Non-Programmatic Savings from Appliance Standards

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Prepared for

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First… A Treatise on Savings Terminology

The list of culprits is long and mercurial: *annual, claimable, incremental, first-year, one-time, cumulative, non-programmatic, programmatic, standards-induced, naturally occurring, in-the-baseline, baseline-adjusted*, etc. The first 20 pages of this report would prove an inadequate space for the definitions of all the different types and categories of "energy savings" used in the Northwest and in the industry at large. The jargon is often necessary for making distinctions among how savings are calculated, or how they are aggregated over time, or how they are adjusted for attribution and baseline issues. However, the nomenclature can render the uninitiated reader utterly nonplussed, downright angry (*why don't the values in second row sum to that column in the bar chart?!?!*), or worse – skeptical. Meanwhile, the initiated may apply their own understanding to the same terms and embark unawares of what we really mean to say.

To avoid a confused and potentially hostile readership, we define and discuss a few key terms. We use these terms—and only these—to define the savings we report herein.

Energy savings. All reported savings in this report reflect the energy savings achieved by an above-baseline measure *in the first year following its installation*. This understanding is often referred to as "first-year" savings. Even though the measure continues to save energy throughout its life relative to the baseline, only the kilowatt-hour savings that accrue in the first year are reported for that measure. Those savings are assumed to occur in perpetuity. Furthermore, any time we report savings for more than one year, those savings reflect the simple addition of year-by-year first-year savings. This meaning is consistent with how the Bonneville Power Administration, the Northwest Power and Conservation Council (NWPCC or the "Council"), and the Northwest region calculate and report savings toward the Sixth Power Plan's target.

The reason for the detailed explanation here is that this meaning is *not* consistent how the U.S. Department of Energy (DOE) estimates and reports savings from its standards rulemakings, which are central to this project. DOE's reported savings include all savings from an above-baseline unit throughout the life of that unit, as well as its replacement, and its replacement's replacement, and so on, over some finite analysis period (typically 30 years). This accounting method is appropriate when viewed from the standpoint of assessing a standard's cost effectiveness to the consumer or accounting for carbon abatement. It is unnecessary for analyses aimed at quantifying the power resource provided by energy efficiency.

Non-programmatic savings (NPS). NPS is an umbrella term meant to capture all savings that occur in the market, relative to an NWPCC plan baseline, but which are *not* achieved through programmatic activity. While NPS have many drivers, including standards, what is most important to understand about NPS is the following:

1. NPS *exclude* savings achieved through programs.
2. NPS must be above an NWPCC plan baseline.
3. NPSs are *real* savings. Consider the fact that at least *some* above-baseline widgets or measures occur outside of programs. In fact, significant shares of above-baseline sales are not run through programs in some markets. Yet those non-rebated widgets achieve savings just the same—same unit, same baseline, and, ultimately, the same resource. That is why the Council is indifferent to how the target is achieved (and why NPS count toward the target).
4. NPS estimation has the following two key challenges:
    a. Data availability. While programs typically have data on the number of units sold or jobs performed, NPS quantification often requires a broader set of market-level data (in order to assess what occurred outside of programs). Market research is paramount.
    b. Risk of double-counting or undercounting. One cannot simply estimate total market savings—again, relative to an NWPCC plan baseline—and then subtract out programmatic savings. First, program baselines do not always align with NWPCC plans. Second, Northwest Energy Efficiency Alliance (NEEA) initiatives drive savings that must be reconciled with NPS estimates.

Standards-driven savings. These are energy savings achieved in the region because of national minimum efficiency standards, as modeled in this analysis.

The relationship between non-programmatic savings and standards-driven savings. Given the above definition of standards-driven savings, it is tempting to think that because these savings are not achieved through programs, they must be non-programmatic savings. In reality, however, some savings are and some are not. This is because the standard may have been assumed in an NWPCC plan baseline (recall that to count as NPS, the savings must be above an NWPCC plan baseline). If, for example, the Council knows a DOE standard will take effect in the first year of an NWPCC plan period, then it would likely make the new standard the baseline for that plan. Therefore, in this instance, the new standard cannot drive any non-programmatic savings: the standard is not above the plan baseline.

Thus, the savings impact of a hypothetical DOE standard would be captured in *neither* the claimable programmatic savings nor the claimable non-programmatic savings. Does that mean the DOE standard caused no savings, no resource for the region? No. The savings from the standards are simply already "in the baseline" of the new plan. The standards-driven savings are quite real (and, as you see in this report, quite substantial); they simply are not claimable toward the target in this case. Conversely, if a standard takes effect that the Council did *not* assume in a plan, then the savings from the standard would be counted as non-programmatic savings because the standard generates savings above the plan baseline— and these savings are just as "real" as they are when included in the baseline. The planners' choice of where to draw a plan baseline has no bearing on the actual impact of the resource provided by the standard to the region.

One-time baseline adjustment. The one-time baseline adjustments were made to reconcile the available potential in the Sixth Power Plan forecast to what the team modeled as being actually available with the benefit of hindsight. The project conducted extensive data collection for each of the modeled products, providing the team with historical data that was unavailable to the NWPCC when it developed its forecast. New data from NEEA's Residential Building Stock Assessment, for example, provided updated operating hour and duty cycle information for a number of end-uses. The new data led to different baseline unit energy consumption in the new models compared to the Sixth Power Plan—even if the same efficiency metric was used as the baseline in each model. Similarly, new shipment data provided a different picture of the market size and mix for some products. The one-time baseline adjustments represent the difference in potential when modeled with the new data. The adjustment value is given in average megawatts and can be either positive or negative, depending on whether the actual potential was less than or greater than the Sixth Power Plan forecast value.

Abbreviations and Acronyms

aMW – Average megawatts

AHAM – Association of Home Appliance Manufacturers

ASAP – Appliance Standards Awareness Project

BPA – Bonneville Power Administration

CAC – Central air-conditioning

CBSA – Commercial Building Stock Assessment

CFL – Compact fluorescent lamp

CFLK – Ceiling fan lighting kit

CFR – Code of Federal Regulations

CSIQ – Codes and Standards Impact Quantification

DHW – Domestic hot water

DOE – U.S. Department of Energy

EF – Energy Factor

EIA – U.S. Energy Information Administration

EISA – Energy Independence and Security Act

EPACT – Energy Policy Act

EPS – External power supply

EUI – Energy use intensity

EUL – Effective Useful Life

HID – High-intensity discharge

HVAC – Heating, ventilation, and air-conditioning

LED – Light-emitting diode

LFL – Linear fluorescent lighting

NAECA – National Appliance Energy Conservation Act

NEEA – Northwest Energy Efficiency Alliance

NIA – National impact analysis

NPS – Non-programmatic savings

NWPCC – Northwest Power and Conservation Council

PTAC/HP – Packaged terminal air-conditioning/heat pump

RBSA – Residential Building Stock Assessment

RTF – Regional Technical Forum

TSD – Technical support document

UEC – Unit Energy Consumption

UES – Unit Energy Savings

WICF – Walk-in coolers and freezers

Executive Summary

A major dynamic is changing the way energy efficiency and resource planners view efficiency acquisition. Dozens of new federal mandatory efficiency standards have already or will soon require compliance, effectively removing from the market the most inefficient products across all end-uses and sectors. The steady flow of new standards has already achieved significant savings for the Northwest region and altered the landscape for demand-side management policy and strategy. For Navigant Consulting, Inc. (Navigant), the major objective of this research was to measure the magnitude of these standards-driven savings in the Northwest and leave a foundation of data and analysis tools to enable strategic planning for future resource acquisition.

More specifically, this project had three goals:

1. Estimate the total energy resource provided by 30 mandatory federal appliance standards through 2034;
2. Track the non-programmatic savings[1] toward the Bonneville Power Administration's (BPA's) energy efficiency Sixth Power Plan achievements; and
3. Build a data resource and modeling structure for future updates, which would be useful to a variety of future regional efficiency efforts.

The project team conducted extensive secondary data collection to build product-specific stock-turnover models for 30 products, based on the best available energy and market data.[2] Consistent stakeholder engagement, and review with the Northwest Power and Conservation Council (NWPCC or the "Council") in particular, helped align the data, assumptions, and models with the region's Fifth and Sixth Power Plans. With this collaboration, the project team built 15 spreadsheet models covering 30 products, each capable of comparing scenarios with and without the new standards in order to estimate the standards' energy savings impact relative to the Plans' assumptions from 2005 to 2034.

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[1] Non-programmatic savings are achieved through codes and standards, shifts in the baseline relative to the Northwest Power and Conservation Council's (NWPCC's or "the Council's") planning assumptions, and general non-incented market trends toward more efficient products. Consequently, regional savings from the U.S. Department of Energy (DOE) federal appliance standards are considered non-programmatic savings that count towards the Bonneville Power Administration's (BPA's) conservation commitment, as long as the given standard was not accounted for by the Council in the Sixth Power Plan baseline.

[2] A stock-turnover model is a spreadsheet (in this case) that tracks the year-by-year installed base of a given appliance in a given area (i.e., stock) by modeling the annual retirements out of, and installations into, that stock in each year. The model also tracks the energy usage characteristics of each vintage of installations, enabling comparison of different future end-use consumption forecasts based on the different assumptions for stock growth and efficiency changes.

Key Insights

Both the modeling and the data collection activity yielded several key insights:

The efficiency resource from standards is extremely large. For example, savings from products such as refrigerators and freezers, residential clothes washers, water heaters, and dishwashers are estimated to total 120 average megawatts (aMW) during the 2016-2020 period. Despite their likely inclusion in the Seventh Power Plan baseline (because these standards are already "on the books"), the resource achieved by these standards is real, large, and significantly alters the planning horizon.

Distribution transformer standards are driving significant non-programmatic savings. Distribution transformers account for substantial energy consumption in the commercial and industrial sectors. The U.S. Department of Energy (DOE) and Congress have promulgated standards on all major types of distribution transformers in recent years. These standards have recently gone into effect and substantially increase the efficiency of the new installations relative to the existing stock, in part because of the transformers' very long life.

The lighting market should be viewed as a cohesive whole and light-emitting diodes (LEDs) appear poised to take off on their own. The team elected to model the impact of standards on lighting technologies by modeling the entire lighting market as a single aggregate. This was done for two reasons. First, the substitutability and competition among products in the lighting market increases the likelihood that a standard on one product will influence the sales of another (e.g., incandescent and compact fluorescent lamps). Therefore, modeling just one individual product would miss the impacts on others. Second, LEDs hold the potential to affect all other technologies and applications should their costs continue to decrease and performance continue to improve. Therefore, it was necessary to consider in our forecasts the impact of LED sales on the savings from each standard and also the total impact on the end-use itself. The model predicts LED sales will account for 20.1 percent of all regional lumen-hours[2] sold by 2020 and 45.2 percent by 2030. When looking at only the new fixture market, LED penetration is estimated to be 35.4 percent and 69.6 percent. This model can serve as a valuable tool in resource planning amid this rapid change.

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[2] As more-efficient technologies, such as LEDs, enter the market, watts become an increasingly poor measure of market share. Therefore, we use the term "lumen-hours," both in this report and in the model, to denote the service performed by lighting technologies.

Better data is needed to estimate and track the impacts of standards. The thorough data collection effort—enhanced by stakeholder involvement and idea sharing—uncovered several important data gaps that cause uncertainty in the results of some models. The most pressing examples include the dearth of data on end-user operating use, duty cycles, and load profiles; standard compliance rates of new walk-in coolers and freezers; and sales data on most commercial equipment.

Results

Before discussing the high-level results, to avoid confusion, it is worth defining what we mean by "savings," because energy savings are often expressed differently. Unless otherwise stated, the savings expressed herein refer to incremental savings in each year, sometimes referred to as "first-year savings," consistent with how savings are typically discussed by the Council, BPA, and other regional stakeholders. The assumption is that the savings from an above-baseline measure occur in perpetuity, while only the savings that occur in the "first year" count toward the target. This is different from how DOE reports savings from its rulemakings.[3]

BPA's share of standards-driven non-programmatic savings from 2010 to 2015 are 14.5 aMW in the residential sector and 20.85 aMW in the commercial sector, excluding lighting products.

Navigant also calculated "one-time baseline adjustments" for each product to account for the difference between the Sixth Power Plan baseline and that of the model, which had the benefit of retrospectively using data unavailable to the developers of the Sixth Power Plan forecast. The "one-time baseline adjustments" reconciled the available potential in the forecast to what was determined in hindsight to be actually available, leading to adjustments that were either positive (when the actual potential was less than forecasted) or negative (when the actual potential was greater than forecasted) adjustments. These baseline adjustments total 17.4 aMW and 1.2 aMW in the residential and commercial sectors, respectively. All reported savings have been adjusted for line losses.[4]

Table ES-1. Summary of BPA Residential and Commercial Standards Savings for 2010-2015

	2010	2011	2012	2013	2014	2015	Total
Residential	0.53	0.55	0.56	0.77	0.5	11.54	14.45
Commercial	3.38	3.40	3.32	3.54	3.59	3.62	20.85
Total	**3.91**	**3.95**	**3.88**	**4.31**	**4.09**	**15.25**	**35.39**

[3] See Section 1 for a full description of the difference between how savings are reported by DOE and in this report.

[4] Busbar factor = 1.09056

NEEA reports savings for residential dishwashers and clothes washers. Navigant subtracted the first-year savings from these two products from BPA's claimable savings. The deduction amounts to 0.61 aMW from 2010-2015.

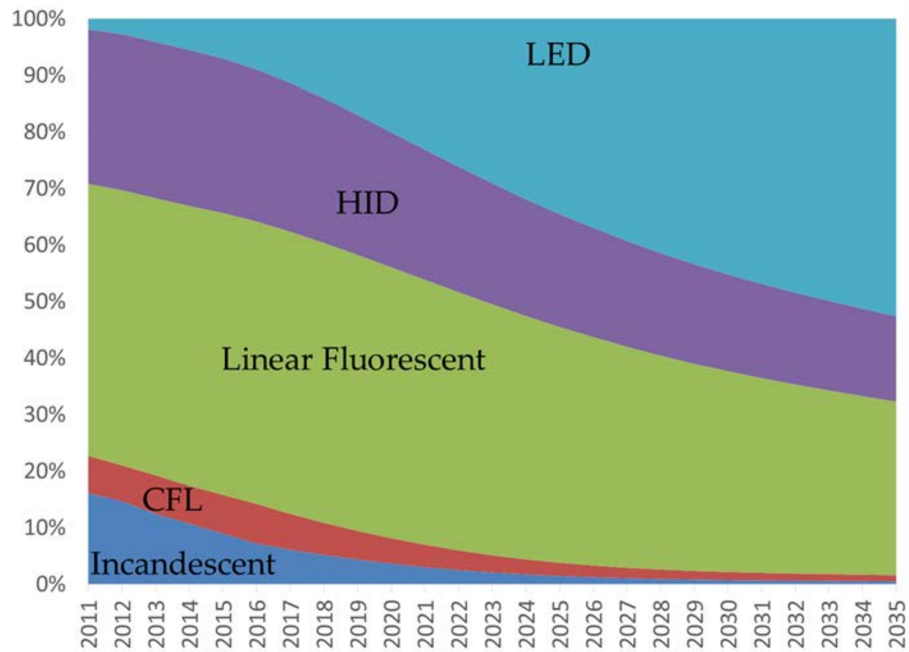
Table ES-2. BPA Residential and Commercial Claimable Savings after Adjustments for 2010-2015

	Non-Programmatic	Baseline Adjustment	Total
Residential	14.45	17.4	31.85
Commercial	20.85	1.21	22.06
Total	35.3	18.6	53.91
Less Reported by NEEA	0.61	0	0.61
Total Remaining Claimable	**34.69**	**18.6**	**53.3**

As discussed previously, the team modeled the standards' impact on lighting products together in a single model. Throughout this report, we report results from lighting separately from the other residential and commercial sector results for a few reasons. Both BPA and the Northwest Energy Efficiency Alliance (NEEA) track the lighting market and both have reported non-programmatic savings, which include standards-driven savings, in separate reports. The lighting model's estimated savings, BPA's share of which totaled 33.9aMW across all sectors in the Sixth Power Plan period, are not meant to be additive to the totals reported separately by BPA and NEEA, though the total illustrates the substantial impact of standards on the market.

The striking outcome of the lighting analysis was not just the magnitude of the savings from standards, but the overall long-term savings driven by the modeled penetration of LEDs. The lighting model has an econometric diffusion component that "competes" technologies against one another based on their relative first costs and lifetime operating costs. The primary unit of analysis is "lumen-hours," the service performed by lamps. That is, lighting technologies provide light, measured in lumens, over some period, measured in hours. Lumen-hour demand is created when lamps burnout, are retrofitted, or new space is constructed. By tracking these events across all major technology categories and sub-types, and assuming lighting density (lumens per square foot) remains constant over time, the model computes the lumen-hour demand that must be serviced each year. It then allocates market share to the various technologies based on the application, applicable standards, and economics of each technology relative to those it competes with in typical applications (e.g., medium screw base or linear fluorescent applications). Because of the projected decline in LED prices and increase in their efficacy,[5] LED shipments increase dramatically over time as they become relatively more economically compelling and more diffused. Figure ES-1 illustrates the penetration of LEDs over time. The model does not account for any incentives paid by utilities or other energy efficiency organizations.

Figure ES-1. Forecast of Lumen-Hour Shipments by Technology Type



It is worth noting that the forecast shown in Figure ES-1 includes *all* lamp shipments, including replacement lamps on existing ballasts (i.e., on high-intensity discharge [HID] and linear fluorescent lighting [LFL] fixtures). The penetration of LED into the new fixture market (renovation, new construction, and those situations where the entire system is replaced) is projected to be dramatically higher than shown in the chart above. For example, the forecasted penetration of LEDs in terms of lumen-hour sales across all sectors in 2020 is 20.1 percent, but in the new fixture market it is 35.4 percent. Section 3.5 discusses this comparison of LED penetration in more detail.

[5] LED price and performance projections are sourced from DOE's Solid State Lighting Multi-Year Program Plan. Available here: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2013_web.pdf

Introduction and Purpose

The Northwest Power and Conservation Council (NWPCC or the "Council") establishes regional energy conservation targets every five years. In 2009, when the Council established a target of 1,200 average megawatts (aMW) for the 2010-2015 "Sixth Power Plan" timeframe, Bonneville Power Administration (BPA) committed to achieving the public power portion of that resource target—approximately 504 aMW. The Council is indifferent to how those savings are achieved, whether through utility programs and incentives, codes and standards, or other means of market transformation. Consistent with that philosophy, BPA's strategy for achieving its substantial share of the target includes the acquisition of two types of savings: programmatic (those savings BPA directly pays for) and non-programmatic (all non-incented savings).

Codes and standards are a significant source of non-programmatic energy savings in the Northwest, and since 1980, an estimated 40 percent of conservation energy savings in the region have come from codes and standards. In the years preceding and during the Sixth Power Plan, the U.S. Department of Energy (DOE) and Congress were particularly active in establishing new or higher efficiency standards, creating the possibility of substantial standards-driven non-programmatic savings in the region. To estimate the regional impact, BPA contracted Navigant Consulting, Inc. (Navigant) to conduct an analysis of many DOE standards on important residential appliances and commercial equipment.

The overarching standards impact analysis methodology—coined the Codes and Standards Impact Quantification (CSIQ) Process—was developed by Navigant in 2011.[6] The methodology envisioned the construction of product-specific stock-turnover models that would be built using the best available energy and market data in the region and nation. These models will be used to:

- Retrospectively estimate non-programmatic savings due to standards;
- Serve as a transparent tool for multiple parties to inform future regional efficiency efforts; and
- Provide custom standards impact assessments integrating current regional efforts and existing data sources.

