Beyond Supply Curves

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ABSTRACT

Utility resource planners use estimates of the available energy efficiency resources to choose how much conservation to fund, and how much fossil generation and transmission and distribution construction can thus be deferred. To deal with an initially skeptical utility industry, conservation supply estimation techniques have primarily focused on efficiency measures that work and are commercially available. Estimates of savings, cost, and date of entry for individual "near-commercial" conservation have not been accurate and perhaps cannot be given the stop-start nature of product innovation. While conservation is now well established as a resource in many states, the authors wondered if the standard estimation methods produce systematically low estimates of savings available over a 20 year period. We sought a method of forecasting savings that incorporates market and program innovations. We reviewed the history of estimates for several conservation measures and concluded that aggressive program activities tend to help prompt development of consensus techniques to measure efficiency, and accelerate technology innovation and price declines. Thus, the idea that we forecast conservation economics and then make choices to fund cost-effective measures is only partly true. It appears that conservation program entities fund measures and develop programs, and then the affordability, measurability and volume of savings often improves progressively over several years. As policy makers are asking how we can get more conservation faster, the answer may depend on whether we are willing to make technology and program development investments with less certain and longer-term payoffs in energy savings.

Introduction

Conservation Supply Curves have been developed since the advent of energy conservation as a power resource to determine the potential efficiency resource available at various costs over a certain period of time in the future. Typically, the supply curves provide an estimate of the technical potential available (annual therms, annual megawatt hours) at various prices by a certain date. A portion of that potential is assumed to be "achievable." In the Northwest, convention and experience has shown that the achievable rate is 85% of technical potential for most measures. Then, a penetration function is created, based on experience and circumstances more than any mathematical wizardry, to indicate how quickly a measure's achievable potential can be acquired (NPCC 2007b).

Our analysis focuses on the first part of this process, concerning the methods for estimating the *technical potential* for efficiency. In order to understand how we might better forecast the potential for efficiency, the paper reviews how past estimates for selected technologies have evolved over the past 25 years.

While we were hoping (against all reason) to find a pattern of prior conservation estimates that could lead to a new method or correction to conventional forecasting methods, we discovered (as we feared) that the improvements to estimates of savings over time for different measures vary dramatically. After summarizing the evolution of technical potential for three residential efficiency measures, we propose not a new method of developing a point forecasting efficiency, but acknowledgement of the conservative bias of existing methods and greater focus on forecasting the up-side uncertainty in those estimates.

Background

Most credible studies use the same method to estimate technical potential. The forecaster estimates savings per home, square foot of commercial floor area, or per unit of industrial consumption, and then multiplies by the number of units projected to exist in each year of the forecast (e.g. savings per home x number of homes = total savings.) Utility load forecasts and demographic data provide the framework for forecasting savings. Data sources for savings include program evaluations and engineering calculations. The process is done separately for new and existing homes and businesses to reflect the influence of codes and building practices on new structures. The results are aggregated across measures and then building or industry types to arrive at total potential. Care is taken not to count savings twice where measures overlap.

Utilities and regulators use conservation supply curves not only to decide how much conservation to buy, but how much fossil generation *not* to buy because conservation can reduce load less expensively. In addition, supply curves have provided broad guidance regarding what areas and sectors to examine in order to expand or enhance efficiency programs. At the genesis of conservation supply curves (circa 1983) utility and regulatory audiences were unfamiliar with conservation and skeptical of the viability of conservation as a resource. As a result, analysts included only measures that were economically viable and already proven to be available and work. This methodology has continued through present-day estimates. Through much of the 1990's, these conservative estimates were quite adequate, because while there were bursts of interest in conservation among utilities, there were also lulls where activity decreased or was non-existent. Programs did not operate on a sustained enough basis to deplete the forecast available savings, so there was little interest in exploring whether the supply curves were too conservative. At the same time, experience showed that much of the acquired conservation resulted from measures that were either not in the supply curves only a few years before, or were forecast to be too expensive. Innovation was clearly a force in conservation acquisition, but was not relied upon to predict potential savings.

