The Pace of Progress

Improving energy efficiency savings forecasts in Northwest power plans and speeding emerging technologies to market

A NW Energy Coalition issue paper

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NW Energy Coalition

for a clean and affordable energy future

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The report's findings and recommendations are those of the NW Energy Coalition alone and do not necessarily represent the views of all reviewers.

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– NW Energy Coalition, September 2015

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Executive summary

Current energy efficiency planning and forecast methodologies – including those used in developing the 7th Northwest Power and Conservation Plan – underestimate the pace of market changes, overlook synergistic savings and those from operational and behavioral improvements, and are constrained by outdated “achievability” assumptions.

Recent regional energy efficiency efforts have delivered remarkable results, beating expectations every year. This is great news. Still, over the last 15 years the region’s planners have consistently underestimated the amount of cost-effective energy efficiency available. Methodology-based limitations can lead to oversights in identifying cost-effective energy efficiency achievement opportunities.

These methods can be improved. This paper explores two key areas (and their associated programs) for improved energy efficiency planning: better estimating the pace of change for emerging technologies, and applying systems-based approaches to efficiency in buildings.

■ The pace of change

Technology often emerges quickly, and that can be especially true of energy efficiency technologies. How can we make more reliable long-term price and availability estimates in fast-changing markets? Seeking recent market trends that can inform energy efficiency planning efforts, we used multi-year data from the Northwest Energy Efficiency Alliance (NEEA) to calculate the pace of change for products in three different categories.

1. **Quick-turn markets** such as consumer electronics can transform very rapidly with efficiency improvements typically reaching market dominance in three to five years.
2. Well-proven **incremental improvements to appliances** typically reach market dominance in five to seven years.
3. A **disruptive technology**, an enhanced or completely new technology that replaces and disrupts an existing one, must first reach initial product maturity in terms of price, quality and adoption by major marketers and even then achieving substantial market share or sales can take 10 years or more.

Market transformation work (in this case performed by NEEA) is critical to faster adoption of emerging technologies in all categories.

Both consumer electronics and appliance upgrades can achieve market dominance in relatively short time frames, especially compared with the regional power plan's five-year action plan horizon and most utility integrated resource planning outlooks. Markets in which innovation has become standard make accurate forecasts even more elusive. Clearly, the region needs new tools to address the predictive ability of energy efficiency planning methods.

■ Optimization and constraints

Planning efforts, including the 7th Plan, have not adequately accounted for savings from the "marbling" of technologies, operational practices and user or occupant behaviors. This is especially so for building efficiency improvements that work synergistically. Building construction and retrofit managers increasingly take a systems approach, combining various features and actions to further reduce energy use.

Planners, in part due to the traditional measure-by-measure approach to evaluating energy efficiency, have undercounted the results of design optimization. They may also under-predict the pace of market progress for some efficiency technologies acquisition through use of ramp rates and the overall assumption that we can achieve only 85% of any given measure's economic potential. Resource planners assign these constraints to represent their assessments of market barriers to adoption and the achievable pace of conservation.

A shift in how we represent market possibilities, coupled with improved marketing and education programs, should yield greater achievements. For example, assigning constraints on ultra-low-energy buildings based on the short-term incremental cost misses the fact that in most markets the primary barriers to ultra-low-energy buildings are related not to costs, but to consumer and professional education and marketing, which can all be addressed programmatically.

■ Recommendations

Our recommendations fall into three categories.

Modeling

Clearly identify advancing technology in the 7th Plan and all utility conservation potential assessments (CPAs), and provide biennial updates (or at least a planning cycle mid-point update) to assess progress and new emerging technology opportunities.

Explore using this paper's market classifications (*quick-turn markets, appliances, disruptive technology*) to determine a methodology for improved supply curve pacing in power plans. NEEA data could be mined further to assign risk profiles for supply pacing assumptions.

The Council and utilities should investigate end-use approaches to conservation resource supply curve development.

Market transformation

Emphasize and expand support for upstream energy efficiency efforts and market transformation activities.

Regional planning approaches, state utility commissions and utility programs should support market innovations in overall energy performance and integrated design, rather than focus on discrete technologies. This may require new approaches to resource cost tests that focus less on individual measures and more on performance-based outcomes.

Buildings

The 7th Plan and utility CPAs should include a comprehensive approach for advancing zero-energy residential and commercial buildings. Cost-effective deployment of zero-energy buildings (ZEBs) is possible, but further development and education are needed. ZEB manufactured housing should be explored, given prior program success in the Northwest.

The Council should assess the accuracy of current measure-by-measure approaches to high-performing/ultra-low-energy buildings. A new approach to developing conservation supply curves may be needed in future plans to better represent measure bundling and systems-based approaches.

I. Introduction

Regional and individual utility energy planning processes light the way to our energy system future. These processes determine which resources are needed and when. Properly estimating the amount and costs of energy efficiency available several years hence will help avoid the billpayer-covered mistakes such as overbuilding generation, distribution and transmission systems.

But power planning efforts across the region, particularly utility conservation potential assessments (CPAs), may be consistently underestimating and undercounting the energy efficiency savings from emerging technologies and building construction. This paper reviews recent data on these sectors and identifies key trends that could lead to improved planning and implementation of energy efficiency, ultimately helping us acquire more cost-effective demand reductions in the Northwest. We offer recommendations for predicting and capturing these additional energy savings.

We have all lived through changes in technologies we deal with every day … computers, entertainment, communications, and automobiles. Estimating the pace of change in energy-related technology challenges power planners. They must understand what conservation resource they need, when they need it, its features and its cost – just as they would with a generation resource. But whereas generation-side methodologies are quite mature, those for energy efficiency are not. To date, energy efficiency estimates have erred on the conservative side, likely because coming up short on efficiency savings could result in having to buy energy at a premium to meet power demand.

Those fears appear ill founded. The historical record includes many examples of energy efficiency savings estimates considered very aggressive at the time being easily exceeded. For example, over the last 15 years, the Northwest Power and Conservation Council's power plan targets have consistently underestimated energy efficiency achievements (see **Figure 1**).