For this project, Navigant analyzed 30 different products in accordance with the CSIQ methodology, which itself was modeled on DOE's National Impact Analyses (NIAs)—complex stock-turnover models

[6] See the report, "Methodology for Quantifying the Savings from Codes and Standards," available here: http://www.bpa.gov/energy/n/reports/evaluation/multi_sector/pdf/BPA_Codes_Standards_Approach_Final.pdf

built during each DOE appliance standards rulemaking to estimate the savings from potential standards. For most products, the team built independent spreadsheet models for each product. However, due to the high interactivity of many lighting products, the team elected to analyze most lighting products in a single model to better simulate how they compete in the real-world marketplace.

Methodology

The objective of this project was to analyze the impact of standards that took effect during the Fifth and Sixth Power Plan timeframe (2005-2015) over a 30-year analysis period. This section describes the analyses' methodology, which was executed over three phases:

1. Screening standards for the analysis
2. Data collection and analysis
3. Stock modeling and savings estimation

In addition to estimating the energy savings impact of appliance standards, the standards impact analysis workbooks aim to serve as a resource for future regional analyses in the Northwest. With this in mind, extensive stakeholder input, data sharing, and review guided the team's analytical judgments and methodological decisions during each phase of the analysis.

Screening Process

As a first step in the screening process, Navigant identified all federal, Oregon, and Washington appliance and equipment standards that went into effect between 2005 and 2015. In all, the team identified 47 standards on energy-using consumer products and commercial equipment[7] that would affect the residential and commercial sectors.

Due to budget constraints, the project scope called for only 30 of the 47 products to be directly analyzed. Therefore, the team evaluated which 30 of the 47 products would provide most value for BPA and the region, if analyzed directly. BPA, the Council, and the Northwest Energy Efficiency Alliance (NEEA) offered guidance on the screening criteria for selecting the final 30 products, and ultimately, considerations included three key factors:

1. **Magnitude of potential savings**. The team assessed the potential of regional savings from the product standards by reviewing the following:
    - The relative amount of energy consumption the regulated product represented in the region
    - The relative reduction in energy use driven by the standard

[7] The terms "consumer product" and "commercial equipment" have specific regulatory meaning in the context of DOE's Appliance Standards Program. For simplicity, in this report, we will use the term "product" to mean the regulated device, regardless of the sector in which it is used predominantly.

- Whether the standard was included in the Sixth Power Plan baseline (in which case no non-programmatic savings would be possible)
- Whether the regulated product was analyzed by the Council in the Sixth Power Plan at all

2. **Value of data and analysis on each product to regional conservation efforts**. Despite the fact that non-programmatic savings from some product standards were known to be zero or minimal, as the standard was already included in the Sixth Power Plan baseline, new and improved data and analysis could provide a valuable foundation upon which future conservation efforts and analyses could be built.

3. **Potential for interaction among certain products**. Certain regulated products would have to be analyzed together because of the potential for standards (or natural trends) on one product to affect the products with which it competes. This phenomenon is common for lighting products, for example.

Table 1 displays the final products selected for analysis. Refer to Appendix B for the full list of standards that went into effect (or will go into effect) between 2005 and 2015.

Table 1. Products Selected for Analysis

Sector	Products
Residential	• Residential Dishwashers • Residential Clothes Washers • External Power Supplies • Residential Refrigerators • Residential Freezers • Residential Water Heaters • Residential Heat Pumps • Torchieres • Ceiling Fan Light Kits
Commercial/Industrial	• Walk-In Coolers and Freezers • Commercial Refrigeration Equipment • Commercial Clothes Washers • Pre-Rinse Spray Valves • Commercial CAC and Heat Pumps • Packaged Terminal AC and HP • Illuminated Exit Signs • Electric Motors • Distribution Transformers
Lighting	• Metal Halide Lamp Fixtures • Mercury Vapor Lamp Ballasts • Fluorescent Lamp Ballasts • General Service Fluorescent Lamps • General Service Incandescent Lamps • Incandescent Reflector Lamps • Candelabra & Intermediate Base Incandescent Lamps • Medium Base Compact Fluorescent Lamps • High-Intensity Discharge Lamps

Data Collection and Sources

Models are only as good as inputs that drive them. Therefore, before building any of the stock-turnover spreadsheet models, the team dedicated a substantial portion of the project to secondary data collection. Critical data included the timing and nature of each efficiency standard—which is typically more complex than is often appreciated in that a single "DOE standard" can affect many different categories of the regulated product differently and at different times. For example, the standard for "walk-in coolers and freezers" is actually a set of standards on three separate products: the door, the panels, and the refrigeration system. Each of those three product categories is further broken down into a number of product classes, which each individually have their own standard level. Product operating profiles, market data, Fifth and Sixth Power Plan assumptions, and regional housing and floor space data were also necessary for the analysis. In general, the data inputs can be categorized into three groups:

1. **Market data**. This data describes the count, type, and efficiency of the products in both the installed stock and current sales of a given product, including the following, for example:
    a. Product saturation levels (existing stock) and current shipment levels (flows)
    b. The distribution of product types or "classes" within a given product—product classes are often delineated by capacity bins (e.g., >55 gallon or <55 gallon for residential electric water heaters), types (e.g., four-foot lamps vs. eight-foot lamps), or some feature that provides utility to the consumer and affects energy consumption (e.g., side-by-side refrigerators versus top-mounted refrigerators)
    c. The efficiency distributions within each product class (e.g., what share of the current sales was *already* at the new standard level when the standard became effective?)

2. **Usage data**. These data describe the annual unit energy consumption of each product class and includes:
    a. Baseline and standard efficiency levels; and
    b. Usage and duty cycle information, including operating hours and loads per year, etc.

3. **Stock model data**. These data and assumptions generate the number of units in the region's installed stock, as well as the number being retired and installed each year. These data include:
    a. Regional historical and forecast housing, commercial floor space, and electrical sales data;
    b. Product lifetime—in most cases, the product's effective useful life (EUL) was used to model the annual retirement (i.e., turnover) of a fraction of the installed stock each year; and
    c. Standards' effective dates.

To collect these data, Navigant conducted a regional and national data assessment for each chosen product. While best data sources varied by product, the key regional and national data sources were:

1. **Regional Data**: Sixth Power Plan forecast and supply curves, Regional Technical Forum (RTF) Unit Energy Savings (UES) measure workbooks, Residential Building Stock Assessment (RBSA), Commercial Building Stock Assessment (CBSA), and NEEA market reports.

2. **National Data**: DOE NIAs, U.S. Energy Information Administration (EIA), Appliance Standards Awareness Project (ASAP), DOE Technical Support Documents (TSDs) and underlying data, and Association of Home Appliance Manufacturers (AHAM).

All other things being equal between national and regional sources, regional data was clearly the preferred source for model inputs. Of course, everything else was never equal as sources varied in timeliness, comprehensiveness, validity, etc. The team relied heavily on the project's stakeholders to evaluate which data source to use, particularly whenever both national and regional data were available. Typically, when regional data was available, the team used it in the models. When it was not, the team assumed national data—adjusted as necessary for parameters such as floor space or population—was representative of the Northwest.

The team developed product-by-product "data forms," which maintained key data input values (e.g., baseline, lifetime, duty cycles, etc.) and their sources. These forms facilitated the comparison of national versus regional sources. The team presented the data forms on a series of stakeholder webinars to recommend and discuss the merits of one source (e.g., a three-year old DOE NIA assumption) versus another (e.g., a regional study with limited sample size). Often, this exercise sparked someone's memory of another data source that had not yet been identified. Each product's data form can be found in Appendix C and includes the rationale for selecting one source over another, when applicable.

Modeling

The goal of the project, again, was to model the regional savings impact through 2034 of recent or imminent DOE efficiency standards. Just as DOE does to forecast the impact of its own standards, the team built spreadsheet *stock-turnover models* for each product (with the exception of lighting products, discussed below) to assess the savings impact of each standard on the region.

By way of background, a stock-turnover model (an Excel spreadsheet in this example) tracks the year-by-year installed base of a given appliance in a given area (e.g., we estimate there are 7.6 million residential refrigerators in the Northwest in 2014, and that the total will grow to 10.1 million by 2034). The team does this by modeling annual retirements (which then flow out of stock) and annual new installations (which flow into it). Equipment failure drives annual retirements, which are a function of the product's lifetime and the installed stock. New installations, on the other hand, reflect replacements for those retired units, as well as new units shipped for new construction growth. The model also tracks the energy usage characteristics of each vintage (a cohort of units installed in a given year) over time. This tracking enables a comparison of different end-use consumption forecasts based on different assumptions for stock growth and efficiency changes, as well as other variables.

Product Substitution

As mentioned above, the team built separate product-specific stock-turnover models for each product. In other words, the standard impact on one product was assumed independent of the impacts of most other standards.

The exception was standards on lighting products, which were modeled together in a single, more complex model. A high degree of product switching and substitutability characterizes the market for most lighting applications. That is, different lighting technologies “compete” (e.g., incandescent lamps versus compact fluorescent lamps [CFLs]) to serve many common applications. When standards increase the relative price of one or more competing technologies, consumers may shift from one technology to another—an effect that would go unaccounted for if each technology was modeled independently. A second reason for modeling all lighting products together was the rapid change in LED technology. The expectation that the price and performance of LEDs will continue to improve is well accepted. This development will likely lead to natural LED market penetration, which will reduce the available market for traditional products. Thus, we need to account for this penetration to prevent overestimating savings from standards on other traditional technologies, which, if not for LEDs, would have higher energy savings potential in aggregate.

Because of this substantial difference in approach, we largely separate our discussion of product-specific model methodology from that of the lighting model. Section 2.3.3 discusses the methodology for estimating savings from the independent product-specific spreadsheet models and section 2.3.4 discusses the more complex lighting model’s methodology.

Scenarios Analyzed

The quantification of the non-programmatic savings due to standards was one of the primary goals of this analysis. Recall that non-programmatic savings (which can be driven by standards) must be above the relevant Plan baseline. Therefore, the team modeled a scenario, coined the “Pre-Case,” which was intended to represent the Sixth Power Plan’s baseline assumptions. Therefore, against this scenario, non-programmatic savings could be calculated. As discussed previously, tremendous collaboration with the architects of the Sixth Power Plan was required in order to align the Sixth Power Plan assumptions with those in the models’ Pre-Case. It is important to note that if the Council was aware while developing the plan that a standard was scheduled to take effect during the Sixth Power Plan, the Council included that standard in the Plan baseline (effectively reducing the target because it would be captured with or without regional action). For this reason, the Pre-Case scenario for some products includes the DOE standards of interest. In addition, because non-programmatic savings must be above the Plan baselines, no non-programmatic savings from such standards existed.

The team modeled a second scenario for comparison, a "Post-Case," which included the products' standard(s) that took effect or will take effect during the analysis period (2005 to 2034).

Model Components

In essence, the team developed two integrated modules for each product model to develop each product's energy consumption forecast.

1. **Unit energy consumption (UEC) module.** The UEC module calculates the product's average unit energy consumption at various efficiency levels and operating conditions.
2. **Stock-turnover module.** The stock-turnover module tracks the quantity of units installed in the region at any one time (i.e., the stock) throughout the analysis period. It also projects the annual retirements and new installations that flow out of and into the stock each year. This module tracks the vintage of the units in the stock, which, depending on their age, may have different UEC profiles.

The following two sections describe each module in detail.

Unit Energy Consumption Module

The UEC module estimated the market average annual UEC in each of the analyzed scenarios.

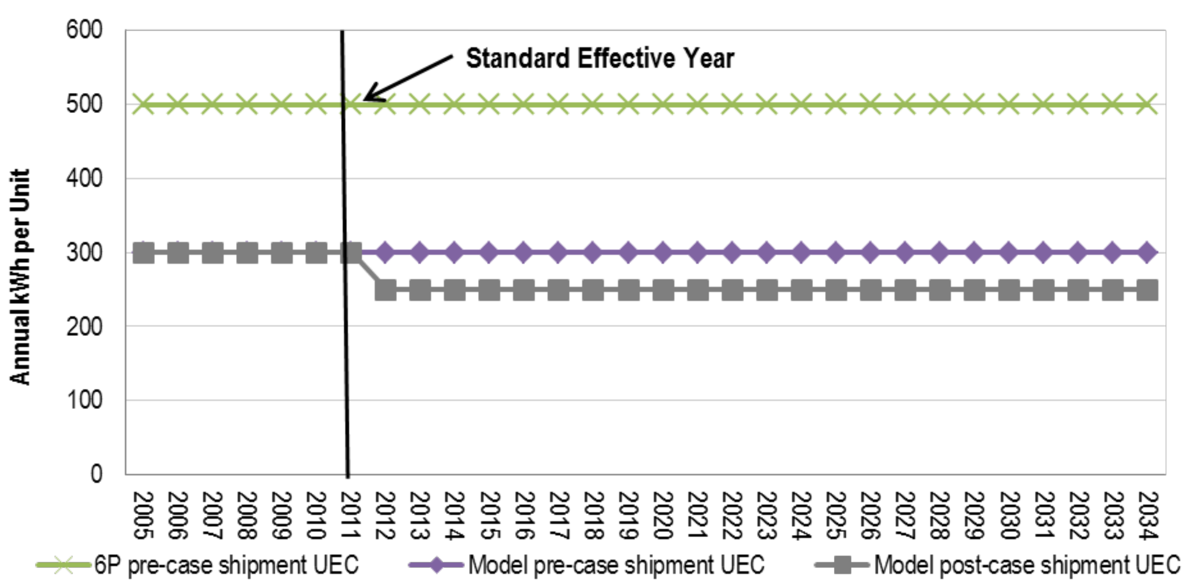
As discussed previously, the Pre-Case represented a scenario in which no standard other than those captured in the Fifth and Sixth Power Plan baselines would take effect. By contrast, the Post-Case scenario represented a scenario that accounted for the impacts of appliance standards not included in the Fifth and Sixth Power Plans. Therefore, the difference between the Pre-Case UEC and the Post-Case UEC was typically the average per UES attributable to efficiency increase required by standards.

In calculating the average appliance UEC, each analysis considered the available product classes in the market. Navigant collected market share data to inform the distribution of the product classes and efficiency levels. For example, top-loading and front-loading clothes washers are different product classes with different average annual UECs. The standards impact analysis weights the product UEC by the market distribution of top-loading versus front-loading clothes washers. For some products, the model takes into account the efficiency distribution of products over time in both Pre-Case and Post-Case. Appendix C captures the details of key data fields and assumptions.

As illustrated in Figure 1, Navigant calculated three UECs over the analysis. The first two are easily understood: the Pre-Case UEC and the Post-Case UEC. The third, the Sixth Power Plan UEC, begs the question, "why isn't that the same as the model Pre-Case UEC, given the model's Pre-Case scenario was meant to be aligned with the Sixth Power Plan?" The reason is that more-recent data was available to the team, which affected inputs into the UEC. So, even when the team maintains the baseline efficiency (say, the .65 EF for dishwashers) used in the Sixth Power Plan, the annual UEC is different because of changes in duty cycles assumptions. Section 2.3.3.4 includes a discussion of how the team reconciled the fact that these differences in UECs (and different shipments forecasts, for that matter) created different forecasts of available potential. The following characterizes each modeled UEC.

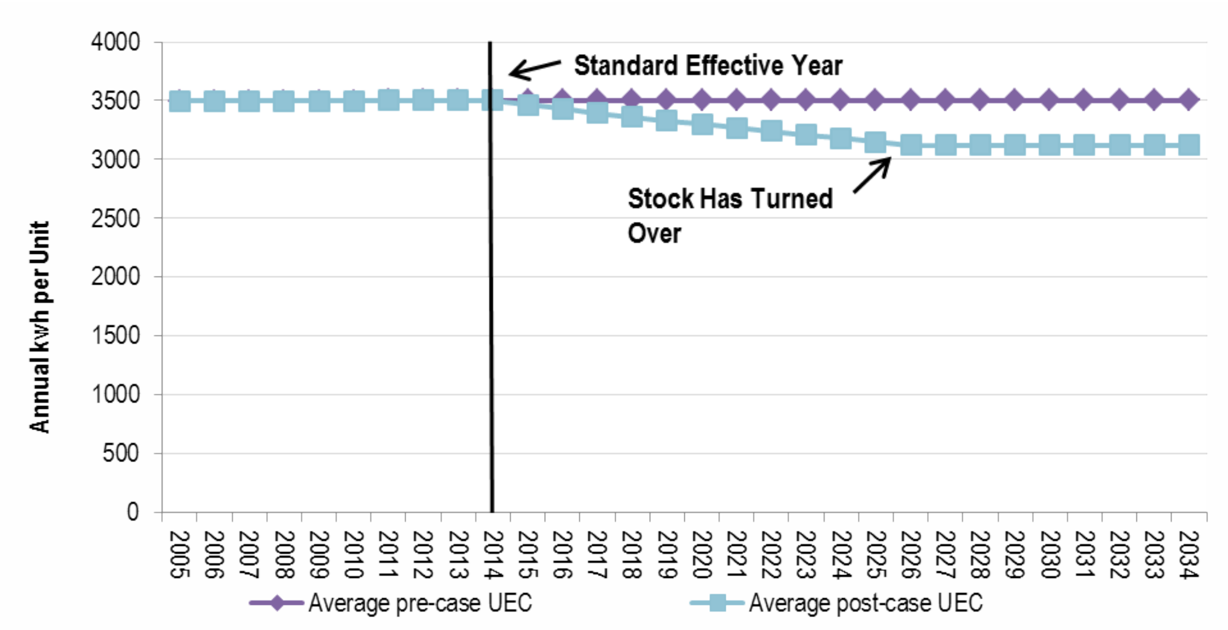
- **Model Pre-Case UEC** refers to the Pre-Case appliance UEC updated with best available data (although it maintains the frozen Sixth Power Plan efficiency assumption) and modeled through the analysis period.
- **Model Post-Case UEC** refers to the Post-Case appliance UEC, calculated based on the market average UEC *after* the standard took place. (This value may or may not be different from the model Pre-Case shipment UEC, depending on whether the standard was assumed in the Sixth Power Plan.)
- **Sixth Power Plan UEC** refers to the Pre-Case appliance UEC captured in the Sixth Power Plan.

Figure 1. Illustration of Pre-Case and Post-Case Shipment Unit Energy Consumption



These UECs plotted in the figure reflect the annual *shipment* UEC. That is, each represents the average UEC of the units that are shipped each year. They do *not* represent the average UEC of the installed stock, which is composed of shipments installed over many years. An example of the installed stock average UECs, calculated in the model, are shown in Figure 2. The figure demonstrates that the average UEC changes more gradually over time after the standard becomes effective as the new installations (which must meet the higher standard) begin to saturate the stock. Once the stock has completely turned over, the average UEC flattens out because each new unit has the same UEC as the one it replaces.

Figure 2. Illustration of Pre-Case and Post-Case Installed Stock Unit Energy Consumption



Stock-Turnover Module

The purpose of the stock-turnover module is to track the installed stock and shipments in each year of each appliance from 2005 to 2034. This allows the model to estimate savings from new standards as the affected new shipments—now subject to more stringent efficiency requirements—gradually saturate the installed stock, until the entire stock is replaced with new standards-compliant units. The following is a discussion of each of the key components of the stock models.