As the cost of fossil generation and natural gas, and the interest in reducing carbon emissions have increased, questions from Northwest utilities, regulators, and other energy planning entities have focused more on whether there is more efficiency available. With the hopes of answering these questions, the authors of this paper studied how supply curves have changed over the past 25 years, and the factors causing the changes. We hoped this would provide some information to address the thorny question "how else could you do it?"

The most consistent and longest-running series of supply curve estimations are those of the Northwest Power and Conservation Council (NPCC or The Council.) The Council has produced supply curves in support of a new Power Plan every few years since 1983. As time has passed, these estimations have become more detailed, reliable, and purposeful. The analysis within this paper uses the series of conservation supply curves developed by the Council beginning with the First Power Plan in 1983.

Table 1 illustrates the changes to 20-year conservation supply curve estimates across the range of Power Plans from the NPCC. The numbers reflect the medium forecast achievable potential MWa savings for all cost-effective measures for each sector, except where noted.[1] As can be seen from the forecast savings in the table, there is hardly a linear trend on the amount of estimated efficiency in the supply curves at the sector level. These changes over time serve as the impetus for this project.

Table 1. NPCC Conservation Forecast (MWa)[2]

Year of Plan:	1983	1986	1991	1996	2005
Residential	2415	1895	1160	696	1275
Commercial	1435	1162	1051	451	1100
Industrial	550	500	490	565	350
Total	4400	3557	2701	1712	2725

Source: (NPCC 1983, 1986, 1991, 1996, 2005)

The forecasts do not follow a clear upward or downward trend. The primary causes are (1) the lesser detail and less evolved methods used in the first two plans, (2) the fact that achieved conservation was deducted progressively from each plan, and (3) lesser levels of effort put into identifying new resources in 1996, both by the Power Council and by efficiency programs. These complex factors mask the evolution of technical potential and led the authors to focus on individual measures to understand how the technical resource evolved.

Residential Windows in Existing Homes

Background

In Pacific Northwest homes, a significant fraction of the electric use comes from space heating due primarily to the climate and the higher-than-typical saturation of electric heat. Since the Council's First Power Plan, there has been great attention given to the potential savings from weatherization programs. Energy savings resulting from the installation of efficient windows for existing houses have been included in each of the Council's five plans and have constituted a significant component of the potential savings from each plan.

Methodology

Understanding of the influence of technological change on residential replacement window efficiency is complicated by a number of factors including: the variety of window designs, fuel source choice, climate variations, existing housing stock, engineering approaches to

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[1] Achievable savings were more consistently available from various forecasts than technical potential. Achievable is forecast for most measures is technical potential x 85%. So the trends would also apply to technical potential.

[2] The estimates for the Power Plans in 1983 and 1986 correspond to the "high" forecast.

energy usage, changes in baseline, and product testing methods. To address these factors simply, the analysis focuses on the electric efficiency per square foot of an "average" window in an existing 1350 square foot home, for a weighted-average Northwest climate.[3] This "average" window is designed to represent several windows types. It is combined with other housing sizes to provide total region-wide potential savings. The 1350 square foot house was chosen since it was included in each plan and its characteristics remained constant over time.[4]

Analysis

The Council's first three plans relied on savings estimates based on the recommended calculations in the ASHRAE handbook (NPCC 1983, 1986, 1991). When these efficiency levels were translated into actual products for marketing, they meant something similar to "single pane with aluminum frames," "double pane with wood frames" and "triple pane with thermally broken aluminum frames." A standard scale and procedure for rating window efficiency did not exist until the establishment of the National Fenestration Rating Council (NFRC) and the adoption of U-values as the testing and certification criteria in 1991. NFRC certified labels were eventually made available on windows manufactured beginning in 1993. Once NFRC testing and certification was in place, the penalties for aluminum frames and heat transfer through "spacing bars," etc. became more apparent. Efficiency analysts (and the manufacturers) realized what was previously thought to be equivalent to a U-30 product was in actuality only a U-50 product. Similarly, what was previously believed to be equivalent to a U-90 product was actually only a U-120 product (NFRC 2005).