FIGURE 1:
ENERGY EFFICIENCY PLAN GOALS VERSUS ACCOMPLISHMENTS
(incremental)

Source: Northwest Power and Conservation Council

A retrospective report from the Council in 2007[1] indicates that estimates of efficiency gains in new construction and emerging technology were regularly exceeded:

- By 2002 all states in the region had met the Council's original residential model conservation standard (MCS) and exceeded its original commercial MCS by at least 10%.
- The 1983 power plan foresaw achievement of a 43% improvement in the efficiency of new residential refrigerators by 2002. Not only was this improvement reached 10 years earlier (1992), but by 2002 new refrigerators used only 55% of the energy they did in 1983, even though they were 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 1st Plan's efficiency target in 1984, and by 2002 these appliances were using 45% less energy than was considered "achievable" in 1983.
- Dishwashers in 2002 used 32% less energy than they did in 1983, far exceeding the 1st Plan's goal of a 24% savings.

[1] Northwest Power and Conservation Council, "Achievable Savings: A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions," 2007.

But why should it matter if programs exceed goals and achieve impressive levels of energy efficiency more rapidly than foreseen in planning processes? Again, it's about avoiding unneeded new generation resources and unnecessarily higher consumer bills.

Energy, Economics and Environment (E3) analyzed Portland General Electric's need to replace the Boardman coal plant's power in 2020. It compared (**Figure 2**) the energy efficiency "known" to be available and cost effective by the Energy Trust of Oregon[2] with a broader supply curve based on a Lawrence Berkley National Lab emerging technology report. The green supply curve shows the potential savings if most currently known efficiency technologies become available and cost effective for utility program implementation over the PGE IRP plan horizon.

The gap between the two curves is large. While reality probably lies somewhere between the two, it is critical that PGE understands how much energy efficiency will likely be available and at what cost to make good resource decisions going forward.[3]

FIGURE 2:
ENERGY SAVINGS PROJECTIONS: TWO VIEWS

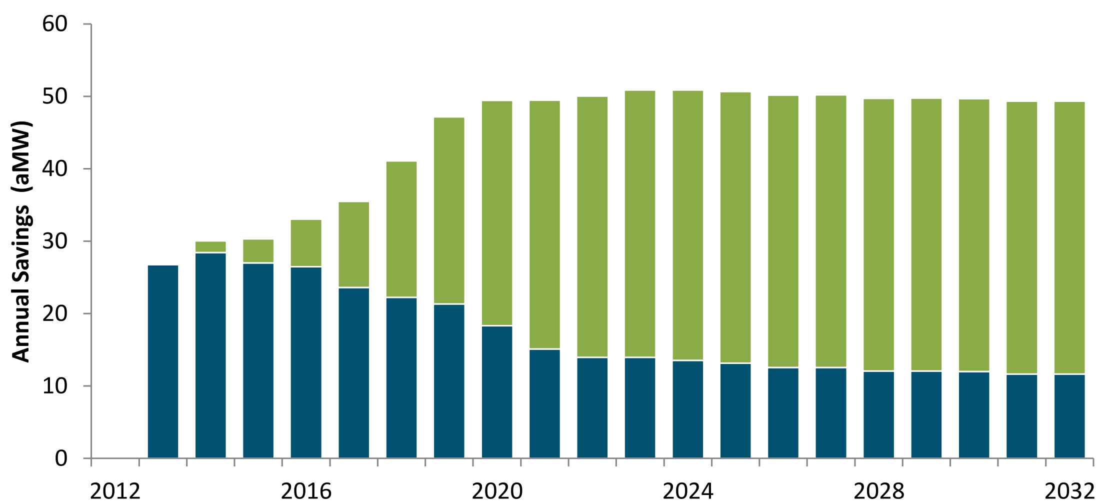


Figure 2 illustrates the gap between Energy Trust of Oregon energy efficiency "achievability" projections and more inclusive projections from the Lawrence Berkeley National Laboratory.

Green= Lawrence Berkley National Lab high energy efficiency incremental savings
Blue= Energy Trust of Oregon cost-effective achievable

[2] The Energy Trust of Oregon (ETO) implements PGE's energy efficiency programs.
[3] ETO is currently working on the next phase of this research.

Better understanding of what may become available also can strengthen programs that improve energy savings performance. Our analysis of NEEA data finds market transformation strategies critical to increasing the amount and pace of emerging technology adoption.

To move us toward more accurate predictions, more comprehensive savings measurements and quicker identification and capture of additional energy savings opportunities, the following sections address and provide recommendations associated with:

- The pace of change for several markets and emerging technologies, primarily in the residential sector, based on trend data developed by NEEA.
- Opportunities in systems-based approaches, as opposed to individual technologies, with an emphasis on building design and construction.

■ A note on methodology

The Northwest Energy Efficiency Alliance tracks the annual market shares for many of the energy efficiency products it has worked on over the past 20 years. NEEA provided emerging technology sales trend data for a number of its initiatives.

These data were analyzed, with an emphasis on residential measures, for generalizable pace-of-change information to assist future planning. NEEA's multi-year data help to establish pace-of-change time frames for three different types of products to identify recent market trends that can inform energy efficiency planning efforts.[4]

[4] Particular NEEA sources include Evergreen Economics, "Next Step Home Baseline Estimation Study - Final Report," Northwest Energy Efficiency Alliance, November 2014; and Evergreen Economics, "Northwest Ductless Heat Pump Initiative: Market Progress Evaluation Report #3," Northwest Energy Efficiency Alliance, April 2014. An additional source is "Setting the Pace for the Race to Zero Energy Ready Homes" by Sam Rashkin and Eric Werling from the American Council for an Energy-Efficient Economy (ACEEE) summer study 2014.

II. The pace of change

This report analyzes Northwest Energy Efficiency Alliance data, with a focus on the pace of change, within three broad markets:

Quick-turnover consumer electronics. This market is characterized by the speed of innovation and transition in the existing marketplace. New products are introduced constantly and the market is extremely competitive. NEEA data address such products as televisions and computers.

Incremental appliance upgrades. Home appliances are major energy users, and small changes to energy use result in large regional savings over time. Examples chosen are clothes washers and dishwashers.