Installed stock. To establish the installed stock (number of units) at the beginning of the analysis period, Navigant typically backcast shipments starting with recent historical data, or the best available proxy. For example, the team used appliance saturation levels found in the RBSA and housing stock estimates from the Sixth Power Plan to establish an installed stock in 2010, the year in which RBSA data was collected. A similar approach with commercial floor space and the CBSA was used for products primarily used in the commercial sector. Navigant then backcast annual shipment units to 1980 by calibrating replacement unit shipments, such that the stock maintained a steady and reasonable growth, reflective of actual, historical new construction growth and market saturation. Where regional data was not available, the team scaled national data (usually from DOE NIAs) down to the region.

Annual shipments. Annual product shipments (which are assumed to be installed in the year in which they are shipped) comprise two separate unit flows: (1) those shipped to replace failed units and (2) those shipped to accommodate new construction growth.

1. **Replacement units** are driven primarily by the assumed product lifetime (or distribution of lifetimes). For most models, products are assumed to have a single lifetime (e.g., 13 years). The model tracks all units shipped each year and retires those that fail based on the product's lifetime (e.g., those units installed 13 + 1 years ago). These failures must be replaced and those units become new shipments (which, notably, must meet any new efficiency standards that may apply).[8]
2. **New construction units** are driven by regional new housing construction or floor space growth forecasts from the Sixth Power Plan, as well as saturation data, typically from the RBSA and CBSA.

Each year, the model subtracts product failures from the beginning-of-the-year stock and then adds new shipments (composed of replacement units and new construction units), resulting in the end-of-year stock, which becomes the beginning-of-the-year stock for the next year. The stock and flow of the units is given by the following equation:

$$\text{Installed Stock}_{\text{year 1}} = \text{Installed Stock}_{\text{year 0}} - \text{Retirements} + \text{Replacements} + \text{New Construction Units}$$

[8] To generate the Sixth Power Plan forecast, shipments of each product were modeled using the assumption that replacement units would be equal to the installed stock in the start year (2005) divided by the lifetime of the product. This assumption, often called a "1/lifetime" turnover assumption, is often used in mature slow-growth markets that are not experiencing much change in efficiency over time. This method of turnover replaces, in effect, the average unit in the stock, rather than the unit installed "1+lifetime" years ago. By comparison, the stock-turnover models built in this study provide additional granularity on the likely performance of the retiring units by tracking the vintage of the shipments by year.

Energy Consumption and Savings Estimates

Combining the UEC module with the stock-turnover module, the team forecast total energy consumption for each modeled product in each year of the analysis. As discussed previously, the team modeled two scenarios that differed based on their assumptions about whether a standard goes into effect.

1. **Pre-Case scenario**: a scenario in which no standard other than those captured in the Sixth Power Plan baseline would take effect. In this scenario, the product's aggregate energy consumption across the region was calculated based on an installed stock developed using the frozen efficiency levels assumed in the base year of the Sixth Power Plan. For products that had not been explicitly modeled in the Sixth Power Plan, the Pre-Case efficiency defaulted to the basecase assumption utilized in DOE's NIA for that product.

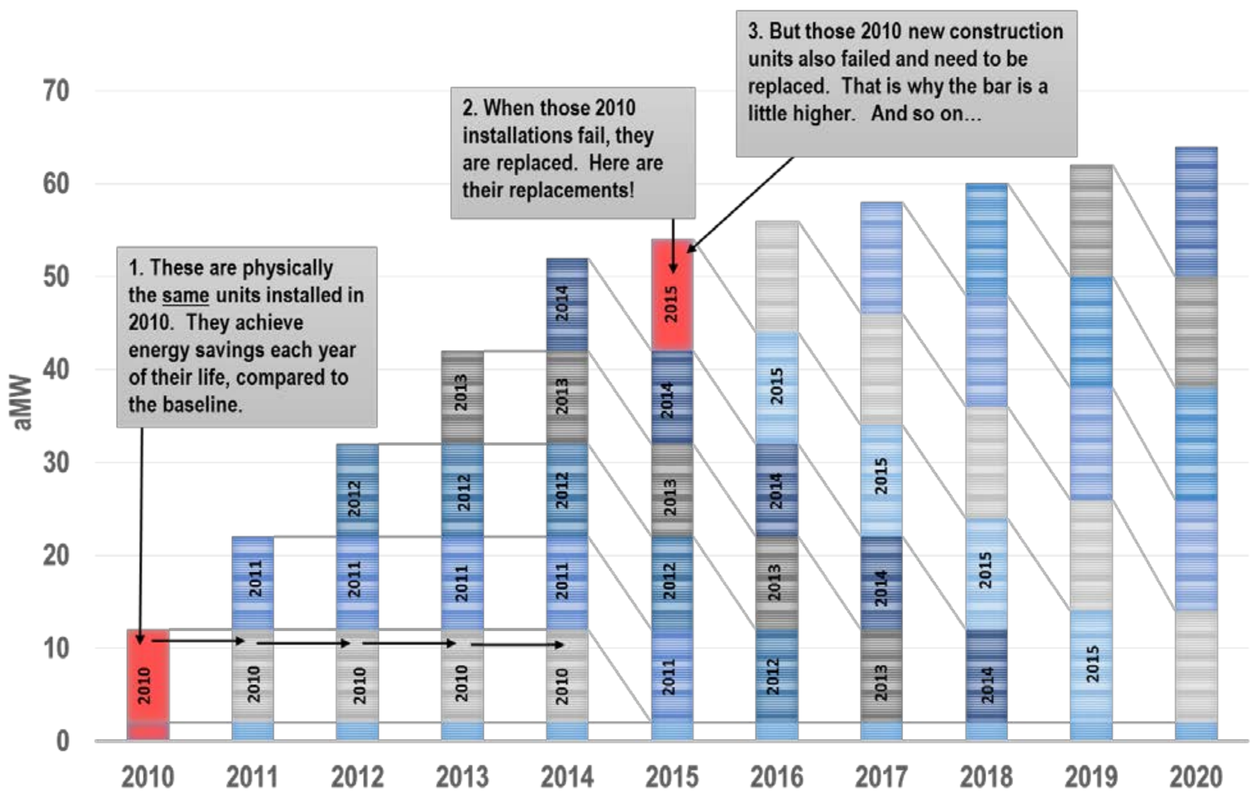
2. **Post-Case scenario**: a scenario accounting for the impacts of appliance standards not included in the Sixth Power Plan. Product efficiency levels increase to the standard efficiency levels after the standards became effective.

The difference between the region's energy consumption in the two cases yielded the impact of the standard, if any, relative to the Sixth Power Plan baseline. The magnitude of savings for each product was driven by (1) the change in the product's UEC due to the standard and (2) the volume of shipments (e.g., market size) of the regulated product.

As discussed at the beginning of this report, energy savings relative to the Sixth Power Plan baseline are counted for each above-baseline unit installed, but only for the year of its installation—regardless of the life of the product. Cumulative savings refer to the sum of these first-year savings over a given period. In contrast, DOE's NIAs—which, again, model energy savings impacts from DOE efficiency standards—accrue savings from above-baseline products if calculating carbon reductions from a measure (i.e., the savings from products installed in year 1 continue to accrue in year 2, year 3, and so on).

Figure 3 illustrates one way to look at the different types of savings discussed above for an imaginary product with a five-year lifetime that is regulated by a new standard on January 1, 2010. The first column shows the savings from the shipments in 2010. The savings occur relative to the old baseline for every single unit installed. As shown in the second column representing the savings that occur in 2011, again relative to the baseline, those units installed in 2010 are *still* saving energy because they are still in operation and more efficient than they would have been absent standards. With the addition of those units installed in 2011, total annual savings are much higher than in 2010. However, "incremental" or "first-year" savings are roughly the same as in 2010 because roughly the same number of units in the stock needed to be replaced and the number of units installed for new construction (in this example) is constant from year to year. This continues for five years (the lifetime of the product) until the entire stock has "turned over," or been replaced. Thereafter, only the standard causes savings from new construction units (as the replacement units have already been upgraded to the new standard level).

Figure 3. Illustration of Shipment Model Results for 2005-2034



Baseline Adjustments

Heretofore, for simplicity, we have discussed the Pre-Case as being aligned with the Fifth and Sixth Power Plans, such that savings from standards only above the Plan baseline accrue in the Post-Case. The reality is more complicated. Extensive data were available to the team, including actual sales and saturation data, which were unavailable to the Council when it developed the Sixth Power Plan. This means the model's Pre-Case average product UEC calculation that uses all best available data—as our models do—will not yield the same UECs embedded in the Sixth Power Plan baseline, *even if we assume the same baseline efficiency,* because more-recent data argue for different operating hours, duty cycles, and market mix assumptions. Similarly, new shipment, saturation, and lifetime data mean that the region's installed stock and annual installations in our stock-turnover models do not exactly match that of the Sixth Power Plan (which was a forecast, after all).

Different UECs and shipment volumes in the models' Pre-Case and in the Sixth Power Plan create a difference in efficiency potential between the two models. To reconcile this difference, the team calculated one-time baseline adjustments for each product. The baseline adjustment accounts for the discrepancy between the Sixth Power Plan projections and the real market conditions in shipment units and UEC in 2010, and follows the following equation.

$$\text{Baseline Adjustment} = (\text{6P Shipment Units} \times \text{6P UEC}) - (\text{Modeled Shipment Units} \times \text{Modeled UEC})$$

A positive adjustment means the total energy consumption forecasted in the Sixth Power Plan was higher than the real market energy consumption, and thus less savings potential is available than forecasted. Conversely, negative adjustment means the forecasted total energy consumption in the Sixth Power Plan is lower than real market conditions and thus more savings potential is available than forecasted.

Savings Aggregation

Navigant has combined the standards analysis results by sector, namely, the residential and the commercial/industrial sector. The residential aggregated results are further broken down to the three residential building types: single family, multi-family, and manufactured homes. As the water heating fuel type distribution varies by building type, residential products with water heating requirements (e.g., electric water heater, dishwashers, and clothes washers) were analyzed at the building type level and aggregated to show the total sector results.

Due to the general lack of regional data granularity for commercial appliances, the Sixth Power Plan estimated the baseline energy consumption of most commercial equipment as an end-use bundle. For example, the heating, ventilation, and air-conditioning (HVAC) end-use consumption was represented by the energy use intensity (EUI) in kilowatt-hours (kWh) per square foot.

Navigant compared the regional EUI and the DOE shipment data and found that the rigor of the DOE shipment data was higher. Therefore, the DOE shipment data were the better data to use for the standard impact analysis and Navigant relied on DOE shipment data for the commercial refrigeration products, commercial HVAC products, motors, and distribution transformers.

Lighting Model

As mentioned earlier, because of the interactivity among lighting products, the team decided to model all lighting products together in a single model. That model was based on a model developed by Navigant for DOE to estimate the energy savings potential of LEDs nationally.[9] The model structure was largely maintained for this analysis, but Navigant scaled most inputs to the region or modified the inputs to reflect regional data sources. The model forecasts shipments and the installed stock of all major lighting technologies in the region, disaggregated into four sectors: residential, commercial, industrial, and outdoor.

Initial installed stock. The team computed the regional installed stock of lamps in 2010 (the initial year for the lighting model) by scaling according to the national lighting installed stock developed by Navigant in a separate DOE report.[10] A comparison of national and regional floor space was used for the scaling.

Initial installed product mix. Navigant compared the national product mix (distribution of technologies installed in each sector) from the DOE report to regional data sources to determine if any adjustment would be necessary to account for market differences in the Northwest as compared to the nation as a whole. Based on the product mix, found in the RBSA, the CBSA, as well as a recent BPA lighting market

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[9] The DOE report on the model and findings is titled "Energy Savings Potential of Solid-State Lighting in General Illumination Applications" and can be found here: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_jan-2012.pdf

[10] The "2010 U.S. Lighting Market Characterization," available here: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

characterization, Navigant modified the national product mix to match regional mixes for two product areas:

1. The mix of CFLs and incandescent lamps installed in the commercial and industrial sectors (national data showed a higher share of incandescent than in the Northwest)
2. The sales mix of T12 and T8 lamps in the commercial and industrial sectors (national data implied a slower shift from T12 lamps to T8 lamps than was occurring the Northwest based on BPA Lighting Market Characterization)

Market segments. The model tracks four market segments, each of which create lighting demand on an annual basis.

- **New construction.** The Sixth Power Plan residential housing stock and commercial floor space growth forecasts drive lighting demand associated with new construction.
- **Retrofits.** The installations to replace existing lamps, ballasts, or fixtures retired during renovation or remodeling create lighting demand each year. The Sixth Power Plan average commercial retrofit rate of 7.6 percent is used in the model.
- **Lamp replacements.** Lamp burnout, based on lamp life and average operating hours, creates a need for lamp replacements, another driver of lighting demand.
- **Ballast replacements.** Ballast failure, based on ballast life and average operating hours, similarly creates lighting demand because the ballasts and the lamps operating on them must be replaced.

As in the real world, various technologies compete to meet the lighting demand driven by these four market segments in the lighting model. The competition is simulated using an econometric consumer choice model, which is discussed briefly below and more fully described in the aforementioned DOE report.[10] The model assigns the analyzed technologies to discrete submarkets meant to represent similar applications. For example, incandescent, halogen, compact fluorescent, and LED lamps compete in the "medium screw base" submarket. The technologies within each submarket compete to meet annual market demand for lighting. The lighting model consists of the five submarkets shown in Table 2.

Table 2. Analyzed Lighting Submarkets

Submarket	Lighting Products in Submarket
General Service–Medium Screw Base	Incandescent, Halogen, CFL, LED
Directional	Incandescent, Halogen, CFL, LED
Linear Fluorescent	T12,T8,T5, LED
High-Intensity Discharge	Mercury Vapor, High Pressure Sodium, Metal Halide, LED
Miscellaneous	Others

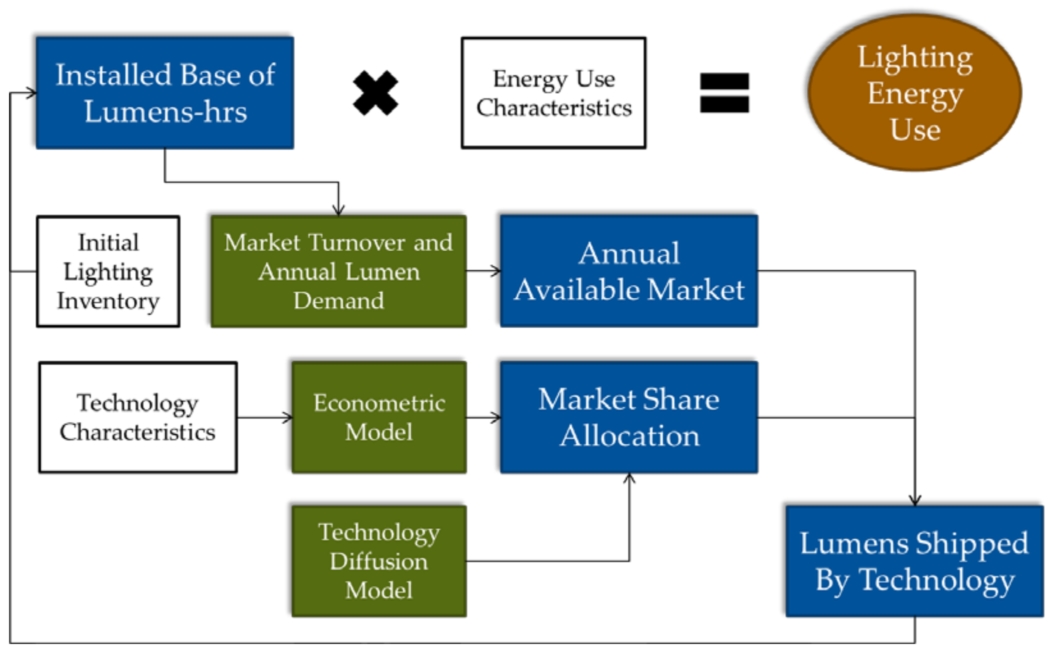
Lumen-hour demand (market turnover). The aforementioned four market segments drive lighting demand in each of the five submarkets. That demand is tracked sector by sector in the model. As lighting technologies become increasingly efficacious, watts or unit-counts become an increasingly poor measure of market lighting demand. Consequently, Navigant converted the initial installed stock of each technology (which was given by unit count) into an installed stock of "lumen-hours" by incorporating the average lamp wattage, efficacy, and operating hour characteristics for each lamp type. Lumen-hours, the service performed by the lamps (i.e., the provision of lumens over time) are the primary unit of account in the model.

Because of the great variation in performance across lamp types, a given level of lumen-hour demand could be met by, for example, a large number of inefficient incandescent units or a much smaller number of more-efficient lamps. The model tracks the shipped product mix as it changes year-to-year because these technologies' varying lifetimes greatly affect failure rates, which, in turn, generate new lighting demand.

Calculation of shipped market share of each product type. Lumen-hour demand is created as lamps burn out, are retrofitted, or new space is constructed. In reality, several lighting technologies simultaneously compete for the available market share created by these events. The eventual market share a given technology earns is a function not only of its own cost and performance (and acceptance in the market), but also of all the other technologies with which it competes. In the model, market share is allocated based on the combination of three key inputs: (1) a technology diffusion curve, (2) the econometric logit model, and (3) and market acceptance rate.

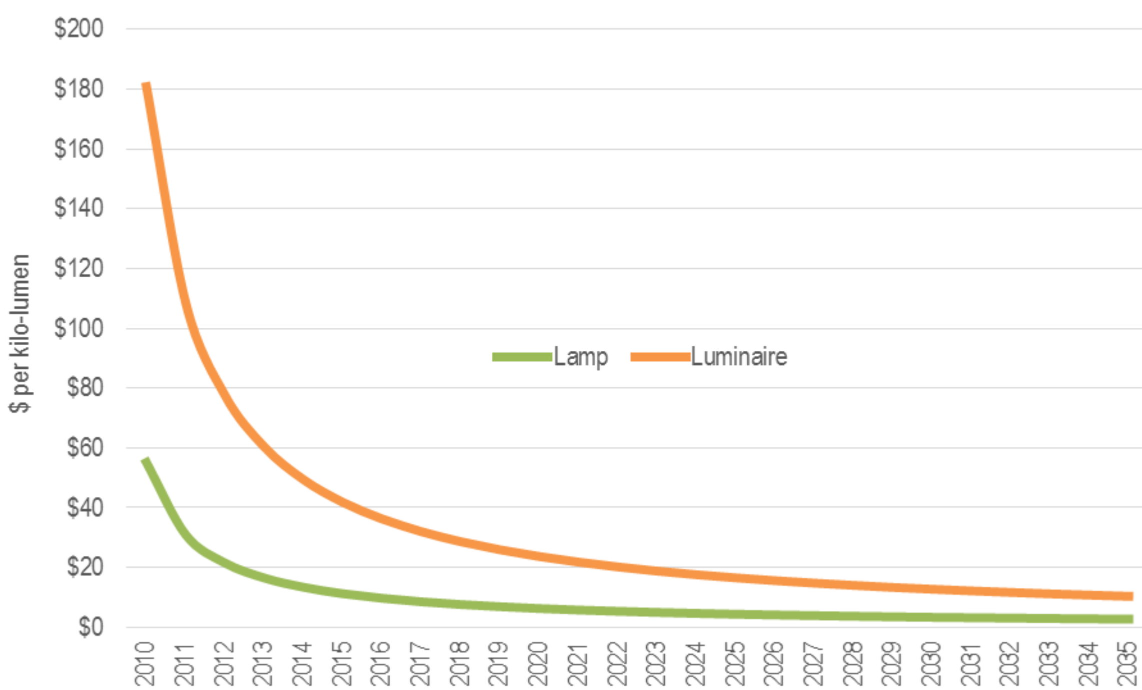
1. **Technology diffusion curve**. This curve, often called a Bass Diffusion Curve, governs the rate at which new technologies diffuse into market.
2. **Econometric logit model**. The econometric model uses a logistic regression of historical data on market share, first cost, and operating and maintenance cost. In effect, the logit model weighs how consumers are likely to trade off first-cost versus lifecycle-costs in making purchase decisions.
3. **Market acceptance rate**. Market acceptance rates constrain the market adoption of some technologies based on non-cost factors, such as DOE standards, or performance consideration, such as the color quality of the lamp.