As Table 2 shows, the efficiency of both baseline windows and efficient windows in the Council's first two plans were overestimated by over 13% due to the lack of a reliable testing procedure. The improved testing procedure determines the heat loss of the entire window, including the frame and glass, whereas the previously reported ASHRAE estimates reported savings based upon center of glass heat loss. The implementation of a consistent testing procedure and rating system resulted not only in more reliable efficiency estimates, but also allowed for additional technological advancements beyond what had been available at the time the NFRC adopted U-values.

Table 2. Existing SF Window Savings and Use[5]

	U-Factor		Annual Use and Savings		
Existing Homes	Original Assumption	Revised – Tested	PNW Plan 1-3	PNW Plans 4-5	
Single Pane Aluminum	0.90	1.20	13,074	14,511	
Dual Pane Wood/Alum Thermal break – Clear Glass	0.30	0.50	10,051	11,079	Difference
Delta U-factor	0.60	0.70	3,023	3,431	13%

Source: NPCC Internal Analysis

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[3] The Council defines three climate zones in each of its plans, based on a level of heating degree-days. Zone 1 corresponds to Portland/Seattle, Zone 2 is typified by Spokane, and Zone 3 is Missoula.

[4] The other two existing single-family home sizes are 850 and 2100 sq. ft.

[5] The kWh/yr totals in Table 2 are regionally weighted for the typical 1350 sq. ft. home.

The consensus among manufacturers and analysts for enhanced testing methods (and therefore better savings estimates) led to product improvements such as vinyl frames and improved spacer material. In addition, the emergence of "low-e" coatings and "gas fills," which reduced the heat transfer through the glass, allowed manufacturers to achieve the actual U-values that were previously reported. Thus, while rated efficiency levels were static through the first three plans, the new products could meet the efficiency levels that the old products were thought to meet. In addition to this compensation for incorrect early ratings, Class 25 (U-.25) windows were included in the Council's Fourth Plan in 1996 and in the Fifth plan. This inclusion represents the highest level of savings for efficient windows in the supply curves, with a 33% improvement in the energy use compared with the original baseline units from the Council's plan in 1983, as shown in Table 3.

Table 3. Existing SF Window Efficiency Savings[6]

Existing Homes	U-Value	Energy Use (kWh/yr)	% Change from baseline[7]
1983 Baseline (actual)	U 1.2	14,511	-
1983 Baseline (assumed)	U .90	13,074	10%
1983 Efficient Case (actual)	U .50	11,079	24%
1983 Efficient Case (assumed)	U .30	10,051	31%
Best Efficient Case in 2005	U .25	9,790	33%

Source: NPCC internal analysis

Supply curve analysis improvements and program activities clearly co-evolved and were interdependent. With the introduction of the U.S. DOE Energy Star Windows Program in 1997, window manufacturers wishing to participate and receive Energy Star recognition first had to obtain performance values by implementing NFRC testing procedures (NFRC 2005). The establishment of a nationally recognized testing program brought credence to the Energy Star window labels, laying the groundwork for further efficiency enhancements. With an authorized, national efficiency benchmark in place, utilities and regional efficiency organizations such as the Northwest Energy Efficiency Alliance could begin program efforts to acquire additional electric savings, achieve market transformation, encourage better building energy codes, and work with manufacturers to develop further technologies to advance energy efficient windows (NEEA 2002).

The major lesson from this experience is that standardized testing procedures, developed in collaboration with manufacturers, are essential to reliable supply curve estimates and to driving innovations in efficiency. With a transparent benchmark in place, U-35 and U-30 windows have become available for most window types, and efforts are underway to make U-25 and U-20 windows more affordable and available, and to explore further efficiency gains. This collaborative standards development process is more feasible for measures where efficiency programs are active.

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[6] The kWh/yr use figures are based on a regionally weighted 1350 sq. ft. house.

[7] The percentage change is from the actual 1983 baseline of U-1.20.

