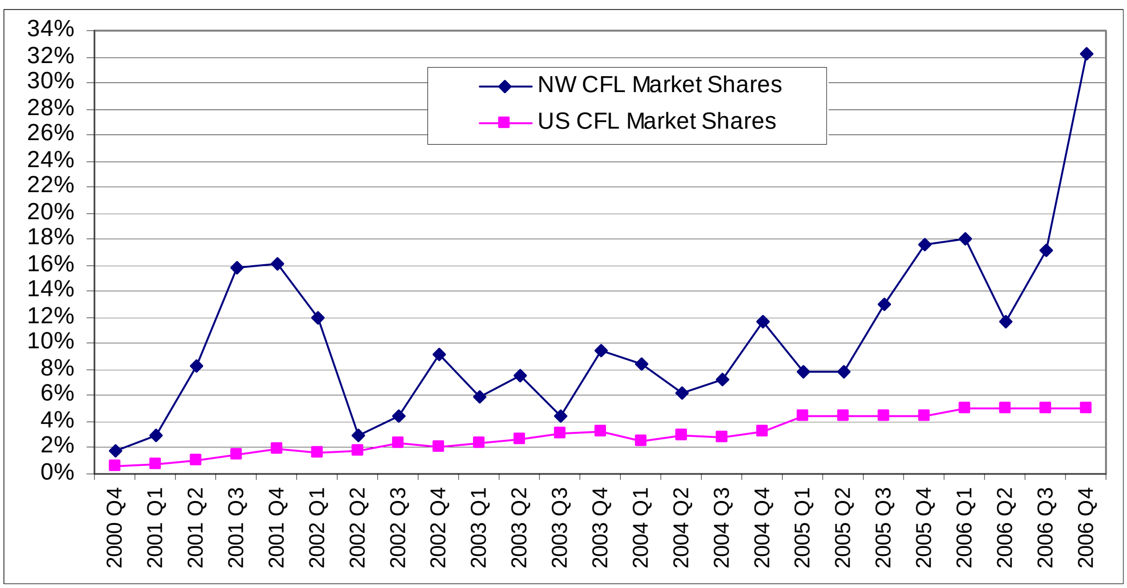




The 1983 Plan also anticipated efficiency improvements in residential lighting. That plan assumed that by 2002 the average home would use approximately 170 kilowatt-hours per year less for lighting than it did in 1983. While the 1983 Plan assumed that linear fluorescent lighting technologies could be 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.

Since 2002, the penetration of CFLs in the residential sector has increased dramatically. Figure 8 shows that the regional market share of CFLs increased from 9 percent in the fourth quarter of 2002 to 32 percent in the fourth quarter of 2006. Such evidence does not prove the region can reach an 85 percent penetration rate in 20 years. But it is a strong indicator that high penetration rates for some non-lost opportunity measures are possible in a short time frame. The high market share for CFLs is due to a combination of mechanisms which rely heavily on federal and regional market transformation strategies, as well as utility incentives which have been a fraction of measure cost.

Figure 8 -Estimated ENERGY STAR CFL Market Share for the Northwest and U.S., 2000-2006



Sources: NW CFL sales 2000-2006: PECI and Fluid Market Strategies sales data reports; and NEEA estimate of an additional 1.5 million WAL-MART CFLs sold region-wide in 2006 (See Appendix A [Section 9.1.1] of MPER3 for more detail); U.S. and NW population estimates 2000-2006: U.S. Census 2004; U.S. market shares and non-CFL sales 2000-2005: Itron California Lamp Report (2006); U.S. market share 2006: D&R International (personal communication).

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

Commercial Sector

The available data for commercial buildings tell a similar story; 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 Fifth Power Plan) the largest portion of the commercial sector's 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. Table 5 shows 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 warehouses 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 that 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 farther 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 night-time control of interior lighting is required in all four states for all but the smallest buildings.

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 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 period 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 20-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. Because 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 fluorescent light sources themselves -- the lamps and ballasts. 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]. By combining the 50-percent improvement in fluorescent source efficacy with additional improvements in fixture design, reduced lighting levels, and conversion from incandescent lighting to fluorescent lighting and other high-efficacy sources, it is clear 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.

[11] PNNonRes Phase II Results, Table 10c

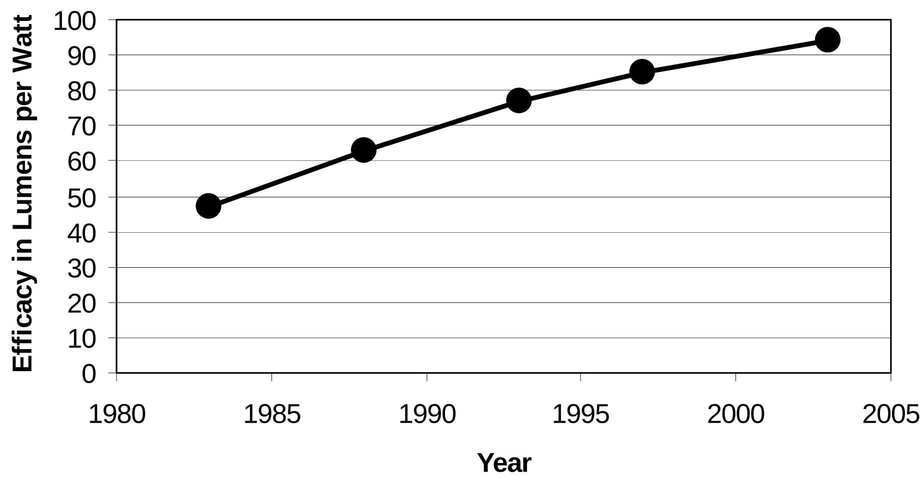


Figure 9 - Typical Fluorescent Source Efficacy

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 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.