Figure 4. Lighting Model Structure Flow Diagram



Technology cost and performance forecasts. As LED performance improves and cost declines, LED lamps become more attractive to consumers relative to traditional technologies (a factor captured by the econometric logit model). A critical input into the model, therefore, is the forecast of LED technology's cost and performance. Navigant used the forecast projected in DOE's Solid-State Lighting Research and Development: Multi-Year Program Plan.[11] Figure 5 shows the forecasted decline in cost for LED lamps and luminaires. Note that the cost is given in dollars per kilo-lumen. While LED costs are declining substantially, efficacy is also increasing dramatically, leading to the exponential decline in cost per lumen shown in Figure 5.

Figure 5. Projections of LED Cost and Efficacy



For traditional technologies, the team also assumed the same increases in performance and reductions in cost that DOE assumed in its model. The typical improvement in efficacy and lifetime was 10 percent over the analysis period (2010 to 2034), coupled with a 10 percent reduction in price. These changes are much more modest than the improvements forecast for LEDs, but reflect our judgment that traditional technologies will continue to improve at the margin.

[11] Report available here: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2012_web.pdf

Energy use calculation. After the model assigns lumen-hour market share to each technology type in a given year, it applies average technology characteristics (watts/lamp, lumens/watt) to back out the number of lamps shipped each year. The lamps are added to the previous year's installed base (and the retirements are subtracted from it) to arrive at the next year's installed base. Next, the energy use of the stock is calculated by applying typical lamp characteristics (e.g., average wattage and operating hours) by sector to the installed lamps.

Scenarios analyzed. The model has several user-inputs that allow the user to turn on and off lighting standards in order to assess the standards' impact. The standards' impact can be modeled against two scenarios, which vary based on their assumptions about emerging technology penetration. The first, the "frozen efficiency" scenario, aligns with the Sixth Power Plan assumption of a frozen efficiency baseline. This scenario constrains the penetration of emerging technologies. To calculate savings from standards, relative to the Sixth Power Plan, the team used this scenario and compared the results of the Pre-Case, in which only the standards assumed in the Plan baseline take effect, with the results of the Post-Case, in which all DOE standards take effect.

The second scenario, the "technology shift" scenario, takes into account the projected improvement in LEDs and concurrent reduction in price. It represents the team's best judgment of what will occur in the market. A comparison of energy consumption in the two scenarios provides the energy savings expected from the natural migration of LEDs and more-efficient traditional technologies into the market, relative to a frozen baseline.

Results

In this section, we first discuss the results from the residential sector and commercial sector product analyses. Next, we show the aggregated one-time baseline adjustments calculated to reconcile the Sixth Power Plan forecast with the models built in the project using the best available data (which was unavailable at the time of the Sixth Power Plan's forecast development). Finally, we discuss the savings results of the standards modeled in the lighting sector, as well as the forecast of LED penetration modeled in an alternative scenario that is not constrained by the Sixth Power Plan's "frozen efficiency" assumption.

Residential Sector Results

Table 3 displays the regional residential site savings and BPA residential sector site savings impact of the analyzed standards from 2010 to 2015 and from 2016 to 2034. The aggregated non-programmatic savings due to standards before program adjustments of the analyzed products is 34.40 aMW (with line loss, or "busbar" accounted for) from 2010 to 2015 for the Pacific Northwest and 14.45 aMW (with busbar) specific to the BPA region.

Table 3. Residential Standards-Induced Non-Programmatic Savings (aMW) with Busbar

Product	Region		BPA	
	2010-2015	2016-2034[12]	2010-2015	2016-2034
Residential Dishwashers	1.45	6.85	0.61	2.88
Residential Refrigerators	8.03	140.12	3.37	58.85
Residential Freezers	1.45	30.48	0.61	12.8
External Power Supplies	0.0	0.0	0.0	0.00
Residential Clothes Washers	0.0	0.0	0.0	0.00
Residential Water Heaters	15.50	198.50	6.51	83.37
Ceiling Fan Lighting Kits	3.75	4.63	1.58	1.94
Torchieres	2.91	1.21	1.22	0.51
Residential Heat Pumps	1.31	22.19	0.55	9.32
Total Residential	**34.40**	**403.98**	**14.45**	**169.67**

[12] Note that the standards-induced savings during this timeframe (2016-2034) are not "non-programmatic" because, by definition, non-programmatic savings must be above the Plan baseline, which does not yet exist for this period. Presumably, in keeping with past Council patterns, the Seventh Power Plan will account for the standards, generating these savings in the baseline. That is not to say the savings are not real—they are indeed a substantial, real resource—but only that these savings occurring after the conclusion of the Sixth Power Plan will not count as non-programmatic savings towards any target.

Note that some products do not result in savings from 2010-2015:

- External Power Supplies (EPS): EPS are included as a measure in the Fifth Power Plan, but not in the Sixth Power Plan. Under the assumption that all savings from EPS would have been captured by the end of the Fifth Power Plan period, there are no savings associated with EPS.
- Residential Clothes Washers: The Sixth Power Plan captured the efficiency level of the standard.
- Residential Heat Pumps: The Sixth Power Plan already included the standard efficiency.

Commercial/Industrial Sector Results

Table 4 displays the regional commercial sector results of the analyzed standards from 2010 to 2015 and from 2016 to 2034. The aggregated non-programmtic savings due to standards before program adjustment of the analyzed products is 49.65 aMW for the Pacific Northwest (with busbar), and 20.86 aMW specific to the BPA region (with busbar). The majority of the non-programmatic savings come from standards on distribution transformers.

Table 4. Commercial/Industrial Standards-Induced Non-Programmatic Savings (aMW) with Busbar

Product	Region		BPA	
	2010-2015	2016-2034 [13]	2010-2015	2016-2034
Commercial Clothes Washers	1.71	8.26	0.72	3.47
Illuminated Exit Signs	0.0	0.0	0.0	0.0
Pre-Rinse Spray Valves	0.0	0.0	0.0	0.0
Commercial Refrigeration Equipment	0.0	0.0	0.0	0.0
Walk-In Coolers and Freezers	2.23	9.56	0.94	4.02
Electric Motors	0.66	2.56	0.28	1.06
Distribution Transformers	44.93	318.85	18.87	133.92
CAC Air-Cooled	0.00	0.20	0.00	0.08
CAC Water-Cooled	0.01	0.06	0.00	0.03
Packaged Terminal Air-Conditioning/Heat Pump	0.12	0.36	0.05	0.15
Total Commercial	**49.65**	**339.85**	**20.86**	**142.73**

[13] As discussed in footnote 12, these savings are technically not "non-programmatic" because they are not above any plan baseline.

Several products have no standards-induced savings above the Sixth Power Plan baseline from 2010-2015:

- Pre-Rinse Spray Valves: The standard was included in the Fifth and Sixth Power Plans.
- Commercial Refrigeration Equipment: The standards on these products are included in the Sixth Power Plan.
- Illuminated Exit Signs: This product was not included in the Sixth Power Plan because it was assumed to already be at or above the standard with negligible potential remaining.

One-Time Baseline Adjustments

As discussed in section 3.3, for each product's analysis, Navigant calculated a one-time baseline adjustment to account for the difference between the Sixth Power Plan's assumed market shipments and baseline UEC in 2010 and those the team modeled in the Pre-Case using the best available data. Navigant used the following equation to estimate the baseline adjustment.

$$\text{Baseline Adjustment} = (\text{6P Shipment Units} \times \text{6P UEC}) - (\text{Modeled Shipment Units} \times \text{Modeled UEC})$$

Residential sector. The sum of all residential product baseline adjustments for the entire region was 41.5 aMW. BPA's share of this total is 17.4 aMW. As shown in Table 5, the total adjustment was primarily driven by dishwashers, clothes washers, and water heaters, which in hindsight diverged from the Sixth Power Plan estimates most substantially.

Table 5. Residential Products' Baseline Adjustments – Regional and BPA

Product	Regional Sixth Plan Baseline Adjustment (aMW)	BPA Sixth Plan Baseline Adjustment (aMW)
Residential Dishwashers	5.8	2.4
Residential Refrigerators	-4.0	-1.7
Residential Freezers	5.0	2.1
External Power Supplies	0	0
Residential Clothes Washers	7.1	3
Residential Water Heaters	23.1	9.7
Ceiling Fan Lighting Kits	0	0
Torchiers	0	0
Residential Heat Pumps	4.5	1.9
Total Residential Sector Adjustments	41.5	17.4

Commercial sector. The sum of the one-time baseline adjustments from the commercial products was 2.9 aMW for the region (and 1.2 aMW for BPA's share). Illuminated exit signs, pre-rinse spray valves, and commercial refrigeration products contributed to total.

Table 6. Commercial Products' Baseline Adjustments – Regional and BPA

Product	Regional Sixth Plan Baseline Adjustments (aMW)	BPA Sixth Plan Baseline Adjustments (aMW)
Commercial Clothes Washers	0.0	0.0
Illuminated Exit Signs	2.7	1.1
Pre-Rinse Spray Valves	-0.1	0.0
Commercial Refrigeration Equipments	0.2	0.1
Walk-In Coolers and Freezers	0.0	0.0
Electric Motors	0.0	0.0
Distribution Transformers	0.0	0.0
HVAC Equipments	0.0	0.0
Total Commercial Sector Adjustments	2.9	1.2

Reconciliation with NEEA's Reports

Other programs and organizations in the region also track the markets of products that were analyzed in this project. In particular, NEEA reports savings from several of its initiatives that cover products analyzed in this report. Therefore, the savings found in this analysis for those products NEEA tracks will be reported by NEEA elsewhere and are removed from the totals claimable by BPA, as shown in Table 8.

Specifically, savings from standards on the following products are subtracted from BPA's claimable savings:

- Residential Dishwashers
- Residential Clothes Washers

Table 7 summarizes the residential and commercial results by year from 2010 to 2015 before subtracting NEEA's savings.

Table 7. BPA's Non-Programmatic Savings by Sector by Year (2010-2015) with Busbar

	2010	2011	2012	2013	2014	2015	Total
Residential	0.53	0.55	0.56	0.77	0.5	11.54	14.45
Commercial	3.38	3.40	3.32	3.54	3.59	3.62	20.85
Total	**3.91**	**3.95**	**3.88**	**4.31**	**4.09**	**15.25**	**35.39**

Table 8 summarizes BPA's claimable savings and baseline adjustments, as well as the adjustment for what NEEA will report.

Table 8. BPA's Non-Programmatic Savings and Baseline Adjustments for 2010-2015 with Busbar

	Non-Programmatic	Baseline Adjustment	Total
Residential	14.45	17.4	31.85
Commercial	20.85	1.21	22.06
Total	35.3	18.6	53.91
Less Reported by NEEA	0.61	0	0.61
Total Remaining Claimable	**34.69**	**18.6**	**53.3**

Lighting Model Results

BPA reported non-programmatic savings for lighting in a separate report.[14] For the results in this section, we discuss some of the more far-reaching results of the model.

Scenarios

[14] Northwest Non-residential Lighting Market Characterization, available at http://www.bpa.gov/energy/n/reports/evaluation/commercial/pdf/Northwest_NonRes_Lighting_Market_Characterization.pdf

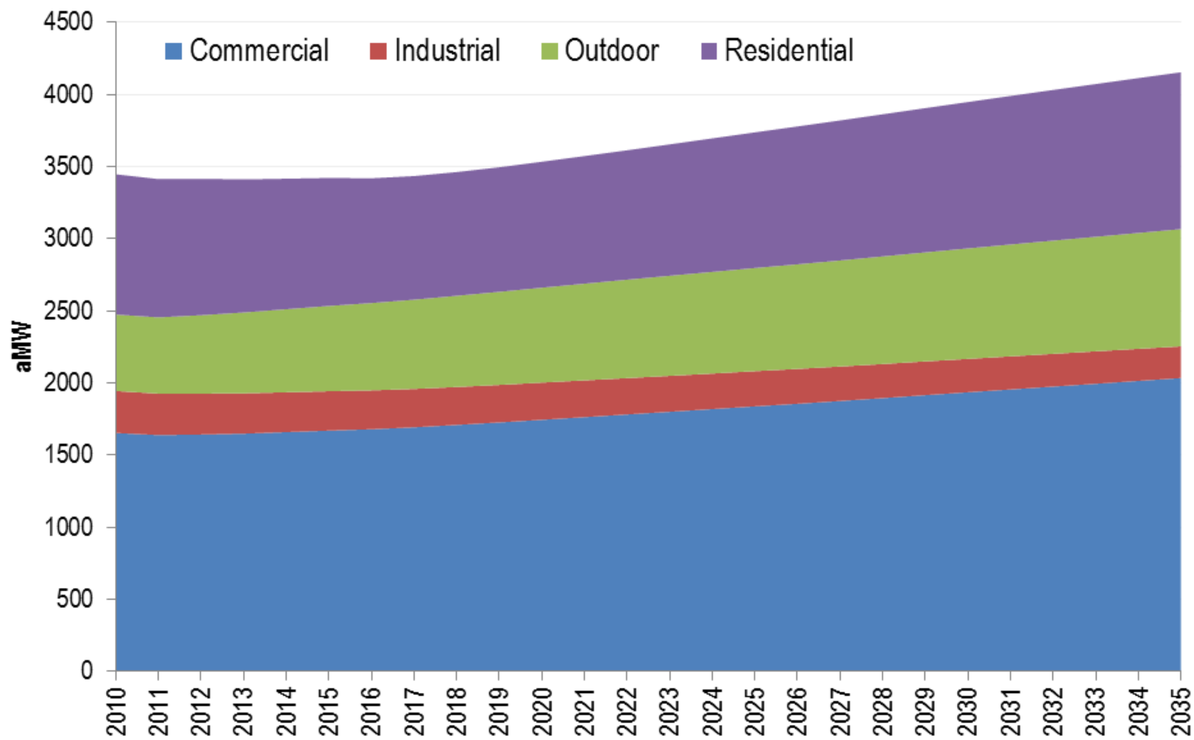
As discussed in section 2.3.4, Navigant modeled two scenarios in the lighting model. The first was the “frozen efficiency” scenario, intended to mirror the assumptions made in the Sixth Plan. The second was the “Technology Shift” scenario which represented the model’s forecast of the lighting market when technologies are “allowed” to penetrate the market (because the “frozen baseline” assumption is lifted). Each scenario can be run with any or all of the standards turned on (assumed to take effect as intended by the law) or off (in the case where a given standard was not modeled by the Sixth Plan.

Table 9. Lighting Standards Modeled

Standard	Year Active	Assumed in Sixth Plan?
GSFL	2012	No
Fluorescent Ballast	2015	No
Mercury Vapor	2008	Yes
Metal Halide	2010	No
General Service Incandescent	2012	Yes
Halogen Reflector	2012	No
Candelabra	2012	No

In order to assess the impact of these lighting standards, relative to the Sixth Plan, the team modeled, in the “Pre-Case,” the “frozen efficiency” scenario and assumed only the standards that were embedded in the Sixth Plan would take effect. Figure 6 illustrates the results of the “Pre-Case.” As evidenced by the chart, lighting consumption is moderated as the standards assumed in the Sixth Plan take effect. After the more standards-compliant lamps turn over, energy consumption begins to grow over time as the new construction is added to the stock (and the “frozen efficiency” assumption translates more lighting demand in proportionally greater energy consumption).

Figure 6. "Pre-Case" Regional Lighting End-Use Energy Consumption, by Sector



For the "Post-Case," the team again modeled the "frozen efficiency" forecast but assumed all the lighting standards will take effect. Figure 7 illustrates the results of the "Post-Case." As evidenced by the chart, lighting consumption declines more significantly in the initial portion of the analysis period than in the "Pre-Case." This occurs because more standards-compliant lamps penetrate and saturate the installed base, resulting in lower energy consumption. As in the "Pre-Case," however, after the standards-compliant lamps turn over, energy consumption begins to grow over time as the new construction is added to the stock (and the "frozen efficiency" assumption translates more lighting demand in proportionally greater energy consumption).

Figure 7. "Post-Case" Regional Lighting End-use Energy Consumption, By Sector

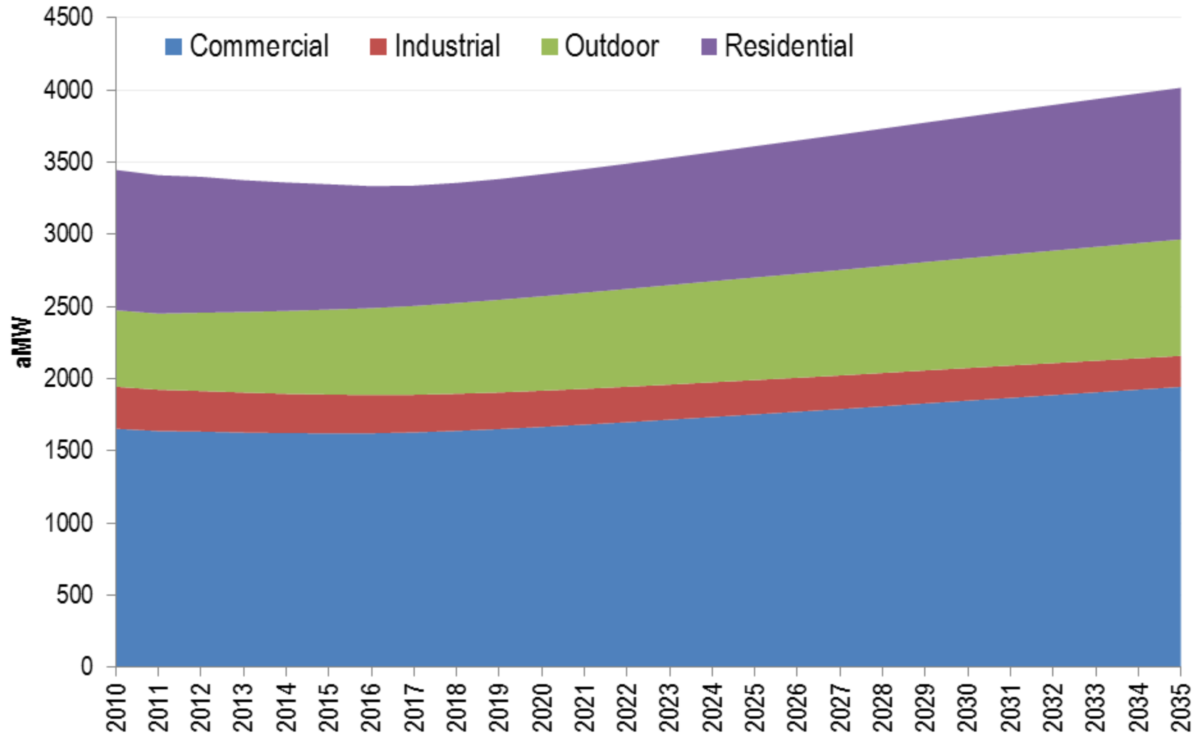


Figure 8 illustrates the difference in lighting consumption between the two cases. The chart shows the divergence in energy consumption in the initial years of the analysis period, particularly after 2012, when several standards not assumed in the Sixth Plan take effect. Then, by approximately 2017, the installed stock has largely turned over and the only incremental savings occur in new construction (which, absent standards, would have been installed at lower efficacies.