Compact Fluorescent Lamps for Homes

Background

It is difficult to overstate the magnitude of the shift in the conservation potential for compact fluorescent lamps (CFLs) for residential lighting between the years 1983 and 2005. In the 22 years between the Council's First and Fifth Power Plans, compact fluorescent light lamps became the largest available residential conservation resource, with an estimated 625 MWa available (NPCC 2005). The shift from scant mention to the most valuable resource happened suddenly, and recently. Table 4 below shows the dramatic increase in savings over time attributable to CFLs. The variations in price reflect both changes in estimated bulb cost and the assumed number of bulbs installed per home.

Table 4. Estimates of Residential CFL Savings for 20-Year Periods

Plan/Year	Achievable Savings (MWa)	Assumed Cost per Bulb
Plan I- 1983	105	—
Plan II- 1986	Not included	—
Plan III- 1991	24	$12
Plan IV-1996	44	$10
Plan V- 2005	625	$3

Source: (NPCC 1983, 1986, 1991, 1996, 2005)

Early Estimates

The initial estimate of savings for CFLs was modest. In 1983, CFLs were an exotic concept, barely on the market. Their inclusion in the plan (with other fluorescent technologies) was based on price and product development expectations that were not met for many years. The measure was included to indicate its future importance, and because with very little experience, the first plan criteria for inclusion of measures was not as exacting as for later plans. In the Second Power Plan in 1986, there was only a simple mention of the possibility that CFLs could replace incandescent light bulbs to achieve energy savings. In that year, the Council only examined the impact of replacing a 75 watt incandescent with an 18 watt fluorescent (NPCC 1986). Ensuing plans concluded that the technology was applicable only to a few fixtures per home, with appropriate wattages and geometry suited to the limited range of available products, and enough hours of use to justify the high price. The Plan allowed that the estimation methods at that time were "rough" due to the lack of reliable data on run times and fit for the variety of fixtures and room use in a home (NPCC 1986).

The estimation procedure was nearly identical for the Council's Third and Fourth Power Plans, with one significant difference. The similarities included the same assumptions for yearly watts displaced (50), the number of installed bulbs per existing home (3), the percentage of homes with installations (50%) and the electric space heat interaction effects (22%).[8] The main distinction in estimation methodology between these two plans was improved information about

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[8] This is the average interaction with electric heat and cooling, including gas heated homes. The interaction for an individual electric heated home is roughly double this number, due to high heating loads and small air conditioning loads in the Northwest.

"on-time" of each lamp per day. The Fourth Plan assumes 3 hours for interior and 5 hours for exterior fixtures while the Third Plan assumed only 2 hours for all fixtures. The effect of this assumption, in addition to any changes in housing stock forecasts, explains the increase in potential savings (NPCC 1991, 1996).

The similarity in estimations would seem to indicate that there were no major technological breakthroughs or major market transformations taking place. In fact, in both of these plans, the Council makes recommendations for a manufacturer buy-down approach by utility conservation programs in the interest of increasing actual efficiency savings. Also worth noting, the period during the decade when these two plans were released has been characterized as one where there was an energy surplus and a lapse in regulatory attention to efficiency, conditions that meant there was only modest interest in upgrading conservation supply estimates (NPCC 2007). These combined effects (which were common across much of the country), and the absence of a regionally established conservation mechanism helped contribute to the lack of a technological breakthrough necessary for widespread availability and adoption of CFLs.

Technological Improvements

Early compact fluorescent light bulbs were an immature, market-unfriendly product. In addition to the enormously high initial cost in comparison to today's prices and the prices of incandescent bulbs, CFLs suffered from a variety of problems that limited their early adoption, including size, color, and reliability, lack of products for specialty fixtures, power factor issues, limited available wattages, and flicker. At the time of the Council's Third Plan, there were no CFLs that could replace the full output of a 75-watt incandescent bulb (NPCC 1991).