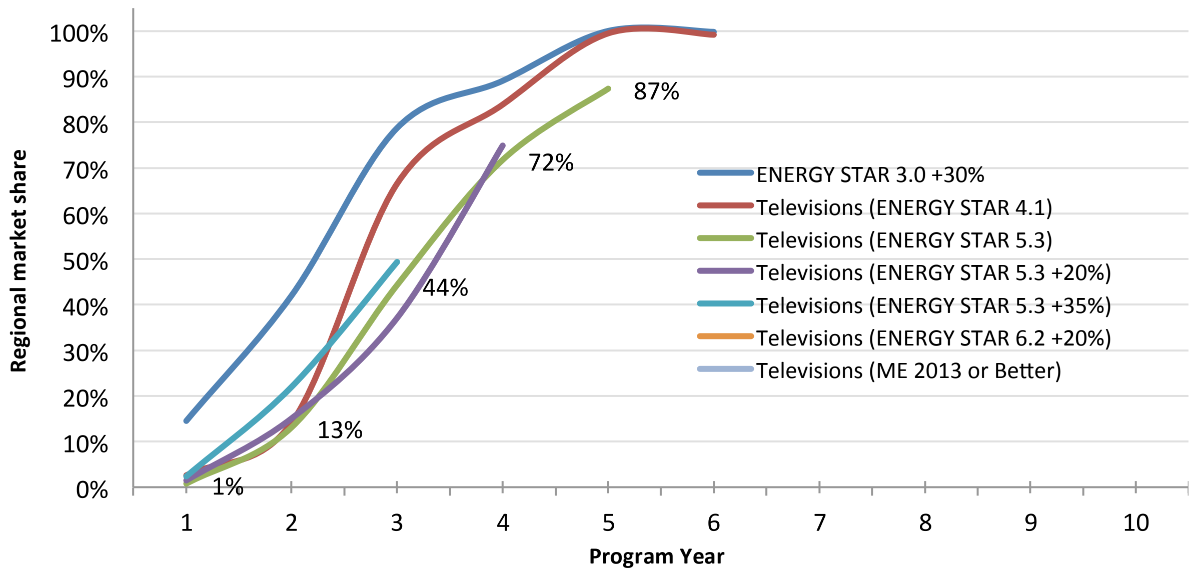
Disruptive technology. Disruptive technology refers to any enhanced or completely new technology that replaces and disrupts an existing technology, rendering it obsolete. It is designed to succeed similar technology already in use. Examples chosen are compact fluorescent lights (CFL), heat pump water heaters (HPWH), ductless heat pumps (DHP) and the first generation of efficient clothes washers (i.e., those incorporating horizontal axis technology).

A. Consumer electronics

The constant stream of consumer electronics innovation distracts both manufacturers and consumers from attention to energy saving technologies. How many people know how much electricity their phone uses versus another model? Still, some technologies – think efficient power supplies for computers –have transformed the market. Such advances provide momentum for subsequent flurries of energy efficiency product development, offering more features to attract consumers.

Figure 3 shows the pace at which televisions have incorporated power-conserving technologies. The data – covering a series of changes within one family of products under similar market transformation practices – are quite consistent. In general, energy efficiency elements dominate the market within three years and completely or almost completely transform the market within five years.

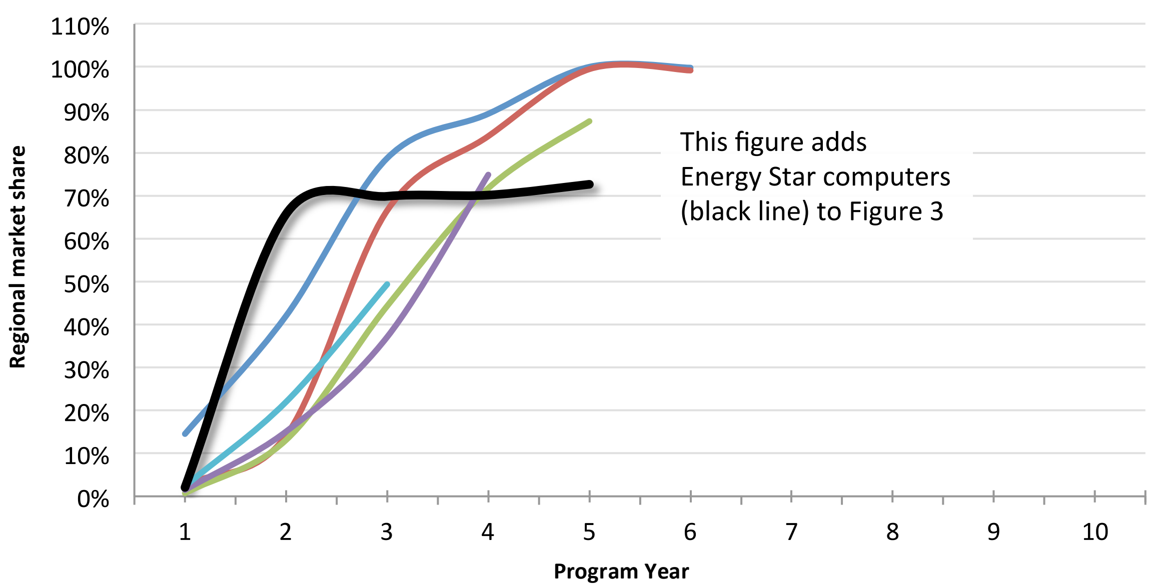
FIGURE 3:
TELEVISIONS



(Here and in subsequent figures, "Program year" refers to how long the product has been part of the Northwest Energy Efficiency Alliance promotion and tracking program.)

Figure 4 adds Energy Star® computers to the televisions' market share curve. Once included in the Energy Star® specification, the computer power supply upgrade was rapidly adopted by most major manufacturers. This demonstrates the important role Energy Star® specifications and federal or state standards play in market transformation. Both branding and developing standards attract manufacturers' attention.

FIGURE 4:
TELEVISIONS AND ENERGY STAR COMPUTERS



Major market transformation in consumer electronics is possible in three to five years. This time frame applies to frequently updated products, highly competitive consumer markets, products associated with broadly recognized brands, such as Energy Star, ® or those subject to heightened efficiency standards.

B. Appliance upgrades

Appliance efficiency upgrading has been a central market transformation strategy for more than two decades. Federal standards for refrigerators have been modified four times to capture increased efficiency opportunities from improving technology.

The NEEA data for several generations of more-efficient clothes washers and one generation of dishwashers are shown in **Figure 5** below. While the adoption curves vary, federal standards clearly affected both dishwashers and MEF (modified energy factor[5]) 1.42-1.71 clothes washers. The two other washers were adopted by the majority but not all of the market.