Figure 8. Regional Lighting End-Use Energy Consumption, Pre- and Post-Case Comparison

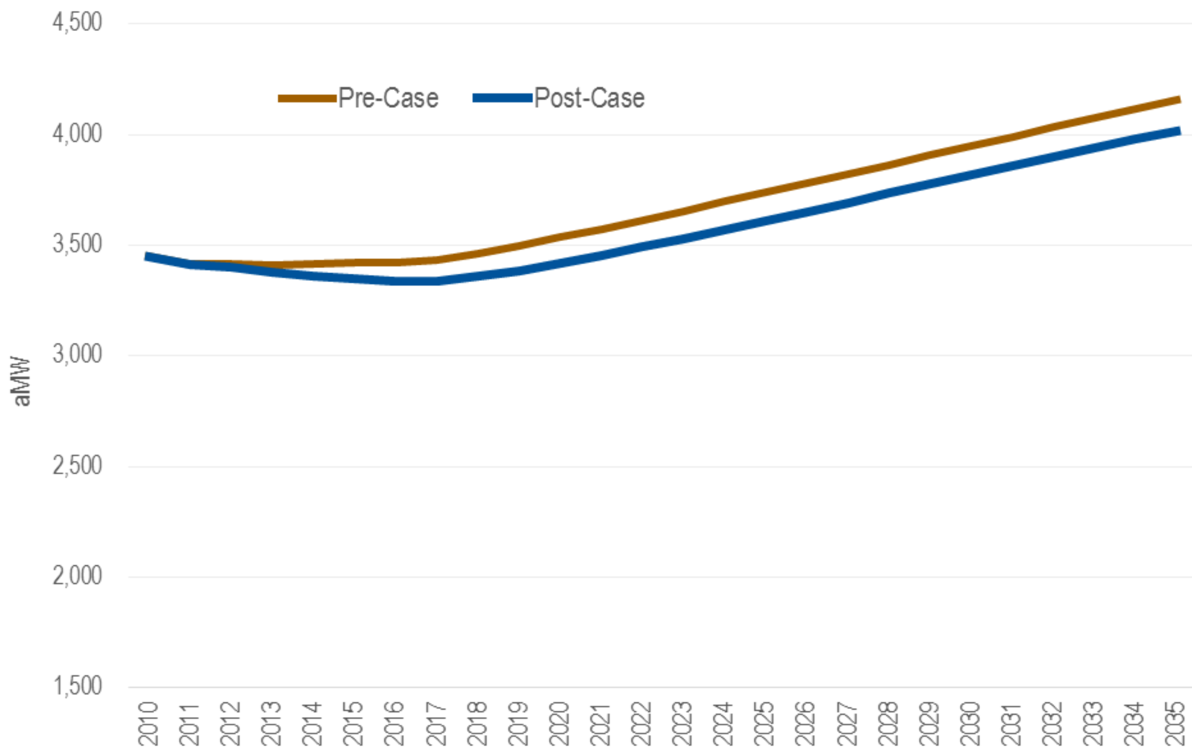


Table 10 shows the year-by-year first-year regional energy savings driven by DOE lighting standards relative to the Sixth Plan.

Table 10. Regional Lighting Standards-Driven Energy Savings (2010-2015) with Busbar

	2010	2011	2012	2013	2014	2015
First-Year Savings (aMW)	0	3.27	16.36	22.9	21.81	16.35

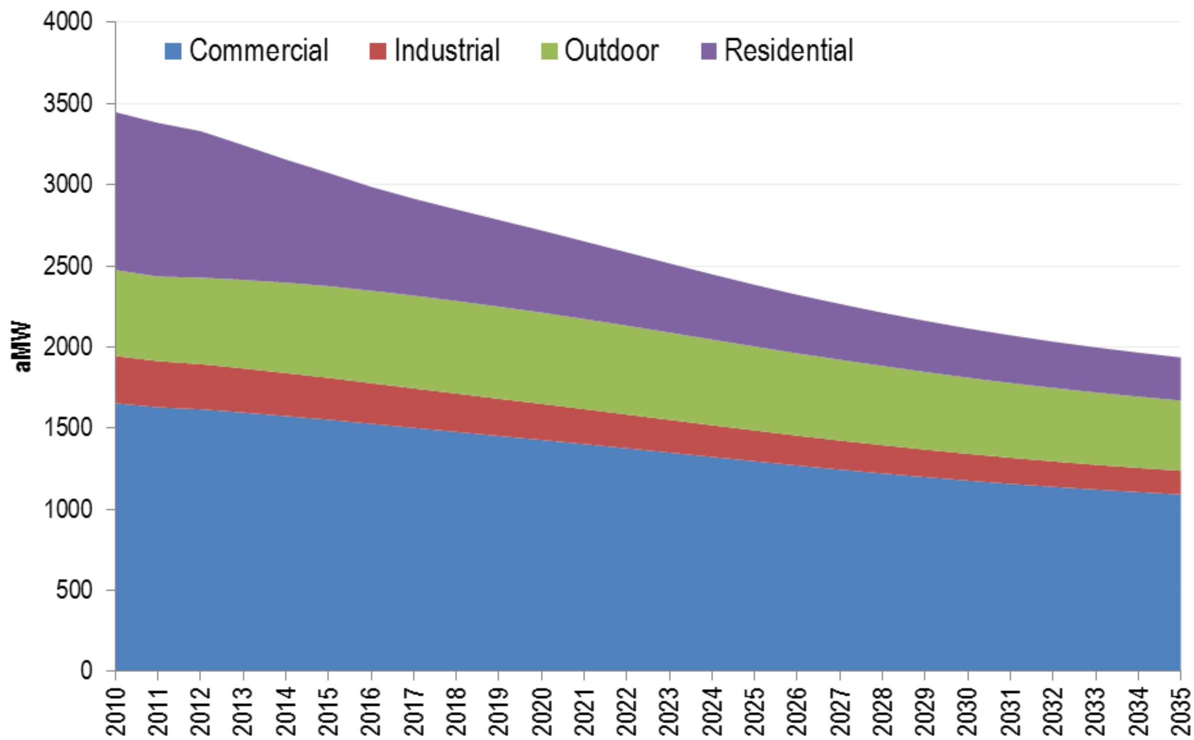
Table 11 shows the cumulative first-year regional energy savings driven by DOE lighting standards relative to the Sixth Plan in five-year bins. As expected, savings decline over time as the stock is saturated with standards-compliant lamps. The standards-effect on lighting regional consumption after 2026 is limited to the new construction market.

Table 11. Regional Lighting Standards-Driven Energy Savings by Year-Bin with Busbar

	2010-2015	2016-2020	2021-2025	2026-2030	2031-2035
First-Year Savings (aMW)	80.70	46.89	7.63	5.45	4.36

"Technology shift" scenario. As discussed, one of the goals of the study was to leave a tool in place for BPA and other regional stakeholders to use to model the complexities of the lighting market, including the specter of emerging technology penetration, most notably LEDs. This was done with the "Technology Shift" scenario which forecasts the real-world expected penetration of higher efficiency technologies based on their relative cost and performance improvements over time. The "Technology Shift" scenario results below include all standards currently slated to take effect regardless of whether they were included in the Sixth Power Plan. As shown in Figure 9, the shift in technologies to more efficiency options, namely the modeled penetration of LEDs into the stock, causes a dramatic decline in regional lighting energy consumption by 2034. Compared to the "frozen efficiency" scenario, this results in nearly a 50 percent decline in energy consumption by 2034.

Figure 9. Regional Lighting End-Use Energy Consumption, "Technology Shift" Scenario, By Sector



Because of the projected decline in LED prices and increase in their efficacy, LED shipments increase dramatically over time as they become relatively more economically compelling and more diffused. Figure 10 illustrates the penetration of LEDs over time, which causes the project decline in lighting energy consumption.

Figure 10. Forecast of Lumen-Hour Shipments by Technology Type

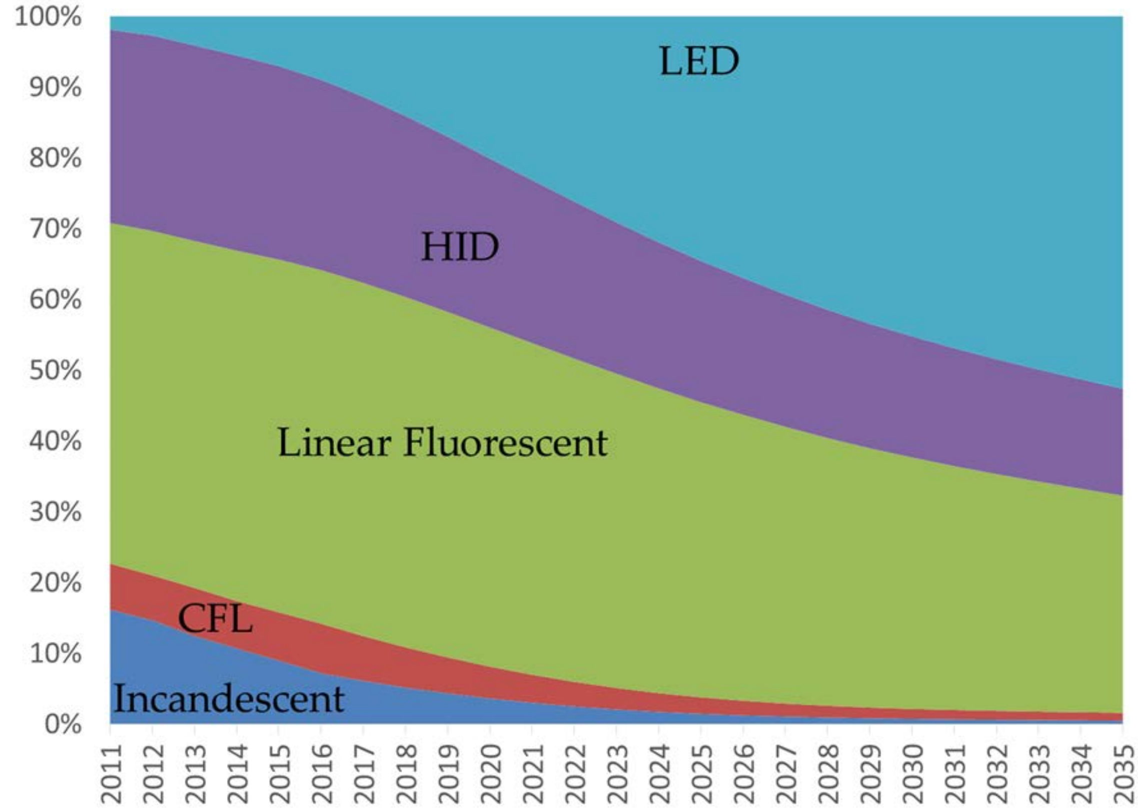


Figure 10 shows the LED penetration into all lumen-hour sales. However, when looking at only new fixtures the penetration is much higher across all market segments. In other words, the LED penetration for new lighting systems is higher than for lamp sales in general.

Table 12. Comparison of LED Penetration: All Lamp Sales vs. New Fixtures

	2011	2015	2020	2025	2030	2035
New Fixtures Only	3.1%	11.9%	35.4%	57.8%	69.6%	83.1%
All Sales	1.9%	7.0%	20.1%	34.5%	45.2%	61.9%

Future Model Enhancements

Enhancements to Models

The current lighting and non-lighting impact analysis models quantify the energy savings from appliance standards and can be utilized as a tool to forecast the potential savings for future standards. Future enhancements of the model could include the following:

- **Commercial building type disaggregation**. Energy consumption varies by building type in both residential and commercial sectors. There is considerable variation in saturation and usage data across different commercial and residential building types. Modeling impacts and forecasts by building type would allow greater insight into the composition of savings and the nature of existing potential, arming programs with better information for acquisition strategies. With the completion of the 2014 CBSA, a significant new dataset would be available for breaking out these models by building type. Operating hours, saturation levels, turnover assumptions, and equipment types are examples of parameters that would vary by building types.
- **Demographic data centralization**. For residential sector products, the team linked several individual models to a central file with historical and forecast Northwest housing stock data. This approach allows an update to the regional housing forecast for all product models with just one update in one location. Any changes flow through to each of the product-specific models. A similar approach would work well for commercial sector products. Specifically, the individual commercial products would link back to centralized commercial floor space data, disaggregated by building type. This could also be done for other regional variables, such as electricity sales.
- **Residential building type disaggregation.** Many of the residential models built for this project are already broken out by residential building types—priority was placed on those end-uses that used hot water. However, others could be disaggregated as well, including, for example, refrigerators and freezers.
- **Turnover assumption research**. Each model's turnover assumption—the rationale used by the modeler to "retire" some of the installed stock each year—is the dominant driver of the models' annual shipment forecasts. Most of the models completed for this project use a "one-over-lifetime" approach. This straightforward approach makes the implicit assumption that the product fails at a uniform rate and simply divides the installed stock by the average lifetime of the product to calculate annual unit failures (and replacement shipments). The suitability of this approach varies by product. For mature markets with slow steady growth, it is appropriate in most cases. For emerging technologies or for products of varying lifetimes, more sophisticated approaches using survival curves can be worth the extra effort to characterize the reality of non-uniform failure rates. The analyses could benefit from additional research comparing the two methods on savings impact and appropriateness.
- **Linking to other regional analyses**. Linking the individual analyses to regional data source workbooks may enable the automation of the individual analyses. For example, the heat pump

model could be linked to the regional "SEEM" model. SEEM is the residential heating and cooling energy use model developed by the RTF and is utilized for many of its residential efficiency measures.[15] The heat pump model, for example, could link to the SEEM model to directly extract inputs for calculating the product UEC.

Data Gaps

The standards impact analysis models were designed to mirror, as closely as possible, the structure and assumptions made in the Sixth Power Plan potential assessment. The purpose of the Sixth Power Plan was to assess energy resource potential and it therefore focused on products and product classes, which, at the time of the Plan's development, were thought to offer material potential. DOE's NIA models, which also were used extensively in the modeling for this project, often analyzed more product classes with more granularity than could be mapped to Sixth Power Plan assumptions. Data collection and mapping to DOE's product class and efficiency distributions, in general, would help improve the analytical rigor and updatability of the models.

Residential Sector Data Gaps

- **End-use load research for many residential products.** There is a dearth of data regarding operating use, duty cycles, and load profiles for many residential products. Such data would greatly enhance the accuracy and rigor of the models. Load shape data would enable assessment of a broader set of demand-side management activities.
- **Ceiling fan lighting kits and torchieres**. Data for these two products are particularly sparse nationally and regionally. The saturation of these two products was sourced from the Single-Family Residential Existing Construction Stock Assessment conducted in 2007. More-recent data will support more rigorous savings estimates from these two products.

Commercial Sector

- **Walk-in coolers and freezers (WICF).** There is no regional assessment on WICF products. Future efforts would be enhanced by market research that assessed the density and market distribution of WICF by system type. Compliance rates with standards are completely unknown in the region.
- **HVAC equipment.** Regional shipment data is not available for commercial HVAC equipment. Consequently, this analysis scaled the DOE NIA national data to the region and developed saving estimates from values specific to the Pacific region. The analysis would benefit from regional shipment data, most likely available from equipment distributors, broken out by equipment size and efficiency.
- **Distribution transformers**. As with the HVAC equipment, current shipments and market size are scaled from national data by regional electricity sales. Actual sales data—perhaps gathered

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[15] More information on SEEM is available at: http://rtf.nwcouncil.org/subcommittees/seem/

by querying regional utilities, the major purchasers of the highest volume (by energy use) product class within transformers—would make the model more regionally specific.

- **End-use consumption distribution.** A study on EUI by end-use and building type could help validate the energy savings estimates.

Additional Products Covered by Standards

Table 13 shows all regulated products that were not analyzed as part of this project cycle. Most of the products listed have small energy savings or primarily use gas.

Table 13. Additional Products Covered by Standards

Sector	Products
Residential	• Compact Audio Equipment • DVD Players and Recorders • Pool Pumps • Portable Electric Spas • Dehumidifiers • Residential Ceiling Fans • Battery Chargers • Microwave Ovens • Residential Clothes Dryers • Residential Furnace • Residential Cooking Ranges and Ovens • Pool Heaters • Residential Central Air Conditioners • Residential Room Air Conditioners • Residential Boilers • Direct Heating Equipment
Commercial/Industrial	• Water Dispensers • Hot Food Holding Cabinets • Commercial Warm Air Furnace • Commercial Water Heating Equipment • Commercial Package Boilers • Commercial Unit Heaters
Lighting	• Traffic Signals Modules and Pedestrian Modules

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Product Standards That Took Effect from 2005 to 2015

Product	Initial Federal Legislation	Last Standard Issued	Effective Date of Last Standard	Issued By
Residential				
Residential Refrigerators and Freezers	NAECA 1987	2011	2014	DOE
Central Air Conditioners	EPACT 1992		2006	DOE
External Power Supplies	EPACT 2005	2007	2008	Congress
Heat Pumps	EPACT 1992		2006	DOE
Dishwashers	NAECA 1987	2012	2013	DOE
Residential Clothes Washers	NAECA 1987	2012	2015	DOE
Dehumidifiers	EPACT 2005	2007	2012	Congress
Boilers	NAECA 1987	2007	2012	Congress
Residential Room Air Conditioners	NAECA 1987	2011	2014	DOE
Direct Heating Equipment	NAECA 1987	2010	2013	DOE
Cooking Ranges and Ovens	NAECA 1987	2009	2012	DOE
Pool Heaters	NAECA 1987	2010	2013	DOE
Compact Audio Equipment	None			
DVD Players and Recorders	None			
Pool Pumps	None			
Portable Electric Spas	None			
Residential Ceiling Fans	EPACT 2005	2005	2007	Congress
Commercial/Industrial				
Distribution Transformers: Liquid-Immersed and Medium-Voltage, Dry-Type	EPACT 1992	2007	2010	DOE
Commercial CAC and HPs (Air-Cooled, Small)	EPACT 1992	2007	2008	Congress
Commercial CAC and HPs (Air-Cooled, Large)	EPACT 1992	2005	2010	Congress
Walk-In Coolers and Freezers	EISA 2007	2007	2009	Congress
Commercial Refrigeration Equipment	EPACT 2005	2009	2012	DOE
Commercial Pre-rinse Spray Valves	EPACT 2005	2005	2006	Congress
Distribution Transformers: Low-Voltage Dry-Type	EPACT 2005	2005	2007	Congress
Unit Heaters	EPACT 2005	2005	2008	Congress
Commercial CAC and HPs (Air-Cooled, Very Large)	EPACT 1992	2005	2010	Congress
Commercial Clothes Washers	EPACT 2005	2010	2013	DOE
Refrigerated Beverage Vending Machines	EPACT 2005	2009	2012	DOE
Automatic Commercial Ice Makers	EPACT 2005	2005	2010	Congress