CFL program support grew slowly in the late 1990's in parallel with development efforts by manufacturers. Manufacturers offered lower-cost, higher-quality CFLs to the market shortly before the 2000-2001 West Coast power crisis. During the years before this crisis, the Northwest Energy Efficiency Alliance (NEEA) had established a network of retail outlets that carried CFLs. NEEA also worked with manufacturers to improve product quality. The result, especially as utilities expanded CFL programs to meet the crisis, was a huge spike in CFL sales (an increase of over 3 million from 2003 to 2005 (NEEA 2006). While not every CFL worked perfectly and although CFLs did not fit every fixture, the increase in consumer acceptance, augmented considerably by lower prices, influenced resource planners to re-evaluate the future potential of CFLs. Following the sales explosion, manufacturers continued to develop a greater variety of products, and reduce product size. With initial funding from utilities and NEEA, a testing protocol was set up for bulb reliability, and eventually funded by the CFL industry. EPA's ENERGY STAR label gradually increased its quality and efficiency qualification requirements, prodding the industry to further improvements, including smaller size, less mercury content, a variety of color temperatures, more reliability, and longer life.

Recent Estimates

By the release of the Council's Fifth Power Plan in 2005, CFLs had become the largest efficiency option for the residential sector. The confluence of technological breakthroughs and regionally coordinated market transformation efforts led to nearly a fourteen-fold increase in savings between 1996 and 2005 (Table 4). With more market research and engineering information available, there were some significant methodological changes between the two plans. The average number of fixtures, lamps, and on time was estimated separately for different rooms and areas of the house instead of just an aggregate total. The savings were then estimated based on the wattage displacement from replacing an incandescent bulb with an approximately equivalent CFL. Adjustments were also made for removal, take-back, and (as before) space conditioning interaction effects. With more reliable engineering models, the space heat interaction value is only 12% in the Fifth Plan compared with 22% in the prior plans (NPCC 2005).

As a larger variety of bulbs became available, this increased the number of fixtures per home where CFLs are suitable. The additional research conducted between the Fourth and Fifth Plans provided a much firmer basis for estimating the potential regional savings from this technology. In the Fifth Power Plan, the Council assumed a maximum market saturation level of 86% (up from 50%), thus assuming that incandescent bulbs, in 20 years, would enjoy only a 14% market share. In addition, the cost estimate per bulb fell from $11.50 to $3 (NPCC 2005).

To summarize, the emergence of lighting as the largest conservation opportunity within the Power Council's residential supply curves (41% of residential potential) is due mainly to technological changes that increased the applicability, affordability, reliability, life, and availability of CFLs. These changes were driven by and also helped drive regional and national efforts to increase quality, awareness, and sales. The more than tenfold increase in potential from the previous plan shows that analysts were unable to predict the trajectory of this technology and its timing, or at least were unable to make a convincing enough case.

Residential Clothes Washers in Existing Homes

Background

The evolution of energy savings from clothes washers in residential applications illustrates how savings can increase with product and market evolution, but also illustrates many of the complications with analyzing and forecasting innovation. In each plan beginning with the NPCC's First Power Plan in 1983, continuing through the most recent Fifth Power Plan in 2005, residential clothes washers have been listed as a conservation resource. Between 1991 and 2005, the electric efficiency resource available from home clothes washers nearly doubled, even ignoring efficiency that was not included in later plans due to the increase in baseline efficiency (NPCC 1991, 2005). The driving forces behind the changes in potential energy savings estimates for residential clothes washers are (1) technological changes that increased the efficiency of residential clothes washers, (2) increases in baseline levels due to changes to minimum federal standards, resource acquisition programs, and market transformation programs, and (3) improved efficiency estimation methods.

Changes in Savings Estimates

As discussed below, the "yardstick" used by most analysts was changed in the 1990s. To compare consistently the efficiency across plans in this paper we have chosen to analyze the savings per machine per cycle for this paper.

Comparing the baseline assumption in 1991 with the most efficient unit included in the Council's Fifth Plan in 2005 (Table 5), the washer energy use decreases from 3.02 to 0.44 kWh/cycle, reflecting an 85% reduction. Including the effects of dryer energy use, the total energy use decreases from 5.34 to 1.36 kWh/cycle, an improvement of 74% in overall efficiency. Table 5 shows that the "most efficient unit" improved markedly between plans, from 59% of 1991 baseline load in the 1991 plan to 25% of 1991 baseline load in the 2005 plan.