FIGURE 5:
CLOTHES WASHERS AND DISHWASHERS

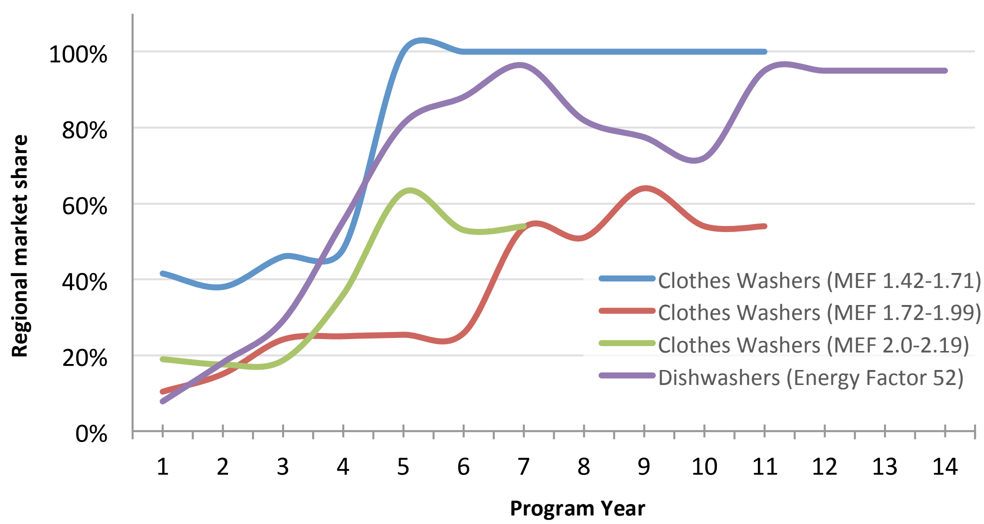


Figure 5 shows the growth in market share for increasingly efficient clothes washers and dishwashers, beginning with energy factor (MEF) 1.42-1.71 models.

[5] MEF is the energy performance metric for Energy Star-certified commercial clothes washers as of March 7, 2015.

These data suggest that market transformation programs can substantially ramp up efficiency achievements in five to seven years, and that federal appliance standards accelerate the ramp-up rate and deepen ultimate market penetration.

C. Disruptive technology

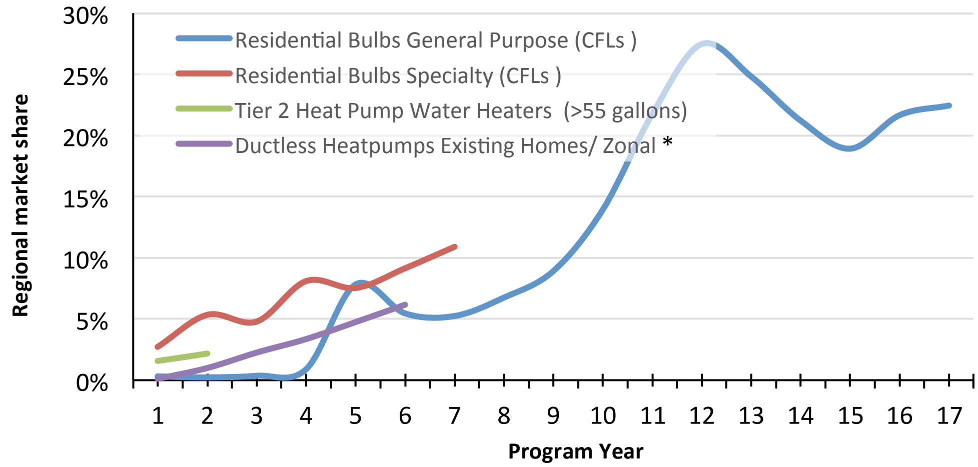
In multiple markets, NEEA has identified representatives of a new class of high-efficiency technology with characteristics of disruptive innovation. Clayton Christensen, a Harvard Business School professor and author of several books on disruptive innovation, says a disruption displaces an existing market, industry or technology and produces something new, more efficient and worthwhile. A classic example is the spread of cell phone technology.

In the energy efficiency field, disruptive technology has included compact fluorescent lighting and the first generation of efficient clothes washers (most involving a switch to horizontal-axis technology). In both cases, the dominant U.S. manufacturers did not produce the new technologies and, over time, were forced to abandon their once market-dominant technologies in favor of higher efficiency products. These were not incremental efficiency improvements but complete product redesigns.

Current programs involving disruptive technology include heat pump water heaters and ductless heat pumps. These new space- and water-heating products offer massive efficiency gains. As with incandescent lamps, the dominant U.S. manufacturers have known of the innovative technology for years, but have been resistant to change products in markets where they've held strong positions for decades.

As Figure 6 indicates, it takes disruptive technologies a long time, more than a decade, to gain a significant market share. Incremental changes build up to dominate the market in five to seven years; in that period, disruptive changes achieve just 5-10% of market share.

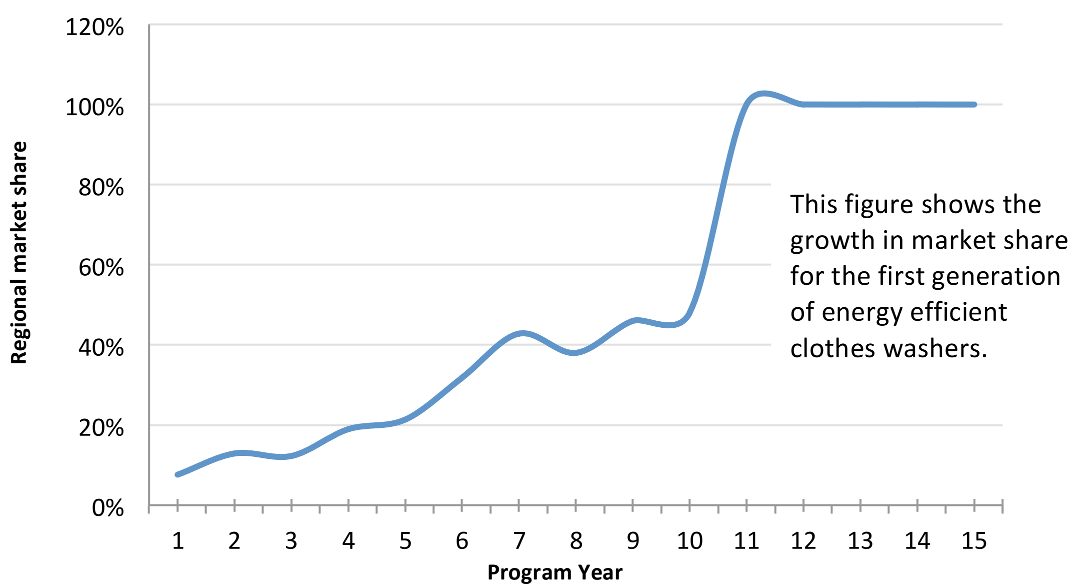
FIGURE 6:
DISRUPTIVE TECHNOLOGY



This figure shows the growth in market share for two types of compact fluorescent lighting and a family of heat pump water heaters, and growing sales of ductless heat pumps (purple line), a truly disruptive technology that can replace electric furnaces, heat pumps, wood, oil or electric baseboards and thus comprise a brand new market. * Ductless heat pump numbers represent percentages of the regional market share of *electrically* heated homes.