Electric Motors	EPACT 1992	2007	2010	Congress
Commercial Packaged Boilers	EPACT 1992	2009	2012	DOE
Packaged Terminal AC and HP	EPACT 1992	2008	2010	DOE
Commercial CAC and HPs (Water- and Evaporatively Cooled)	EPACT 1992	2012	2013	DOE
Hot Food Holding Cabinets	None			
Water Dispensers	None			
General Service Incandescent Lamps	None	2007	2012	Congress
General Service Fluorescent Lamps	EPACT 1992	2009	2012	DOE
Fluorescent Lamp Ballasts	NAECA 1988	2011	2014	DOE
Metal Halide Lamp Fixtures	EISA 2007	2007	2009	Congress
Ceiling Fan Light Kits	EPACT 2005	2005	2007	Congress
Torchieres	EPACT 2005	2005	2006	Congress
Incandescent Reflector Lamps	EPACT 1992	2009	2012	DOE
Illuminated Exit Signs	EPACT 2005	2005	2006	Congress
Traffic Signal Modules and Pedestrian Modules	EPACT 2005	2005	2006	Congress
Candelabra & Intermediate Base Incandescent Lamps	None	2007	2012	Congress
Medium Base Compact Fluorescent Lamps	EPACT 2005	2005	2006	Congress
Mercury Vapor Lamp Ballasts	EPACT 2005	2005	2008	Congress
Products Not in Effect from 2005-2015				
Battery Chargers	EPACT 2005	None	None	N/A
Microwave Ovens	NAECA 1987	None	None	DOE
Commercial Warm Air Furnaces	EPACT 1992	2004		
Commercial Water Heating Equipment	EPACT 1992	2001	2003	DOE
High-Intensity Discharge Lamps	not till 2017			
Residential Clothes Dryers	NAECA 1987	2011	2015	DOE
Residential Water Heaters	NAECA 1987	2010	2015	DOE
Furnaces	NAECA 1987	2011 (revoked)	2013	DOE

Data Forms for Individual Products

Residential Dishwashers

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Cycles per Year	Average annual washing cycle	Yes, different from DOE	5P/6P: 215 cycles/yr (For all Res Housing Types); RBSA (2012): 170 cycles/yr (Single Family) RBSA (2012): 109 cycles/yr (Multi-Family) RBSA (2012): 116 cycles/yr (Manufactured Homes)	215	Update with RBSA values for Single Family and Manufactured Homes. Options for multi-family are either 5P/6P 215 cycles per year or RBSA 2012 170 cycles per year (single family) used for multi-family.	RBSA (2012), NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
	Water Heating Fuel Share	DHW heating market share by fuel type	Yes, different from DOE	55% electric (Single Family);95% electric (Multi-Family); 89% electric (Manufactured Housing)	37% electric, 59% gas, 4% oil	Regional water heating fuel share is used	RBSA (2012)
	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	Yes, different from DOE	Prior Federal Standard EF46 used as Baseline (Standard Configuration), 2005-2009	6 Efficiency Levels for Standard Configuration Dishwashers and three Efficiency Levels for Compact Configuration Dishwashers	DOE has more efficiency tiers and product classes	NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	Yes, different from DOE	Energy Star EF65 used as Baseline (Standard Configuration), 2010-2034			NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
	2010 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	Prior Federal Standard EF46 (484 kWh/yr)	Standard Configuration - 2010 Federal Standard: EF 61 (355 kWh/yr) Compact Configuration - 2010 Federal Standard: EF 83 (260 kWh/yr)	Council's Sixth Plan baseline (Energy Star EF 65) is more efficient than the 2010 Federal Standard for Standard Configuration Dishwashers (EF 61).	NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA

	2013 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	Energy Star EF65 (330 kWh/yr)	Standard Configuration - 2013 Federal Standard: EF 70 (307 kWh/yr) Compact Configuration - 2013 Federal Standard: EF 97 (222 kWh/yr)		
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes, differen t from DOE	1 product class (Standard Configuration) with the same EF	2 product classes with different EF's ; 99.8% Standard Configuration and 0.20% Compact Configuration	The Council's baseline did not distinguish Standard vs. Compact configuration equipment. Suggest to analyze standard configuration only for simplicity	NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
Market	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes, differen t from DOE	Not applicable since the 2013 standard was not included in 5P/6P. 6P baseline is above 2010 standard level.	2 product classes with different EF's ; 99.8% Standard Configuration and 0.20% Compact Configuration for 2010 standard and 2013 standard years	The Council's baseline did not distinguish Standard vs. Compact configuration equipment. Suggest to analyze standard configuration only. Note that Council's Sixth Plan baseline (Energy Star EF 65) is more efficient than the 2010 Federal Standard for Standard Configuration Dishwashers (EF 61).	NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
Market	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, differen t from DOE	100% at EF 46 from 2005-2009; 100% at EF 65 from 2010-2034	Weighted average of 197 kWh/yr	Using frozen efficiency as the Pre-Case	NW Council Supply Curve: EStarResDishwasherFY09v1_0, DOE RES Dishwasher NIA
Market	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, differen t from DOE	Not applicable since the 2013 standard was not included in 5P/6P Baselines	Weighted average of 187 kWh/yr	100% compliance after standard effective year in 2013.	Modeling assumption/DOE RES Dishwasher NIA

	Appliance Saturation	Saturation rate of Res Dishwashers in the NW region	No, same as DOE	5P/6P: 67% RBSA 2012: 89% (SF); 65% (Multi-Family); 77% (Manufactured)	DOE 2011: 96.7%	Use RBSA 2012 value	RBSA 2012
Stock Model	Historical Replacement Units Shipment in 2005	Number of residential dishwashers shipped to region in 2005	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	New Construction forecast	New construction forecast from 2005-2030	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	Product Lifetime	Res Dishwasher Product Lifetime	Yes, different from DOE	5P/6P: 9 yrs RTF UES measure workbook: 15.43	15.43	ACEE commented that the residential dishwasher lifetime should be 11 years on average. DOE NIA uses a 15.43 years average lifetime value based on an analysis of residential dishwasher lifetimes in the field. RTF claims 9 years from assumption in "PNWResSectorSupplyCurveUnits_6th_Fnl" workbook. Using DOE value as it is more current and has been updated to 15.43 years in the TSD based on field research.	DOE source: https://www.federalregister.gov/articles/2012/10/01/2012-23953/energy-conservation-program-energy-conservation-standards-for-dishwashers
	Turnover assumption	Product retirement rate	Yes, different from DOE	1/lifetime	Estimated using survey results from RECS and the U.S. Census American Housing Survey along with historic data on appliance shipments. Survival function (Variability characterized using Weibull probability distribution)	The 1/lifetime assumption is consistent with the Council's modeling practice. However, we can consider using survival functions.	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/dw_direct_final_rule_5_14_2012.pdf

Residential Clothes Washers

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Regional Data Source	DOE Data Source
Usage	Cycles per Year	Average annual washing cycle	Yes, different from DOE	352 (6P); 257 Single Family (RBSA 2012) ; 235 Multifamily (RBSA 2012); 233 manufactured home (RBSA 2012)	Top-Loading: 295 Front-Loading: 320	The RBSA is the most recent and regional data pertaining to SF cycles per year. 4.92 cycles per week.	RBSA2012; NW Council Supply Curve	2011 Residential Clothes Washers Direct Final Rule TSD (chapter 7)
	Washer Capacity	Average clothes washer size	Yes, different from DOE	3.10 cu. ft. (Sixth Plan); 3.46 cu. ft (RTF measure workbook)	3.10 cu.ft	The RTF measure work book is the most recent regional data source for Residential Clothes washers	Regional Technical Forum (2012) Residential Clotheswasher Workbook http://rtf.nwcouncil.org/measures/measure.asp?id=118; NW Council Supply Curve: Clothes Washers and Dryers - Single Family; Regional Technical Forum (2012)	Residential Clothes Washer NIA
	Water Heating Fuel Share	DHW heating market share by fuel type	N/A	64% electric (6P); 55%(SF) 95% (MF) 89% electric (MH) (RBSA 2012)	not available		RBSA2012; NW Council Supply Curve	
	Clothes Dryer Fuel Share	Clothes dryer market share by fuel type	N/A	82% electric (6P); 95% electric (RBSA 2012)	not available		RBSA2012; NW Council Supply Curve:	
	Baseline Device Efficiency	5P/6P Baseline	N/A	1.04 MEF (2004-2006); 1.26 MEF (starting in 2007); Sixth Plan Baseline (2010)- 1.66 MEF	not applicable	6P baseline is above 2007 RCW standard, this was not reflected in the DEE/DSTD workbook	6th Power Plan model code write-up sent to Navigant from the NW Council in 2013. NW Council Supply Curve: Clothes Washers and	

							Dryers - Single Family	
	2011 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	1.26 (2007-2010); 1.66 (2010 onwards)	Top-loading, standard: 1.26; Top-loading compact: 0.65; Front-loading 1.26; water factor 9.5		NW Council Supply Curve: Clothes Washers and Dryers - Single Family	
Market	Pre-Case Product Class Distribution	Number of product class(s) and distribution if standard did not exist	Yes, different from DOE	1 product class	3 product classes- top-loading standard and compact, and front loading	The Council's baseline did not distinguish front loading vs. top-loading equipment. In current analysis, we have two product classes with the same MEF in the Pre-Case	NW Council Supply Curve: Clothes Washers and Dryers - Single Family	
	Post-Case Product Class Distribution	Number of product class(s) and distribution factoring in the effective standard	Yes, different from DOE	1 product class	3 product classes- top loading and front loading	The Council's baseline did not distinguish front loading vs. top-loading equipment. There are two standards in the future that effect RCWs. 1 in 2015 and 1 in 2018. For Top-Loading (1.29 MEF) & Front-Loading (1.84 MEF). Both standards are outside analysis timeframe	N/A	2011 Residential Clothes Washers Direct Final Rule TSD (chapter 7)
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes different from DOE	100% at 1.04 from 2005-2006; 1.26 from 2007-2009; 100% at1.66 from 2010 till 2034	not available	NIA available for 2015 standards only, did not have NIA for 2007 standard		

	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, different from DOE	1.26 from 2007-2009; 100% at1.66 from 2010 till 2034	100% at 1.26 standard level	100% compliance at standard effective year		
	Appliance Saturation	Saturation rate of CCW in the NW region	No, same as DOE	99%	85%		RBSA Single family, multi-family, manufactured home	
Stock Model	Historical Replacement Units Shipment in 2005	Number of CCW shipped to region in 2005	Not applicable	Not applicable	Not applicable	Extracted data from supply curve	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook	
Stock Model	New Construction forecast	New construction forecast from 2005-2030	Not applicable	Not applicable	Not applicable	Extracted data from supply curve	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook	
Stock Model	Product Lifetime	CCW product lifetime	No, same as DOE	14	14.2		NW Council Supply Curve: Clothes Washers and Dryers - Single Family	2011 Residential Clothes Washers Direct Final Rule TSD (Chapter 8)

External Power Supplies

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	UEC	Unit energy consumption (accounts for	Yes	6 kWh pre-2006, 2 kWh post 2006	Varies based on product class and CSL (see Assumptions tab).	DOE more specific	Regional: Code write-up DOE: EISA 2007 TSD

		hours of use per week and device efficiency)					
	Hours per week	Hours of use per week in various operational modes, application states, and usage trends.	Yes	Unclear	Varies based on frequency of use and mode	DOE more specific	DOE: NOPR TSD
	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	Yes	0.983 (2006) (Unclear what units are)	Varies based on product class and CSL. 30% efficiency for 2.75 W rep. unit baseline, 66% for 18 W rep. unit baseline, 78% for 90 W rep. unit baseline	DOE more specific	Regional: Code write-up DOE: EISA 2007 TSD
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	Yes	0.983*1.05 (2008-2034) (Unclear what units are)	Varies based on product class and CSL (see Assumptions tab).	DOE more specific	Regional: Code write-up DOE: EISA 2007 TSD
	2008 Standard Device Efficiency	Device efficiency after standard took effect	Yes	Unclear	Active Mode: <1 W: 0.5 x Nameplate output 1-51 W: 0.09 x ln(Nameplate output) + 0.5 >51 W: 0.85 No-load mode: 0.5 watts	DOE more specific	DOE: 10 CFR 430.32 (w)
	2013 Standard Device Efficiency	Device efficiency after standard took effect	Yes	Not included	TBD (rulemaking not finalized)	DOE more specific	http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/28
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes	No product class separations	EISA 2007: See Table 9.9 in EISA TSD DOE NOPR: See NIA Inputs tab, cells E124:K130	DOE more specific	DOE EISA 2007 TSD DOE NOPR NIA
Market	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes	No product class separations	EISA 2007 TSD: A (0 to < 4 W), B (>= 4 W, <= 60 W), F (> 60 W) DOE NOPR: B (AC-DC, Basic Voltage), C (AC-DC, Low Voltage), D (AC-AC, Basic Voltage), E (AC-AC, Low Voltage), X (Multiple-	DOE more specific	DOE EISA 2007 TSD DOE NOPR NIA

					voltage), H (High power). For B, C, D, E, X: < 1 watt, 1-49 W, >49 W For H:> 250 W		
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes	No product class separations	EISA 2007: See Table 9.9 in EISA TSD DOE NOPR: See NIA Inputs tab, cells E124:K130	DOE more specific; Added market share specified for CSL 0 to market share at CSL 1 and assumed 0% share at CSL 0 for Product Class A.	DOE EISA 2007 TSD DOE NOPR NIA
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes	No product class separations	EISA 2007: See Table 9.9 in EISA TSD DOE NOPR: Roll up assumption	DOE more specific; Calculated efficiency distribution for CSL 3 and higher	DOE EISA 2007 TSD DOE NOPR TSD
	Appliance Saturation	Saturation rate of external power supplies in the NW region	Yes	Sales volume in 2006: 198 million (times 4% for PNW)	Not included	Use 4% of DOE shipments for NW	Regional: Code write-up
Stock Model	Historical Replacement Units Shipment in 2005	Number of external power supplies shipped to region in 2005	Yes	Not included	See NIA EPS tabs (e.g., EPS B 2.5 W) for shipments from 2009-2061.	DOE more specific	DOE NOPR NIA
	New Construction forecast	New construction forecast from 2005-2030	Yes	Not included	Based on population growth rate (0.75 percent)	DOE more specific	DOE NOPR TSD
	Product Lifetime	External Power Supply Product Lifetime	Yes	Not included	DOE NOPR: See NIA Inputs tab, cells AA62:AA68	DOE more specific	DOE NOPR NIA
	Turnover assumption	Product retirement rate	Yes	Not included	DOE NOPR: See NIA Inputs tab, cells AB62:AP68	DOE more specific	DOE NOPR NIA

Residential Water Heater (Single Family, Multi-Family, Manufactured Homes)

	Input	Description	Regional Value Different from DOE	Regional Value	DOE Value	Notes	Data Source

			NIA?				
Usage	Annual days of operation	Number of days water heater operates	No	365	365? (could not find it stated)	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls
	Storage Tank Temperature	Nominal mean storage tank temperature	Yes	135F	138F (annual average)	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Cold Water Temperature	Nominal cold water supply temperature	Yes	58F	51.1F (annual average)	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Daily hot water consumption	Water used per day (gallons)	Yes	49 gallons	66.2 gallons (annual average)	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Heat capacity	Specific heat capacity of water (assumed to be constant at each draw)	Yes	0.99789815612014 Btu/F lb	1.000743 Btu/F lb	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Water density	Density of water in lb/gal at the mean outlet water temperature	Yes	8.204 lb/gal	8.29 lb/gal	Regional value more specific to NW	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	N/A	0.9 EF	N/A	Tom Eckman: Both the 5th and Sixth Plans assumed an average tank size for electric water heating of 50 gal. HPWH were evaluated at both the 80 gal and 50 gal sizes, but I used the 50 gal to represent the average across all building types. We used EF – .90 as the baseline efficiency for	Code write-up

						both the 5th and Sixth Plan, since that was the fed standard for a 50 gal tank.	
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	N/A	DOE 2004 standard level (0.97−(0.00132 × Rated Storage Volume in gallons)) (30 gallons: 0.93 EF, 40 gallons: 0.92 EF, 50 gallons, 0.90 EF, 66 gallons: 0.88 EF, 75 gallons: 0.87 EF, 80 gallons: 0.86 EF, 85 gallons: 0.86 EF, 105 gallons: 0.83 EF, 119 gallons: 0.81 EF)	N/A	Tom Eckman: Both the 5th and Sixth Plans assumed an average tank size for electric water heating of 50 gal. HPWH were evaluated at both the 80 gal and 50 gal sizes, but I used the 50 gal to represent the average across all building types. We used EF – .90 as the baseline efficiency for both the 5th and Sixth Plan, since that was the fed standard for a 50 gal tank.	Supply Curve - RESDHWFY09v1_1.xls
	2004 Standard Device Efficiency	Device efficiency after standard took effect	N/A	N/A	0.97−(0.00132 × Rated Storage Volume in gallons)	Used DOE equations to account for standard	10 CFR 430.32 (d)
	2015 Standard Device Efficiency	Device efficiency after standard took effect	N/A	N/A	For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.960−(0.0003 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 2.057−(0.00113 × Rated Storage Volume in gallons).	Used DOE equations to account for standard	10 CFR 430.32 (d)
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes	30, 40, 50, 66, 75, 80, 85, 105, 119 gallons	30,40,50,66,80,119 gallons	Only 50 gallons modeled	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)

	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes	6P: 30, 40, 50, 66, 75, 80, 85, 105, 119 gallons RBSA: 88.3% 0-55 gallons, 11.7% >55 gallons (SF), 100% 0-55 gal (manuf)	Distribution by efficiency level for each gallon value (Basecase EF tab)	Only 50 gallons modeled	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	No	All at baseline level (which was the same as DOE 2004 standards)	DOE 2004 standard level	DOE and Regional are the same	Supply Curve - RESDHWFY09v1_1.xls, DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes	2015 standard not included	For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.960−(0.0003 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 2.057−(0.00113 × Rated Storage Volume in gallons).	Used DOE standard	10 CFR 430.32 (d)
	Appliance Saturation	Saturation rate of Res Water Heaters in the NW region	Yes	6P: 64% (electric water heating) RBSA: 1.002 water heaters per home (Manu), 1.05 water heaters per home (SF), 88.9% electric in region (Manu), 55.2% electric in region (SF)	44.7%? (Electric WH basecase market share 2006-2045, see NIA New Housing Market Shares tab)	Regional value more specific to NW	6P: PNWResSectorSupplyCurveUnits_6th_Fnl, DHW & Appliance Units Tab; DOE NIA (Residential Water Heater_Final Rule_NIA Workbook.xls)
Stock Model	Historical Replacement Units Shipment in 2005	Number of residential water heaters shipped to	N/A	Data from supply curve	Shipment data on national scale	Regional value more specific to NW. Multiplied by RBSA saturation.	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook; DOE NIA (Residential Water Heater_Final Rule_NIA

		region in 2005					Workbook.xls)
	New Construction forecast	New construction forecast from 2005-2030	N/A	Data from supply curve	Shipment data on national scale	Regional value more specific to NW. Multiplied by RBSA saturation.	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook; DOE NIA (Residential Water Heater_Final Rule_NIA Workbook.xls)
	Product Lifetime	Res Water Heater Product Lifetime	Yes	6P: 12 years (electric water heating) (15 years is used in supply curve)	11.6 years	DOE data more recent	6P: PNWResSectorSupplyCurveUnits_6th_Fnl, DHW & Appliance Units Tab, Supply Curve - RESDHWFY09v1_1.xls; DOE-LCC (2010-03-26_Life_Cycle_Cost_Electric_Storage_Water_Heaters.xls)
	Turnover assumption	Product retirement rate	Yes	1/lifetime	Retirement function based on life expectancy (see Retirement Function tab)	Council assumption	6P: PNWResSectorSupplyCurveUnits_6th_Fnl, DHW & Appliance Units Tab; DOE NIA (Residential Water Heater_Final Rule_NIA Workbook.xls)
	Abandon rate	Retired units not replaced	No	Not included	Not included	N/A	