Table 5. NPCC Plan III-V Baseline and Efficient Clothes Washer Energy Usage

Plan (Year)	Efficiency Level	Washer Use (kWh/Cycle)	Dryer Use[9] (kWh/cycle)	Total (kWh/cycle)	Change (from 1983 baseline)
III (1991)	EF				
Baseline	0.86[10]	3.02	2.32	5.34	
Most efficient	3.19[11]	0.81	2.32	3.13	2.21
IV (1996)	EF				
Most efficient	3.25[12]	0.64	1.37	2.01	3.33
V (2005)	MEF				
Most efficient	2.20	0.44	0.91	1.36	3.98

Source: (DOE 1990), (NPCC 1991, 1996, 2005)

Technology

Prior to the Third Power Plan, the Council estimated the potential yearly savings based on savings from a cold rinse option which saves hot water energy. In the Third Plan, the possibility that a horizontal axis machine might be manufactured and marketed for residential use was considered. Prior to this time, horizontal axis machines were used widely in commercial applications, and by residential users in Europe and Asia (DOE 1990). However, without viable options domestically in the early 1990's, the Council chose to leave out the potential savings of h-axis machines as the high levelized cost of the machine outweighed those savings.

The two predominant technological advancements in clothes washer efficiency with the horizontal axis machine were reduced water usage, leading to still lower hot water energy use, and the addition of high speed spin cycles. The higher speed spin cycles of horizontal axis washers can greatly reduce the remaining moisture content (RMC) of the clothes before they are placed into the dryer, resulting in much less energy required to dry the clothes.

Methodology

The Council's Fourth Power Plan was the first to include the effects of reduced dryer usage into the overall savings attributed to clothes washers. Between the Fourth and Fifth Power Plan, the DOE adopted the MEF rating as the new testing procedure for clothes washers, thus incorporating water factor and RMC into the overall metric for clothes washers. As EF and MEF are not directly comparable, Table 5 above includes both washer and dryer use per cycle to provide for reasonable comparison. The inclusion of RMC into the conservation resource calculation provides a more robust estimation, and reflects the true overall energy savings.

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[9] The savings attributed from reduced dryer usage are not included in supply curve estimates until the Fourth Plan in 1996. The kWh/cycle dryer usage numbers are provided for 1991 to be used for comparison purposes and were taken from DOE/CE 0299P.

[10] The baseline EF level for 1991 was taken from DOE/CE 0299P.

[11] The EF 3.19 unit was taken from DOE/CE 0299 and hypothetically constructed as the "maximum technologically feasible" washer possible given existing technology at the time.

[12] The EF 3.25 also assumes a remaining moisture content of 40%.

Programs

A remarkable combination of local, regional, and national programs has helped improve the efficiency of clothes washers. The early efforts of the Western Utility Consortium (WUC) and implementation of the High Efficiency Laundry Metering and Market Analysis (THELMA) helped establish measurement methods and identify efficient features. These were brought to manufacturers and the DOE and helped establish standardized testing procedures and federal standards. The early programs also created and showed market interest in efficient washers (CEE 2001). Starting in 1997, a regional program coordinated by NEEA and including utilities helped spur the movement towards market transformation. The Consortium for Energy Efficiency followed with a national program using consistent specifications. As markets accepted higher efficiencies, they worked their way into federal standards, and CEE and utility specifications moved to higher efficiency levels (NEEA 2001). After the establishment of the Energy Star program, CEE efficiency tiers for rebates were harmonized with ENERGY STAR efficiency levels. The effect of this accord was reduced confusion among utilities, manufacturers, retailers, and consumers by providing consistent estimates of savings to all parties (CEE 2001).

The primary lesson from this market is that program efforts can drive improvements in technology, testing procedures, and market branding of efficiency. Consistent, reliable and purposeful estimates of savings helps retailers different efficient products and profit from them, which, as efficient units become commonplace and Federal standards increase, leads to accelerated technology development.