Figure 7 shows a complete cycle for the first generation of efficient clothes washers, which was primarily accomplished by bringing disruptive technologies (horizontal-axis washers) prevalent in Europe into the U.S. market place. European models were imported into the U.S. for years, but represented less than 2% of the market until two U.S. manufacturers changed their production lines to manufacture these more efficient machines.

FIGURE 7:
CLOTHES WASHERS (MEF 1.26-1.41)



This clothes washer curve still indicates a more than 10-year cycle of change, but in this case the curve was accelerated by at least two other major factors: a federal standard and modifications making it possible to meet the standard through a package of other efficiency options without adopting the disruptive horizontal-axis technology. The disruptive technology motivated manufacturers to find new efficiency opportunities to compete with the horizontal-axis technology.

CFLs became available in the U.S. about 40 years ago, but the CFL market stalled for years due to poor color rendition, high failure rates and prices of $12 to $24 per lamp. Resolution of technical issues dropped prices below $5 and the involvement of major manufacturers such as GE finally positioned the product for market-transformation success. Quality issues and initial mainstream manufacturer rejection plagued the first generation of HPWHs. European-made clothes washers, while having a bit of success at the high end of the appliance market, were too expensive for mainstream consumers. The entry of U.S. manufacturers brought both respected brand names and lower prices.

Our lengthy market transformation experience with CFLs, clothes washers and early-generation heat pump water heaters indicates that a minimum set of market and/or product conditions must be met before disruptive technologies promoted primarily for their efficiency benefits can expand into the broader consumer market. CFLs and clothes washers began to gain market traction when 1) costs were considered reasonable, 2) quality met consumer expectations and 3) larger/better-known manufacturers and mainstream distribution channels became involved.

> **In summary:**
>
> **Quick-turn markets** such as consumer electronics can transform very rapidly, with efficiency improvements typically reaching market dominance in three to five years.
>
> **Incremental improvements to appliances** are a well-proven strategy typically associated with national appliance standards and Energy Star® branding. These efficiency upgrades typically achieve market dominance in five to seven years.
>
> **Disruptive technologies** that replace existing ones must establish initial product maturity in terms of price, quality and adoption by major

marketers. Even then, achieving substantial market share can take 10 years or more.

Both consumer electronics and appliance upgrades change the market quickly, challenging time frames such as the 7th Plan's five-year action plan. Markets in which innovation has become standard make accurate forecasts even more elusive. Clearly, the region needs new tools for forecasting energy efficiency potential in these areas. By improving existing methodologies or developing new potential assessment methods based on end-use data, planners should assign meaningful cost and risk assessments to emerging technologies.

D. Recommendations

To better assess and accelerate the pace of market change for energy efficiency technologies, the Northwest Power and Conservation Council should:

- Clearly identify advancing technology in the 7th Plan, and provide biennial updates (or at a planning cycle mid-point update) to assess progress and new emerging technology opportunities.
- Explore using market classifications (*quick-turn markets, appliances, disruptive technology*) to determine a methodology for improved supply curve pacing in power plans. NEEA data could be mined further to assign risk profiles for supply pacing assumptions.
- Emphasize and expand support for upstream energy efficiency efforts and market transformation activities.
- Investigate end-use approaches to conservation resource supply curve development. Factoring technology assessments into energy savings opportunity models would facilitate assignment of risk to meeting end-use goals.
- All utilities doing CPAs should consider incorporating these recommendations into their conservation supply curve development.

III. Expanding systems-based methodology

Energy efficiency supply-curve development and cost-effectiveness determinations typically rely on measure-by-measure assessments of energy savings, availability and cost. Increasingly, emerging energy efficiency technologies, particularly in building construction and retrofits, are benefiting from systems approaches that combine various features to achieve maximum energy use reductions.

Current planning methodologies often undercount savings, especially in building efficiency improvements that work synergistically. Residential programs, for example, often consider insulation separately from air conditioning replacement. Planning efforts, including the 7th Plan, have not adequately accounted for additional savings when technologies, operational practices and occupant behaviors are "marbled" together. This leads to underestimating the savings available from design optimization.

Planning efforts built around individual measure supply curves, individual measure cost projections and individual measure cost-effectiveness screening do not lend themselves to a system-based, outcome-oriented approach. Planning methodologies need to incorporate approaches that evaluate performance-based outcomes.

This paper uses zero-energy buildings (ZEBs) to illustrate the systems-based approach, though the lessons apply to all advanced strategies to reduce energy consumption in homes and commercial buildings. ZEBs[6] are the ultimate systems approach, combining state-of-the–shelf technology with careful design and detailed consideration of all energy uses to maximize energy savings.

[6] According to a proposed U.S. Department of Energy definition [docket EERE-2014-BT-BLDG-0050, January 2015], a zero-energy building (ZEB) is: "An energy-efficient building where the actual annual source energy consumption is balanced by on-site renewable energy." This paper uses ZEB to refer to the general concept of zero-energy homes and commercial buildings as well as to ultra-low-energy buildings that reduce energy use like ZEBs, but have no renewables on site.

Zero-energy homes and buildings remain connected to the grid; the goal is to minimize energy use and create enough onsite or community-based renewable energy, typically from solar photovoltaics (PV), to offset their annual energy purchases from the grid. In some cases, the zero-energy approach goes beyond the particular building with its onsite generation to include campuses, communities or portfolios. Building solar beyond single-building scale can be more practical, more efficient and more cost-effective.