Ceiling Fan Lighting Kits

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	Suggested Value	Notes	Data Source
Usage	Operating hours per year	Op hours of ceiling fan kit lights	N/A	631 hrs/yr (SF); 485 hrs/yr (MF); 703 hrs/yr (MH)			Source: RBSA 2012
	5P Baseline Device Efficiency	5th Plan baseline device	N/A	N/A	75kWh (SF); 58 kWh (MF);84		Source: RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment.

		efficiency			kWh(MH)		
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency	N/A	N/A	75kWh (SF); 58 kWh (MF);84 kWh(MH)	Standard came in 5P period. Since this measure was not included in the plans, the Pre-Case stays the same.	Source: RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment.
	2007 Standard Device Efficiency	Device efficiency after standard took effect	N/A	N/A	70 kWh(SF); 45 kWh (MF); 68 kWh (MH)		Source: RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment.
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	N/A	N/A	1 product class		
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	N/A	N/A	1 product class		
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	N/A	N/A	100% at Pre-Case efficacy		Engineering assumption consistent with other products
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	N/A	N/A	100% at Post-Case efficacy		Engineering assumption consistent with other products
	Appliance Saturation	Saturation rate of CFLK in the NW region	N/A	N/A	104%		RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment
Sto ck	Historical Replacemen	Number of Torchieres	N/A	Housing projections	Housing projections		6P Supply Curve; PNWResSectorSupplyCurveUnits_6th_Fnl

	t Units Shipment in 2005	shipped to region in 2005		for residential sector (6P Supply Curve)	for residential sector (6P Supply Curve)		
	New Construction forecast	New construction forecast from 2005-2030	N/A	Housing projections for residential sector (6P Supply Curve)	Housing projections for residential sector (6P Supply Curve)		6P Supply Curve; PNWResSectorSupplyCurveUnits_6th_Fnl
	Product Lifetime	Torchieres Product Lifetime	N/A	N/A	13 years	Ceiling fans have a life expectancy of 7 to 18 years, 13 is the average value. Where the light might outlast the ceiling fan, the lifetime of the CFLK is assumed to be the same as the ceiling fan	Source: Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development;http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Ceiling_Fan.pdf
	Turnover assumption	Product retirement rate	N/A	N/A	1/lifetime		Engineering assumption consistent with other products

Torchieres

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	Suggested Value	Notes	Data Source
Usage	Operating hours per year	Operating hours of torchieres	N/A	N/A	1.95 hrs/day (SF); 1.32 hrs/day (MF); 2.08 hrs/day (MH)	Source analysis attached in workbook.	RBSA 2012
	5P Baseline Device Efficiency	5th Plan baseline device efficiency	N/A	N/A	98 kWh (SF); 66kWh (MF); 104 kWh (MH)		RBSA 2012 .
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency	N/A	N/A	98 kWh (SF); 66kWh (MF); 104 kWh (MH)	Standard came in 5P period. Since this measure was not included in the plans, the Pre-Case stays the	RBSA 2012

						same.	
	2006 Standard Device Efficiency	Device efficiency after standard took effect	N/A	N/A	77kWh(SF) 45 kWh (MF); 73 kWh (MH)		DOE (10 CFR 430.32)
	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	N/A	N/A	45% Incandescent; 41% Halogen; 14% CFL		RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment. Table 46
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	N/A	N/A	45% Incandescent; 41% Halogen; 14% CFL		RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment. Table 46
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	N/A	N/A	100% at Pre-Case device efficiency		Engineering assumption
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	N/A	N/A	100% at Post-Case device efficiency		Engineering assumption
Market	Appliance Saturation	Saturation rate of Torchiere in the NW region	N/A	N/A	32%		RLW Analytics, 2007. Single-Family Residential Existing Construction Stock Assessment

Stock Model	Historical Replacement Units Shipment in 2005	Number of Torchieres shipped to region in 2005	N/A	Housing projections for residential sector (6P Supply Curve)	N/A		6P Supply Curve; PNWResSectorSupplyCurveUnits_6th_Fnl
	New Construction forecast	New construction forecast from 2005-2030	N/A	Housing projections for residential sector (6P Supply Curve)	N/A		6P Supply Curve; PNWResSectorSupplyCurveUnits_6th_Fnl
	Product Lifetime	Torchieres Product Lifetime	N/A	N/A	7 years		LBNL. 1997. Alternative to energy-Hogging Halogen Torchieres Invented Here. http://www.lbl.gov/Science-Articles/Archive/fluorescent-torchiere.html
	Turnover assumption	Product retirement rate	N/A	N/A	1/lifetime		Engineering assumption consistent with other products

Residential Refrigerator (Single Family, Multi-Family, Manufactured Homes)

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Adjusted volume	Refrigerator volume	Yes	see Refrigerator table, adjusted volume updated with new standard equation	See Refrigerator tab	Adjusted volume updated with new standard equation	RBSA 2012
	Adj. volume scalar	Energy use scalar (Federal Specifications) to	No	1.63	Specific to product class, see assumptions tab; each adjustment	same value	2014 Federal Standards Specifications

		account for increased energy use by the freezer			includes an Energy Standard Adjustment Factor(ESAF) and a Volume Calculation Adjustment Factor (VCAF)		
	HVAC Interaction Factor	Efficient refrigerators reduce building internal heat gains, thus reducing cooling loads and increasing heating loads.	N/A	0.86	N/A	Indicated in the Supply Curve workbook, this number is based on weighted average impact across all new residential construction	6P supply curve; EStarRefrigeratorFY09v1_0
	5P Pre-Case annual UEC	Annual energy usage (kWh) from 2005-2009	N/A	19.17 EF which is 545 kWh (need clarification from the Council); no impact on savings, standard occurred during 6P in 2014	weighted average: 541 kWh	Need clarification from the Council	
	6P Pre-Case annual UEC	Annual energy usage (kWh) from 2010- 2014	Yes	Weighted average by market share: 545 kWh; current practice; see refrigerator tables tab	weighted average: 541 kWh	Use regional value, adjust baseline using RBSA data	6P supply curve; EStarRefrigeratorFY09v1_0
	2014 Standard Efficiency	Maximum annual kWh use allowed by standard	No	see Refrigerator Tables tab	See Refrigerator tab	This analysis will calculate kWh with most recent data from RBSA and DOE	10 CFR 430.32(a)
Market	Product Classes	Residential refrigerator configurations	Yes	6 configurations, see Refrigerator Tables tab	32 configurations	Using regional configurations to be consistent with Sixth Plan and other regional efforts.	Residential Refrigerator Supply Curve Workbook: EStarRefrigeratorFY09v1_0
	Product Classes Distribution	Market share of each product class	Yes	RTF bottom freezer w/ice- 6%; bottom freezer w/o ice- 17%; side-by-side w/ice thru door- 38%; side-by-side w/o thru	Product switching occurs, during 2010: 24% Side by side, 58% Top, 11% Bottom. Market share of refrigerator products	Use DOE distribution	Standard-Size Refrigerator and Ref-Freezer NIA Final Rule Workbook

				door- 6%; top freezer w/ic thru door- 0%; top freezer w/o ice thru door- 32%	changes over time. Slight decline of top mount refrigerators over the years. E.g., 59% in 2010, 46.4% in 2043 forecast.		
	Pre-Case Efficiency Tiers and Distribution	Number of efficiency Pre-Case efficiency tiers and distribution	Yes	1 efficiency Tier (market average) for each configuration	Depending on configurations, 3-4 Pre-Case efficiency tiers for each configuration.	Use market 6P Supply curve market average	Residential Refrigerator Supply Curve Workbook: EStarRefrigeratorFY09v1_0
	Post-Case Efficiency Tiers and Distributions	Number of efficiency Post-Case efficiency tiers and distribution	Yes	N/A	100% at 2014 standard level	Modeling assumption: all shipments meet federal standards as standards took effect	Standard-Size Refrigerator and Ref-Freezer NIA Final Rule Workbook
	Saturation	Number of refrigerator in each household	Yes	1.12 (6P); 1.29 (RBSA SF); 1.03 (RBSA MF); 1.2 (RBSA MH)	114%	Use RBSA value	RBSA single family report 2012; RBSA manufactured homes report 2012
Stock Model	lifetime	Product lifetime	Yes	19 years (6P); 17.43 (RTF)	17.43 years	Use 17.43 years (more current data vintage)	2011 final rule TSD Ref and Freezers
	Turnover assumption	Rate of replacement	Yes	1/lifetime	Survival curve	Consistent with other Council analyses	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	Historical Replacement Units Shipment in 2005	Number of refrigerators shipped to region in 2005	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	New Construction forecast	New construction forecast from 2005-2030	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook

Residential Freezer (Single Family, Multi-Family, Manufactured Homes)

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Adjusted volume	Refrigerator volume	Yes	See Freezers Table tab, use RBSA data adjusted with 2014 new test standards adjustments	See Freezers Table tab	The regional and DOE upright freezers show similar volume. Chest freezer has a larger difference.	RBSA 2012 SF, MF, MH data DOE data
	Adj. volume scalar	Energy use scalar (Federal Specifications) to account for increased energy use by the freezer	No	1.73	Specific to product class, see assumptions tab; each adjustment includes an Energy Standard Adjustment Factor(ESAF) and a Volume Calculation Adjustment Factor (VCAF)	same value	2014 Federal specifications
	HVAC Interaction Factor	Efficient refrigerators reduce building internal heat gains, thus reducing cooling loads and increasing heating loads.	Yes	0.86 interaction	N/A	6P has included an interaction factor	6P Supply Curve: EstarResFreezersFY09v1_0
	5P Pre-Case annual UEC	Annual energy usage (kWh) from 2005-2009	Yes, slightly	19.17 EF. 559 kWh	weighted avg. 529 kWh (market avg)	Use regional value, adjust baseline using RBSA data	6P Supply Curve: EstarResFreezersFY09v1_0
	6P Pre-Case annual UEC	Annual energy usage (kWh) from 2010-2014	Yes, slightly	weighted avg. 559 kWh (market avg)	weighted avg. 529 kWh (market avg)	Use regional value, adjust baseline using RBSA data	6P supply curve; EStarRefrigeratorFY09v1_0
	2014 Standard Efficiency	Maximum annual kWh use allowed by standard	No	See Freezers Table tab	See Freezers Table tab	This analysis calculates kWh with most recent data from RBSA adjusted with 2014	10 CFR 430.32(a)

						federal test standards	
Market	Product Classes	Residential freezer configurations	Yes	4 configurations	5 configurations, same configurations as in the 6P plus (built-in) Upright freezers with automatic defrost	Using regional configurations to be consistent with Sixth Plan and other regional efforts.	6P Supply Curve: EstarResFreezersFY09v1_0
	Product Classes Distribution	Market share of each product class	Yes	See Freezers Table tab, about 60% upright freezer	See Freezers Table tab, 40%- chest freezers; 42%- upright freezer- auto defrost; 17%- upright freezer- manual defrost	Use DOE NIA Workbook Distribution	DOE NIA Workbook Distribution
	Pre-Case Efficiency Tiers and Distribution	Number of efficiency Pre-Case efficiency tiers and distribution	Yes	1 Efficiency Tier, market average	Depending on configuration, 3-4 efficiency tiers	Since the roll-up kWh is very similar, use regional 6P baseline	6P Supply Curve: EstarResFreezersFY09v1_0
	Post-Case Efficiency Tiers and Distributions	Number of efficiency Post-Case efficiency tiers and distribution	N/A	N/A	100% at 2014 standard level	Modeling assumption	Modeling assumption
	Saturation	Number of refrigerator in each household	Yes	57% (6P); 53% (RBSA SF); 4% (RBSA MF); 43% (RBSA MH)	34%	Use RBSA data	RBSA 2012 SF, MF, MH data
Stock Model	lifetime	Product lifetime	No	22	22.7	same assumption	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	Turnover assumption	Rate of replacement	Yes	1/lifetime	Survival Curve	Consistent with other Council analyses	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook
	Historical Replacement Units Shipment in 2005	Number of refrigerators shipped to region in 2005	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook

	New Construction forecast	New construction forecast from 2005-2030	Not applicable	Data from supply curve	Not applicable	Regional numbers	PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook

Residential HVAC Heat Pump (Single Family, Multi-Family, Manufactured Homes)

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	5P Baseline Device Efficiency, Used RTF SEEM 92 runs for Regional Heat Pump Upgrades	5th Plan baseline device efficiency tiers - Follows ASHRAE 90.1-1999	Yes, different from DOE	Existing HSPF 7.7/SEER 13 Heat Pump & w/oPTCS Duct Sealing & Commissioning. Zonal Weighting from PNWClimateZones_6thPlan.xls.	Follows 10 CFR 430.32(c) for the following iterations: 1992 for Split Systems (10 SEER, 6.8 HSPF) 1993 for Single Package Systems (9.7 SEER, 6.6 HSPF)	DOE has more efficiency tiers and product classes	NW Council Supply Curve: PNWResSpaceConditioningCurve_6thPlanv1_8 ,10 CFR 430.32(c) , Furnaces & CAC Direct Final Rule NIA (RES North Census Region)
	6P Baseline Device Efficiency, Used RTF SEEM 92 runs for Regional Heat Pump Upgrades	Sixth Plan baseline device efficiency tiers - Follows ASHRAE 90.1-2010	Yes, different from DOE				
	2006 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	Upgrade to HSPF 8.5/SEER 14 Heat Pump & w/PTCS Duct Sealing & Commissioning. Additional Option for Upgrade to HSPF 9.0/SEER 14 Heat Pump & w/PTCS Duct Sealing & Commissioning. Zonal Weighting from PNWClimateZones_6thPlan.xls.	Follows 10 CFR 430.32(c) for the following iterations: 2006 for Split Systems (13 SEER, 7.7 HSPF) 2006 for Single Package Systems (13 SEER, 7.7 HSPF) 2015 for Split Systems (14 SEER, 8.2 HSPF) 2015 for Single Package Systems (14 SEER, 8 HSPF)		
	2015 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE				

Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes, different from DOE	1 product class: Existing HSPF 7.7/SEER 13 Heat Pump & w/oPTCS Duct Sealing & Commissioning. Zonal Weighting from PNWClimateZones_6thPlan.xls.	2 Product Classes: 87.7% distributed for Split Systems, 12.3% distributed for Single Package Systems across all building types and vintages.	DOE has more efficiency tiers and product classes	NW Council Supply Curve: PNWResSpaceConditioningCurve_6thPlanv1_8 ,10 CFR 430.32(c) , Furnaces & CAC Direct Final Rule NIA (RES North Census Region)
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes, different from DOE	1 product class:			
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, different from DOE	100% at 13 SEER 7.7 HSPF from 2005-2010 (5P), 100% at 13 SEER 7.7 HSPF from 2010+ (6P)	Shipments Follows 10 CFR 430.32(c) for the following iterations: 100% from 1992-2005 for Split Systems (10 SEER, 6.8 HSPF) 100% from 1993-2005 for Single Package Systems (9.7 SEER, 6.6 HSPF)		
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, different from DOE	100% at 14 SEER 8.5 HSPF from 2010-2034	Shipments follows 10 CFR 430.32(c) for the following iterations: 100% from 2006-2015 for Split Systems (13 SEER, 7.7 HSPF) 100% from 2006-2015 for Single Package Systems (13 SEER, 7.7 HSPF) 100% for >2015 for Split Systems (14 SEER, 8.2 HSPF) 100% for >2015 for Single Package Systems (14 SEER, 8 HSPF)		

	Appliance Saturation	Saturation rate of Res HPs in the NW region	Yes, different from DOE	Saturation Rates for Existing Construction based on 2011 RBSA by building type for primary electric heating system air-source heat pump distributions. Saturation Rates for New Construction based on Distribution of PNW Existing and New Residential Space Heating Units into PNW Residential Water Heating and Appliance Units Central A/C End-Use from 2007 NEEA New Construction Characteristics study Residential Single Family: 11.40% Existing Construction, 4% New Construction Residential Multi-Family: 1.10% Existing Construction, 1% New Construction Residential Manufactured Homes: 14.40% Existing Construction, 7% New Construction	Based on Historic Shipments Data to North Census Region.		
Stock Model	Historical Replacement Units Shipment in 2005	Number of residential heat pumps shipped to region in 2005	Not applicable	Data from supply curve, adjusted for RBSA 2011 heat pump central AC fractions for all building types	AHRI Shipments Data to North Census Region	Regional numbers	NW Council Supply Curve: PNWResSpaceConditioningCurve_6thPlanv1_8 ,10 CFR 430.32(c) , Furnaces & CAC Direct Final Rule NIA (RES North Census Region)
	New Construction forecast	New construction forecast from 2005-2030	Not applicable	Data from supply curve	Not applicable	Regional numbers	

	Product Lifetime	Res HP Product Lifetime	Yes, different from DOE	5P/6P: 18 Years RTF UES upgrades measure workbooks: 15-20 Years	16.72	DOE value of 16.72 years applicable for split and single package heat pumps	
	Turnover assumption	Product retirement rate	Yes, different from DOE	1/lifetime	Based on Weibull Survival Function	The 1/lifetime assumption is consistent with the Council's modeling practice. However, we can consider using survival functions.	