Conclusion

Through this research, we were unable to identify a systematic trend or mathematical function that helps forecast supply curves beyond established technology. While savings potential grows and prices moderate over time for many measures, this is neither universal nor consistent between measures. The results may suggest that rather than developing a better point estimate of efficiency potential by a certain year, analysts should consider the asymmetric uncertainty around efficiency savings estimates. Integrated resource plans could establish a confidence interval around conventionally derived supply curve-driven savings estimates that acknowledges that there is likelihood of more savings than of less.

For example, a conventional supply curve does not forecast zero net energy new buildings and homes, but there are several entities in the US committed to developing them and demonstration homes and buildings under construction. Zero net energy initiatives generally set a goal of 60-70% energy reduction through efficiency and meeting additional needs through renewable energy. While this is not now proven feasible on a mass scale, forecasters can use this technology to create a “high case” for savings with a modest probability, and assign progressively more certainty to more conservative estimates. Another approach is to analyze potential savings from near-mature measures, without pretension of precision about costs or savings, and then assume that perhaps half of these technologies will mature in the ensuing five years.

How can the precision of these estimates be improved? Our research shows that when programs invest in higher levels of efficiency, this helps drive measurement improvements and technical innovation, resulting in larger and more reliable conservation supply estimates. Thus, it appears that the best way to improve conservation forecasts is to make investments and take risks to prove and acquire additional resources. Given the low current cost of efficiency and high price and delivery reliability compared to fossil resources, a less risk-averse approach to forecasting and program funding than is currently employed by many program delivery entities may be both supportable and financially prudent.

References

[CEE, 2001] Consortium for Energy Efficiency. 2001. *The Residential Clothes Washer Initiative: A Case Study on the Contributions of a Collaborative Effort to Transform a Market.* http://www.cee1.org/eval/RCWI_eval.pdf

[DOE, 1990] United States Department of Energy. 1990. *Technical Support Document: Energy Conservation Standards for Consumer Products: Dishwashers, Clothes Washers, and Clothes Dryers, DOE/CE-0299P.* Washington, D.C.: United States Department of Energy.

[NEEA, 2001] Northwest Energy Efficiency Alliance, 2001. *Energy Star Resource Efficient Clothes Washer Program: Market Progress Evaluation Report #5.* Portland, Ore. http://www.nwalliance.org/research/reports/83.pdf

[NEEA, 2002] Northwest Energy Efficiency Alliance, 2002. *Market Progress Evaluation Report for the Energy Star Windows Project.* Portland, Ore.

[NEEA, 2006] Northwest Energy Efficiency Alliance. 2006. *2005 Annual Report*. Portland, Ore. http://www.nwalliance.org/research/documents/AR2005.pdf

[NFRC, 2003] National Fenestration Resource Council. 2003. *Behind the Glass: A History of NFRC as Told by the People Who Lived It.* Silver Spring, Md. http://www.nfrc.org/documents/NFRC%20History.pdf

[NFRC, 2005] National Fenestration Resource Council. 2005. *The Facts About Windows and Heat Loss.* Silver Spring, MD. www.nfrc.org/documents/U-Factor.pdf

[NPPC, 19833] Northwest Power Planning Council. 1983. *Northwest Power Plan.* Portland, Ore.

[NPPC, 1986] Northwest Power Planning Council. 1986. *1986 Northwest Power Plan.* Portland, Ore.

[NPPC, 1991] Northwest Power Planning Council. 1991. *1991 Northwest Power Plan.* Portland, Ore.

[NPPC, 1996] Northwest Power Planning Council. 1996. *The Fourth Northwest Conservation and Electric Power Plan.* Portland, Ore.

[NPCC, 2005] Northwest Power and Conservation Council. 2005. *The Fifth Northwest Electric Power and Conservation Plan.* Portland, Ore.

[NPCC, 2007a] Northwest Power and Conservation Council. 2007. *Council Briefing Book.* Portland, Ore.

[NPCC, 2007b] Northwest Power and Conservation Council. 2007. *Achievable Savings: A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions.* Portland, Ore.