ZEBs will be ready for widespread market adoption in the Northwest during the next five-year planning cycle, largely due to massive ongoing PV cost reductions. Allowing shared offsite renewables reduces cost and practical barriers to PV integration. And while buildings are complicated and the design and construction industry fragmented, evidence shows ZEBs are poised to expand in the marketplace. Success depends more on market configuration and strengthening the training for designers and builders than on specific technology advancement.

The Northwest will join this expanding market in the next five years because:

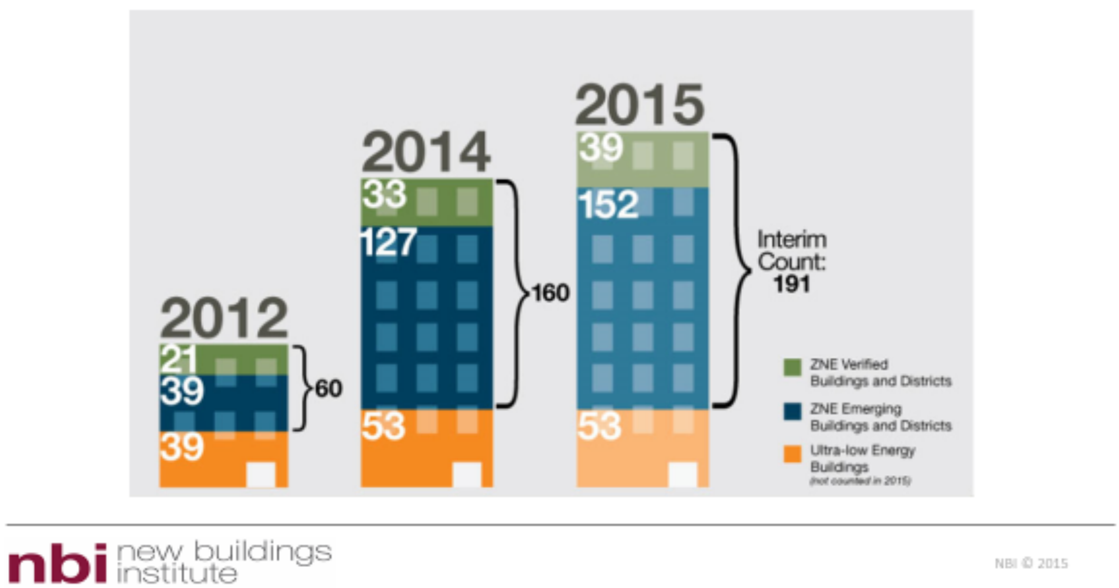
- **ZEBs are technically feasible.** ZEBs are more about careful and comprehensive design/construction than about new technology. While they involve some less-common technologies (ground-source heat pumps, ductless heat pumps, LED lighting, daylighting technologies, more efficient windows, radiant cooling and direct outdoor air systems, for example), all are readily available to the design and construction industry.
- **The design and construction industry can deliver ZEBs.** While the market has been nascent, several firms have designed and constructed a wide variety of building types and designs that meet ZEB definitions throughout the U.S. and Canada.
- **Many ZEBs have been designed and built within normal cost parameters.** The largest identifiable incremental cost – for the PV system – has dropped dramatically in the last few years.
- **ZEBs have policy support. Legislation in Oregon and Washington requires progressively stricter energy codes leading to ZEB or ZEB-ready (without PV) levels of efficiency**. In June 2015 the California Energy Commission unanimously approved residential building energy efficiency standards that will require about 28% less energy for lighting, heating, cooling, ventilation and water heating than 2013 standards required.

- **The Northwest is home to the International Living Futures Institute, the North America-focused New Buildings Institute and the regionally focused integrated design labs** – all unique assets to support a move to ZEBs.
- **The Pacific Coast Collaborative,** a joint effort of the three West Coast governors and the premier of British Columbia, **calls for ZEBs in its policy platform.**

A. ZEB market status

ZEBs are found in all climate zones in the country, including 39 states, as well as in Canada. Today, the ZEB commercial market is very small, with about 200 ZEBs as shown in **Figure 8**.[7] However, the number of ZEBs has tripled in just three years.

FIGURE 8:
NUMBER OF ZERO NET ENERGY BUILDINGS



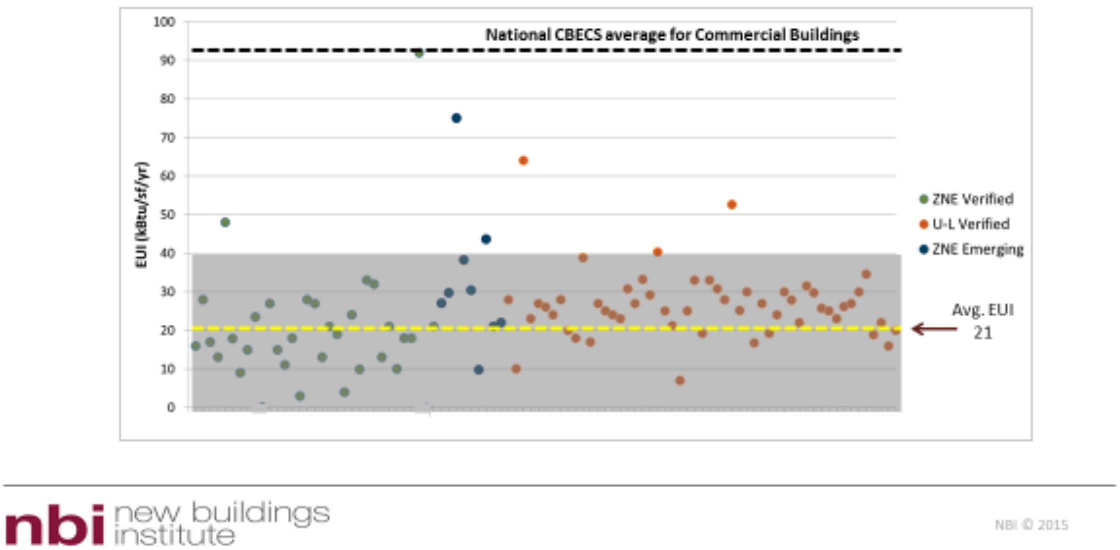
Educational, office and multifamily buildings lead the way, but ZEB status has been pursued for a wide variety of building types including relatively high energy users such as laboratories and health care facilities. Zero-energy systems have been applied to

[7] The Washington state-based New Buildings Institute has tracked the progress of non-residential ZEBs since 2011, and maintains a database of ZEBs across the U.S. and Canada. Source: *"2014 Getting to Zero Status Update," by the New Buildings Institute and related presentations from NBI at its 2015 Getting to Zero national forum.*

increasingly large and complicated buildings over the last few years. Early ZEBs tended to be small offices and uncommon building types as such environmental education buildings; now, more than a third of commercial ZEBs are over 50,000 square feet in size.