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.

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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 (6,826 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.

The 1983 Plan assumed that if all achievable efficiency measures (e.g., reduced pressure, center pivot sprinkler 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.

Further, motor efficiency is a small part of what has been accomplished in the industrial sector. There are many 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 consumption 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 the upper limit on achievable conservation potential. Both the 85-percent upper bound on the achievable potential for non-lost opportunity resources and the approximately 65-percent cumulative upper bound on the achievable potential for lost-opportunity resources over a 20-year period are supported by experience of the last 20 years. Further, the Council’s assumed maximum near-term achievable acquisition rates, which are the critical limiting factor, 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

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

1983 Plan the Council called upon the states in the region to improve residential energy codes by approximately 40 percent and 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 floor space, 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 energy than they did in 1983, far exceeding the first Plan's goal of a 24-percent savings.

It is important to recognize that energy codes for buildings and appliance efficiency standards have contributed greatly to the acquisition of conservation over the last twenty years. Many of the conservation accomplishments outlined in this retrospective rely in part on codes and standards to achieve high penetration rates. Utility influence has been critical to the adoption of better codes and standards. Utility programs have demonstrated that new measures beyond codes are viable and that some can eventually be codified. Past performance does not guarantee future success. But with respect to codes and standards, the region is better positioned today to employ these mechanisms for future conservation acquisition than when the 1983 plan was adopted. When the first plan was adopted there were no federal appliance standards, state energy codes had only been in place for two years and there was no established process for code revision. All of these mechanisms are now in place.

A few conservation measures included in the 1983 Plan, such as residential heat pump water heaters, have not yet realized the anticipated penetration. However, savings from measures not envisioned in the 1983 Plan, such as those from low-flow showerheads and energy-efficient new manufactured housing, more than offset the unrealized savings. The fact that the first plan did not perfectly forecast these outcomes should not alter the overall finding with regard to "achievability." The Council updates its plan's every five years. Adjustments both upward and downward to its assessment of what is technically and economically achievable can be made on the basis of actual program experience and technological changes. Since each planning cycle offers the Council the opportunity to reassess the risk of relying on conservation to defer or reduce the scale of other resource additions near-term experience will always trump long-term forecast.

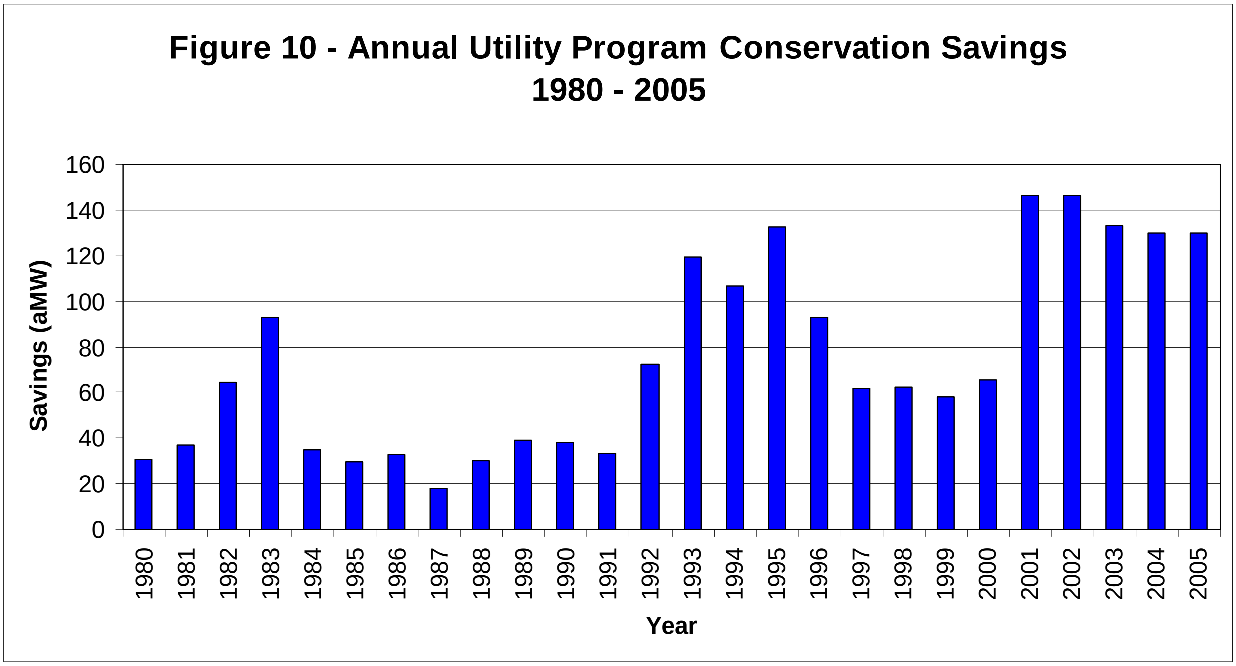
While the Council staff believes there is ample empirical evidence to support existing assumptions of 20-year achievable penetration rates, it is important to note that the 20-year forecast window for achievable conservation is less important today than it was in 1983 when generating resource lead times were long[15]. New generating facilities and transmission system expansions now can 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 into the future 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.

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 10 years or less. In fact, several exceed 100-percent penetration in ten years, far exceeding the Council's near-term assumption of approximately 20-percent penetration in 10 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. There are three periods, in the early part of each decade, where program savings have more than doubled in just 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 1,500 average megawatts of cost-effective non-lost opportunity conservation identified in the Fifth Power Plan.

[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.

Figure 10 - Annual Utility Program Conservation Savings 1980 - 2005



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