The buildings are remarkably efficient. The measured performance of the buildings, before the addition of solar energy, averages about one quarter of the typical energy used in commercial buildings, as indicated in **Figure 9.**

FIGURE 9:
PERFORMANCE RANGE



ZEB construction includes several new energy efficiency measures, primarily those summarized below for commercial properties. But the buildings are more than a sum of these measures. This highlights the critical importance of the resource planning modeling using a systems-based approach to assumed energy efficiency in buildings.

National data on residential ZEBs is limited compared to non-residential buildings. U.S DOE staff informally estimate that 500 to 1,000 single-family ZEBs exist across the nation.

DOE's Zero Energy Ready Home[8] has made an impressive entry into the California housing market. A recent study there identified only 16 ZEB homes but more than 1,000 ZEB-ready and near-ZEB homes in the state. The diversity of builders and locations of ZEB-ready, near-ZEB and actual ZEBs indicate that this type of construction is feasible under different contractor business models and in diverse climates. The largest numbers of ZEB-type homes were built in 2014, constituting about 1% of California's new construction.

SUMMARY OF TECHNOLOGIES

High-performance HVAC systems. Ground-source heat pumps, radiant heating and cooling, chilled beams, energy recovery ventilation, natural ventilation, operable windows, night flush of the thermal mass, demand-controlled ventilation (DCV) through CO2 monitoring, variable volume refrigerant systems with dedicated outside-air systems for ventilation (DOAS), underfloor air distribution, ice storage and evaporative cooling

Advanced lighting and controls. Efficient design with low lighting power density (LPD), daylight photo-sensor controls, occupancy sensors, luminaire-level controls, layered design strategies with task, ambient and common areas, LED task lights, T5 fluorescent lamps, skylights, clerestories

Monitoring and feedback. Wiring for system-level monitoring, energy information and building automation systems, diagnostics, key performance indicator dashboards

Renewables. Photovoltaics on the building or adjacent to the site, solar hot water and some site wind turbines to supplement PVs

Source: "2014 Getting to Zero Status Update" by the New Buildings Institute

DOE's Zero Energy Ready Home[9] has made an impressive entry into the California housing market. A recent study there identified only 16 ZEB homes but more than 1,000 ZEB-ready and near-ZEB homes in the state. The diversity of builders and locations of ZEB-ready, near-ZEB and actual ZEBs indicate that this type of construction is feasible under different contractor business models and in diverse climates. The largest numbers of ZEB-type homes were built in 2014, constituting about 1% of California's new construction market.

While ZEB market development is in an early stage, no technical barriers to widespread deployment exist, unless the ZEB definition requires the solar panels be mounted onsite. Across the country, hundreds of design teams and builders are busy developing ZEBs.

8 http://energy.gov/eere/buildings/zero-energy-ready-home
9 http://energy.gov/eere/buildings/zero-energy-ready-home

B. ZEB costs

From an energy perspective, buildings are a system. Lighting changes affect HVAC needs; a new computer server room requires additional cooling; open and easily accessible staircases reduce elevator use -- and thus direct energy use -- and result in less cooling need.

ZEB cost analysis is complicated by the system aspects and by limited and highly variable data. There are several key elements to understanding ZEB costs. Examining the "incremental" costs typically used to review utility planning and program measure cost effectiveness yields the following conclusions:

- Both residential and commercial ZEBs have been built within standard construction budgets or at the average per-square-foot construction cost.
- Not everything that goes into the design and construction of a ZEB adds costs. For example, many buildings are over-glazed from an energy efficiency perspective. The glazing may make a design statement, but occupants may suffer discomfort from glare and temperature control problems. Cutting back on glazing increases building efficiency while reducing costs. That's a trade-off clients or designers can make to achieve deep energy efficiency.
- The integrated design process that drives ZEB design can, for example, reduce the size of needed HVAC equipment while offering a new menu of equipment types and changes to how heating and cooling serve the entire building. A well-insulated building needs less energy to maintain comfort, and less equipment to deliver and distribute the energy around the building.
- Adding a PV array to the building is a clear incremental cost, but two additional dynamics are currently at work:
- Installed PV costs continue to drop, which complicates use of historic data.
- Customers may choose to buy into community systems, either paying an agreed-upon amount for future kilowatt-hour consumption or buying shares of capacity over time, essentially prepaying all or part of their energy bills.

Commercial ZEBs can and sometimes do cost more, but their costs likely fall within the typical ranges for similar building types. Figures 10 and 11 show the overall construction costs from a national review of two types of non-residential buildings that included high-performance buildings. Buildings were designated as *control* (no green rating used), *green* (some level of green building recognition), *platinum* (LEED Platinum, the highest rating) or NZB (net zero-energy buildings)/Living Buildings (a minimum of zero-net energy measured performance, plus additional green features).

Figures 10 and 11 look at individual low-rise office buildings and individual community centers (horizontal axes) built according to four design types, ranging from those with no "green" features to zero-energy buildings with additional green features. Clearly, the square-footage costs (vertical axes) vary significantly regardless of design type.

FIGURE 10:
LOW-RISE OFFICE BUILDING

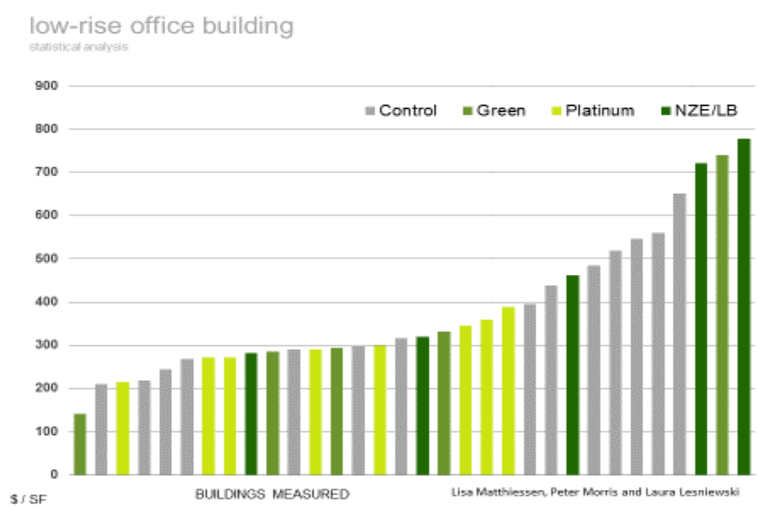
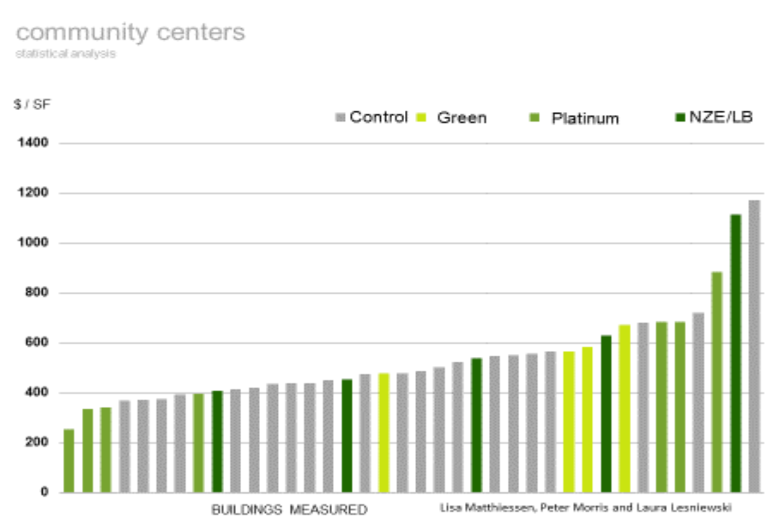


FIGURE 11:
COMMUNITY CENTERS



A 2012 study[10] commissioned by Pacific Gas and Electric (PG&E) finds similar costs for commercial ZEBs. The study finds significant cost variability for both code-compliant and high-performance commercial buildings and notes that "it is possible to construct ZNE commercial buildings at little or no incremental cost."

Cost estimates for residential ZEBs tend to include higher incremental costs, since certain customer expectations limit the tradeoffs builders can make (although HVAC design modification is one cost-reduction strategy). The most recent cost estimates come from a California market study by TRC Energy Services in which high-performance builders were asked to estimate the incremental cost of building a 2,500-square-foot ZEB home compared to a code-built home. Eleven of the builders interviewed provided incremental cost estimates, and their responses ranged from 5% to 15% -- $15,000 to $50,000.[11]

The 2012 PG&E-commissioned study, based on a wide variety of case studies, notes that, "[r]esidential buildings, which generally have a lower potential for 'cost tradeoffs' common to high performance commercial buildings, are estimated to have incremental energy efficiency mortgage (EEM) costs on the order of $2-$8 per square foot for a package of conventional EEMs, with current PV costs on the order of $4.50/ft2."

Updating these figures with reduced PV costs and applying them to a 2,500-square-foot house yields current incremental cost estimates of $13,750 to $29,750 (5% to 10% on a $300,000 new home), likely a more accurate range than in the TRC study.

While currently residential zero energy is not cost effective on a building-by-building basis, ultra-low energy homes (without onsite solar) may be. Including community-scale solar PV in major residential developments can capture scale-related cost reductions and create additional benefits in terms of location efficiency that leads to higher solar generation.

C. Toward a new planning paradigm

Though still quite early in their market development, zero-energy buildings should start coming to scale in the Northwest in the next five years. Utility planners – including the Northwest Power and Conservation Council – and regulators should evaluate whether

[10] *California Zero Net Energy Buildings Cost Study,* prepared by Davis Energy Group.

[11] TRC Energy Services Inc., "Residential ZNE Market Characterization - Final Report," CALMAC Study ID PGE0351.01, February 2015

measure-by-measure approaches to building supply curves, and related cost-effectiveness tests, are capable of evaluating advanced building systems. Our study suggests such approaches underestimate actual savings potential. If so, planners must develop new supply curve methodologies that acknowledge performance-based outcomes.

ZEB buildings are technically feasible. The primary hurdle for commercial ZEBs is consumer and professional education (marketing), not cost. Instead of restricting achievable energy efficiency projections to 85% of the technical potential, planners should push the region's utilities to emulate the country's best market-transformation programs, to focus on behaviors and to engage consumers.

Barriers to ZEB adoption can and should be addressed programmatically. Energy code laws in Oregon and Washington are pushing for ZEB or near-ZEB levels of construction by 2030. Given existing state policy pushes for ZEBs, energy efficiency planning efforts should better align program efforts with policy goals.

In addition:

- Regional planning approaches, state utility commissions and utility programs should support the market to innovate in overall energy performance and integrated design, rather than focus on discrete technologies, in order to demonstrate the most cost-effective approaches to building efficiency. This may require new approaches to resource cost tests that focus less on individual measures and more on performance-based outcomes.

- The 7th Plan should include a comprehensive approach to advancing zero-energy residential and commercial buildings in its five-year action plan recommendations. Cost-effective deployment of ZEBs is realistic, but further development is needed to demonstrate the best approaches and to educate the market. The strategy should include exploration of ZEB manufactured housing, based on previous Northwest program success.

- The Council should investigate end-use approaches to conservation measures' supply curve development. How much energy efficiency would widespread adoption of ZEB principles provide? Energy savings opportunities could be modeled in combination with technology assessment to assign appropriate levels of risk in reaching end-use efficiency goals.

IV. Conclusion

Power planning approaches used throughout the region – including those informing the 7th Northwest Power and Conservation Plan – fall short when it comes to forecasting savings from emerging energy efficiency technologies. The historical record and our analysis of the pace of transformation in consumer electronics, appliance upgrades and new, disruptive efficiency technologies show this to be true.

Current approaches also overlook the additional savings from synergies among multiple efficiency measures and from systemic design optimization, which incorporates both operations and user behavior. The building design and construction market vividly illustrates the divide between conservative planning assumptions and what's being achieved "on the ground."

By recognizing and working to overcome methodological inadequacies, better identifying primary barriers to progress, and placing more emphasis on operations and user behavior, individual utility and regional planners can better predict and motivate future savings. That will avoid building unneeded generation whose extra costs increase consumers' bills.