Commercial CAC Air-Cooled Central Air Conditioners and Heat Pumps

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	Yes, different from DOE	Uses EUI approach, varies by building type. Baseline	Follows 71FR 73170 for the following iterations: Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-CO - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 11 Mixed Market EER: 9.9	DOE has more efficiency tiers and product	NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 71 FR 73170, Furnaces & CAC Direct

	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	Yes, different from DOE	efficiencies follow ASHRAE 90.1 promulgated equipment efficiencies for 2010. Efficiency tiers defined by CEE Tiers 1 through 3 (2008).	Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-BC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 12 Mixed Market EER: 10.56 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PAC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 13 Mixed Market EER: 11.18 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 14 Mixed Market EER: 11.76 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 15 Mixed Market EER: 12.3 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 11 Mixed Market EER: 9.9 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 12 Mixed Market EER: 10.56 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 13 Mixed Market EER: 11.18 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 14 Mixed Market EER: 11.76 Standard Effective Year 2003: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 15 Mixed Market EER: 12.3 Standard Effective Year 2003: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 11 Mixed Market EER: 9.9 Standard Effective Year 2003: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 135,000 and	classes: SAC-CO: Split Air Conditioner - Coil Only SAC-BC: Split Air Conditioner - Blower Coil PAC - Packaged Air Conditioner SHP - Split Heat Pump PHP - Packaged Heat Pump	Final Rule NIA (COM North Census Region)

					<240,000 Mixed Market SEER: 12 Mixed Market EER: 10.56 Standard Effective Year 2003: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 13 Mixed Market EER: 11.18 Standard Effective Year 2003: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 14 Mixed Market EER: 11.76 Standard Effective Year 2003: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 15 Mixed Market EER: 12.3 Standard Effective Year 2003: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 11 Mixed Market EER: 9.9 Standard Effective Year 2003: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 12 Mixed Market EER: 10.56 Standard Effective Year 2003: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 13 Mixed Market EER: 11.18 Standard Effective Year 2003: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 14 Mixed Market EER: 11.76 Standard Effective Year 2003: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 15 Mixed Market EER: 12.3		

	2008 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE		Follows 10 CFR 431.97 for the following iterations: Standard Effective Year 2008: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-CO - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 11.03 Mixed Market EER: 9.920382 Standard Effective Year 2008: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-BC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 12.03 Mixed Market EER: 10.579182 Standard Effective Year 2008: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PAC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 13.03 Mixed Market EER: 11.197982 Standard Effective Year 2008: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 14.03 Mixed Market EER: 11.776782 Standard Effective Year 2008: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 15.03 Mixed Market EER: 12.315582		NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 10 CFR 431.97, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)

	2010 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE		Follows 10 CFR 431.97 for the following iterations: Standard Effective Year 2010: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 11.05 Mixed Market EER: 9.93395 Standard Effective Year 2010: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 12.05 Mixed Market EER: 10.59195 Standard Effective Year 2010: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 13.05 Mixed Market EER: 11.20995 Standard Effective Year 2010: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 14.05 Mixed Market EER: 11.78795 Standard Effective Year 2010: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 15.05 Mixed Market EER: 12.32595 Standard Effective Year 2010: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 11.05 Mixed Market EER: 9.93395 Standard Effective Year 2010: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 12.05 Mixed Market EER: 10.59195 Standard Effective Year 2010: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 13.05 Mixed Market EER: 11.20995 Standard Effective Year 2010: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP -		

					Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 14.05 Mixed Market EER: 11.78795 Standard Effective Year 2010: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 15.05 Mixed Market EER: 12.32595 Standard Effective Year 2010: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 11.05 Mixed Market EER: 9.93395 Standard Effective Year 2010: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 12.05 Mixed Market EER: 10.59195 Standard Effective Year 2010: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 13.05 Mixed Market EER: 11.20995 Standard Effective Year 2010: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 14.05 Mixed Market EER: 11.78795 Standard Effective Year 2010: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 15.05 Mixed Market EER: 12.32595			

	2016 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE		Follows 10 CFR 431.97 for the following iterations: Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-CO - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 11.11 Mixed Market EER: 9.974558 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SAC-BC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 12.11 Mixed Market EER: 10.630158 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PAC - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 13.11 Mixed Market EER: 11.245758 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) SHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 14.11 Mixed Market EER: 11.821358 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled, 3 Phase) PHP - Configuration (Primary-Secondary) <65,000 Mixed Market SEER: 15.11 Mixed Market EER: 12.356958 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 11.11 Mixed Market EER: 9.974558 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 12.11 Mixed Market EER: 10.630158 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 13.11 Mixed Market EER: 11.245758 Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 14.11 Mixed Market EER: 11.821358		

					Standard Effective Year 2016: Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 65,000 and <135,000 Mixed Market SEER: 15.11 Mixed Market EER: 12.356958 Standard Effective Year 2016: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 11.11 Mixed Market EER: 9.974558 Standard Effective Year 2016: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 12.11 Mixed Market EER: 10.630158 Standard Effective Year 2016: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 13.11 Mixed Market EER: 11.245758 Standard Effective Year 2016: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 14.11 Mixed Market EER: 11.821358 Standard Effective Year 2016: Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 135,000 and <240,000 Mixed Market SEER: 15.11 Mixed Market EER: 12.356958 Standard Effective Year 2016: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-CO - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 11.11 Mixed Market EER: 9.974558 Standard Effective Year 2016: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SAC-BC - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 12.11 Mixed Market EER: 10.630158 Standard Effective Year 2016: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PAC - Configuration (Primary-Secondary) >=		

					240,000 and <760,000 Mixed Market SEER: 13.11 Mixed Market EER: 11.245758 Standard Effective Year 2016: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) SHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 14.11 Mixed Market EER: 11.821358 Standard Effective Year 2016: Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled) PHP - Configuration (Primary-Secondary) >= 240,000 and <760,000 Mixed Market SEER: 15.11 Mixed Market EER: 12.356958		
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes, different from DOE	Uses EUI approach, varies by building type. Baseline efficiencies follow ASHRAE 90.1 promulgated equipment efficiencies for 2010. Efficiency	Based on backcast of 2008 and 2010 DOE standard years to 2005. Market Mix determined from 2012 AHRI shipments data disaggregated by DOE standards size categories.	Scaled via SEER and EER ratios	NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 71 FR 73170, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
	Post-Case case product class distribution	Number of product class(s) and distribution	Yes, different from DOE		From AHRI Historic and Projected Shipments from 1972-2009 and DOE forecast out to 2045.		NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 71 FR 73170,

		factoring in the effective standard		tiers defined by CEE Tiers 1 through 3 (2008).			Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, different from DOE				NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 71 FR 73170, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, different from DOE				NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 71 FR 73170, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
	Appliance Saturation	Saturation rate of Commercial Air-Cooled Single Package and Split DX and Heat Pump systems in the NW region	Yes, different from DOE	Uses EUI approach, saturations vary by building type.	Based on Historic and Forecasted Shipments broken out by Product Class, Size, and Configuration for the North Census Region scaled to the PNW.	North Census Region scaled to PNW through ratio of AEO North Census Region Floor space to Council 6P Forecast.	NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
Stock Model	Historical Replacement Units Shipment in 2005	Number of Commercial Air-Cooled Single Package and Split DX and Heat Pump systems shipped to region in 2005	Yes, different from DOE	Uses EUI approach applied to commercial floor space by building type and vintage.	From AHRI Historic and Projected Shipments from 1972-2009 forecasted out to 2045. Market Mix determined from 2012 AHRI shipments data disaggregated by DOE standards size categories.		NW Council Supply Curve: PC-HVACEQUIP-6P-D7, NW COM Master workbook, 10 CFR 431.97, Furnaces & CAC Direct Final Rule NIA (COM North Census Region)
	New Construction	New construction	Yes, different		Based on AEO 2010 for commercial North Census Region.	Scaled to PNW region	

	forecast	forecast from 2005-2030	from DOE			via Council 6P commercial floor space forecast by year.	
	Product Lifetime	Commercial Air-Cooled Single Package and Split DX and Heat Pump systems Product Lifetime(s)	Yes, different from DOE	Lifetime variable by building type ranging from 20 to 30 years.	19.48 years for air-cooled commercial dx commercial air conditioners and 16.72 years for air-cooled commercial heat pumps.		
	Turnover assumption	Product retirement rate	Yes, different from DOE	1/lifetime	Based on Weibull Survival Function with an average lifetime of 19.48 years for air-cooled commercial dx air conditioners, 16.72 years for air-cooled commercial heat pumps, and maximal lifetime of 60 years for all units.		

Commercial CAC Water-Evaporatively Cooled Central Air Conditioners

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	Yes, different from DOE	ASHRAE 90.1-1999 Central, Water-Source HP (>17kBtuh <65 kBtuh): No Standard Central, Water-Cooled AC (<65 kBtu/h): EER 12.1, COP 4.2	**DOE Historic Standards:** EPAct 1992 - ASHRAE 90.1-1999 (66 FR 3336) EPAct 2005 - Amended Standards (70 FR 60407) EISA 2007 - Amended Standards ASHRAE 90.1-2007 (FR 36312)	Both DOE and Council are in-line with ASHRAE 90.1-1999 and ASHRAE 90.1-2007 (2010 values) Standards. 5P and 6P have additional options of higher efficiency tiers	PC-HVACEQUIP-6P-D7, DOE Water and Evaporatively Cooled NIA (EERE-2011-BT-STD-0029-0022), DOE Baseline: 10 CFR

	2003 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	Central, Water-Cooled AC/HP (>65kBtuh <135kBtuh): EER 11.5, COP 4.2 Central, Water-Cooled AC/HP (>135kBtuh <240kBtuh): EER 11.0	**Baseline: DOE Standards and Effective Years (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 1) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, E/N, 11.5, 8, 2003 2) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, O, 11.3, 8, 2003 3) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, E/N, 11, 15, 2004 4) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, O, 11, 15, 2004 5) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, E/N, 11, 35, 2011 6) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, O, 10.8, 35, 2011 7) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, E/N, 11.5, NO MODELS, 2003 8) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, O, 11.3, NO MODELS, 2003 9) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and	such as CEE and Energy Star. "No Models" for representative capacity indicates that DOE did not model the product tier due to limited data availability. Note that DOE also has the option of ASHRAE to 15 EER and 15 EER+ (approaching Max Tech to Max Tech levels).	431.97, DOE Standard: 77 FR 28928
	2004 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE				
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	Yes, different from DOE	ASHRAE 90.1-2007 (Promulgated efficiencies for 2010) Central, Water-Source HP (>17kBtuh <65 kBtuh): EER 12.0 Central, Water-Cooled AC (<65 kBtu/h): EER 12.1 Central, Water-Cooled AC/HP (>65kBtuh <135kBtuh): EER 11.3 Central, Water-Cooled AC/HP (>135kBtuh <240kBtuh): EER 10.8			
	2011 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE				
	2013 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE				

				<240,000 Btu/h, E/N, 11, NO MODELS, 2004 10) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, O, 11, NO MODELS, 2004 11) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, E/N, 11, 40, 2011 12) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, O, 10.8, 40, 2011 **Standard: DOE Standards and Effective Years (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 1) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, E/N, 12.1, 8, 2013 2) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, O, 11.9, 8, 2013 3) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, E/N, 12.5, 15, 2014 4) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, O, 12.3, 15, 2014 5) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, E/N, 12.4, 35, 2014 6) Very Large Commercial Package Air-Conditioning and Heating Equipment		

					(Water-Cooled), >=240,000 and <760,000 Btu/h, O, 12.2, 35, 2014 7) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, E/N, 12.1, NO MODELS, 2013 8) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, O, 11.9, NO MODELS, 2013 9) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, E/N, 12, NO MODELS, 2014 10) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, O, 11.8, NO MODELS, 2014 11) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, E/N, 11.9, 40, 2014 12) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, O, 11.7, 40, 2014		

Market	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, different from DOE	ASHRAE 90.1-1999 Central, Water-Source HP (>17kBtuh <65 kBtuh): No Standard Central, Water-Cooled AC (<65 kBtu/h): EER 12.1, COP 4.2 Central, Water-Cooled AC/HP (>65kBtuh <135kBtuh): EER 11.5, COP 4.2 Central, Water-Cooled AC/HP (>135kBtuh <240kBtuh): EER 11.0	**Backcast at DOE Standards Pre-Case for effective year 2003 (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 1) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, E/N, 11.5, 8, 2003 2) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, O, 11.3, 8, 2003 7) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, E/N, 11.5, NO MODELS, 2003 8) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, O, 11.3, NO MODELS, 2003 **Backcast at DOE Standards Pre-Case for effective year 2004 (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 3) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, E/N, 11, 15, 2004 4) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, O, 11, 15, 2004 9) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, E/N, 11, NO MODELS, 2004 10) Large Commercial Package Air-Conditioning and Heating Equipment	Using frozen efficiency as the Pre-Case	PC-HVACEQUIP-6P-D7, DOE Water and Evaporatively Cooled NIA (EERE-2011-BT-STD-0029-0022), DOE Baseline: 10 CFR 431.97, DOE Standard: 77 FR 28928

					(Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, O, 11, NO MODELS, 2004 **Backcast at DOE Standards Pre-Case for effective year 2011 (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 5) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, E/N, 11, 35, 2011 6) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, O, 10.8, 35, 2011 11) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, E/N, 11, 40, 2011 12) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, O, 10.8, 40, 2011		
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, different from DOE	ASHRAE 90.1-2007 (Promulgated efficiencies for 2010) Central, Water-Source HP (>17kBtuh <65 kBtuh): EER 12.0 Central, Water-Cooled AC (<65 kBtu/h): EER 12.1 Central, Water-Cooled AC/HP (>65kBtuh <135kBtuh): EER 11.3 Central, Water-Cooled AC/HP (>135kBtuh <240kBtuh): EER 10.8	**Postcast at DOE Standards effective 2013 (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 1) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, E/N, 12.1, 8, 2013 2) Small Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=65,000 and <135,000 Btu/h, O, 11.9, 8, 2013 7) Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, E/N, 12.1, NO MODELS, 2013 8) Small Commercial Package Air-	Installed UEC diffusion after DOE standard compliance year rolling up to ASHRAE 90.1-2010 levels. Note that DOE also has the option of ASHRAE to 15 EER and 15 EER+ (approaching Max Tech to Max Tech levels). These distributions were rolled into the ASHRAE standard level for code minimum compliance.	

					Conditioning and Heating Equipment (Evaporatively Cooled), >=65,000 and <135,000 Btu/h, O, 11.9, NO MODELS, 2013 **Postcast at DOE Standards effective 2014 (Product Class, Cooling Capacity, Heating Type, Efficiency Level (EER), Representative Capacity, Compliance Year):** 3) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, E/N, 12.5, 15, 2014 4) Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >= 135,000 and <240,000 Btu/h, O, 12.3, 15, 2014 5) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, E/N, 12.4, 35, 2014 6) Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled), >=240,000 and <760,000 Btu/h, O, 12.2, 35, 2014 9) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, E/N, 12, NO MODELS, 2014 10) Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >= 135,000 and <240,000 Btu/h, O, 11.8, NO MODELS, 2014 11) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, E/N, 11.9, 40, 2014 12) Very Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively Cooled), >=240,000 and <760,000 Btu/h, O, 11.7, 40, 2014		

	Appliance Saturation	Saturation rate of commercial air conditioners in the NW region	No, same as DOE	Baseline saturation at 10%		Use DOE values scaled to region by EIA-AEO 2013 to 6P Council forecast of commercial floor space.	
Stock Model	Historical Replacement Units Shipments	Number of commercial water and evaporatively cooled central air conditioner shipments to region.	Yes, differen t from DOE	EUI approach applied to commercial floor space and saturation by sector and building type.	AHRI historic shipments from 1989 to 2009 and DOE forecast from 2009 to 2046 for Small AC Water-cooled (65 to 134.9 kBtu/h), Large AC Water-Cooled (135 to 249 kBtu/h), Very Large AC Water-Cooled (250 & Over kBtu/h).	Annual AHRI market mix for shipments based on DOE analysis.	PC-HVACEQUIP-6P-D7, DOE Water and Evaporatively Cooled NIA (EERE-2011-BT-STD-0029-0022), DOE Baseline: 10 CFR 431.97, DOE Standard: 77 FR 28928
	Commercial Floor space	Council forecast from 2005-2030	Not applica ble	Data from supply curve	Based on EIA-AEO 2013.	Regional-to-EIA scaling by floor space applied to AHRI national shipment values.	Commercial floor space from Commercial_FlrSpace_Forecast_6P workbook. National EIA data from AEO 2013.
	Product Lifetime	Res Dishwasher Product Lifetime	Yes, differen t from DOE	Varies by sector and building type with lifetime ranging from 20 to 30 years.	15	The mean product lifetime from the prior DOE TSD was 15.4 years. Based on recent sources such as DEER 2008 DOE has lowered the mean product lifetime to 15 years for their analysis of water and evaporatively cooled central air-conditioning products.	PC-HVACEQUIP-6P-D7, DOE Water and Evaporatively Cooled NIA (EERE-2011-BT-STD-0029-0022), DOE Baseline: 10 CFR 431.97, DOE Standard: 77 FR 28928
	Turnover assumption	Product retirement rate	Yes, differen t from DOE	1/lifetime	Based on DOE analysis of product lifetimes and ASHRAE market mix.	The 1/lifetime assumption is consistent with the Council's modeling practice. However, we can consider using survival functions.	

Package Terminal Air-Conditioning and Heat Pump

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Average Annual Energy Consumption per Unit (UEC) by Efficiency Level	Average annual washing cycle	Yes, different from DOE	Regional values are based on EUI estimates from regional and national studies.	Varies by State and Efficiency Level. Example for PTAC 9000 Btuh pulled from LCC data (units in kWh per year): **PTAC Standard Size - 9,000 Btu/h** **Idaho:** Base = 674, Level 1 = 666 **Montana:** Base = 640, Level 1 = 633 **Oregon:** Base = 645, Level 1 = 637 **Washington:** Base = 597, Level 1 = 591 **US Average:** Base = 1045, Level 1 = 1026 Note that DOE calculated the weighted average annual energy use for each PTAC and PTHP equipment class in each state through the population weighting of the representative climate location(s) within the state. DOE further aggregated the energy use at the state level to national average energy use using the 2000 Census population data, published by the U.S. Census Bureau.		Council Data Source: PC-HVACEQUIP-6P-D7 workbook, DOE Data Source: PTAC/PTHP NIA workbook, Chapter 7 of the PTAC & PTHP NIA TSD: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ptac_pthp_tsd/chapter_7.pdf
	Equipment Fuel Share	PTAC & PTHP market share by fuel type	Yes, different from DOE	Cooling and Heating Loads are estimated as a best guess based on several sources including: CBECS, CEUS, EUITYPCool, and ETO (New & Existing). Electric resistance space heat electric equivalent estimate best guesses are based on gas heat	DOE used the variable "ELHT18" (electricity used for main heating) to exclude buildings using fuel sources other than electricity for space heating, because PTAC and PTHP equipment using electricity are the only equipment considered in the federal rulemaking.		

				estimates from CBECS, CEUS, and ElecHtEUITYPHeat.			
	HVAC Interactive Effects	Interaction factor with other measures which reduce cooling loads	Yes, different from DOE	90%	Interactive factor is lumped with Average Annual Energy Consumption per unit (UEC) by Efficiency Level. DOE used a complex whole-building hourly energy simulation approach with DOE-2.1E (generally referred to as DOE-2). DOE used the Energy Information Agency (EIA) 2003 Commercial Building Energy Consumption Survey (2003 CBECS) as the primary source of data to develop the representative building size and other building characteristics for the analysis (i.e. aspect ratio, building construction type, etc.).		
	5P Baseline Device Efficiency	5th Plan baseline device efficiency tiers	Yes, different from DOE	The Council's basecase EERs are based on ASHRAE 90.1-1999 from 2004 to 2008. From 2008 onwards the Council basecase EER's are based on ASHRAE 2010 efficiencies. 5P documentation looks to show an update to 2008 standards and CEE efficiency tiers (in the "to do" tab from Council data source completion dated 10/15/2008).	DOE's baseline device EERs (efficiencies) are based on the efficiency levels specified by AHSRAE/IESNA Standard 90.1-1999).		
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency tiers	Yes, different from DOE				
	2010 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	Council standard device efficiencies are at the highest 2008 CEE efficiency level for four types of equipment: Unitary, Chiller, Water-Source HP, and Air-Source HP. These are not	2010 Standard device efficiencies pertain to "Non-Standard-Sized" units manufactured on or after September 30, 2010 only. "Non-Standard-Sized" units are represented in the DOE NIA for PTAC & PTHP at the 11000 Btuh size.		

	2012 Standard Device Efficiency	Device efficiency after standard took effect	Yes, different from DOE	explicitly documented in the "National Standards - Unitary" tab as indicated in the "6PSourceSummary" tab in the Council source. Baseline device efficiencies for cooling (PTAC & PTHP units) and heating (PTHP units) are however documented in the Council source within the "National Standards - Unitary" tab.	2012 Standard device efficiencies pertain to "standard-sized" units manufactured on or after September 30, 2012 only. "Standard-Sized" units are represented in the DOE NIA for PTAC & PTHP at 9000 & 12000 Btuh sizes.		
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	Yes, different from DOE	Pre-Case product class distribution based on ASHRAE 90.1-1999 (DOE rulemaking inputs) and Post-Case product class distributions are based on ASHRAE 90.1-2007 (with promulgated ASHRAE Equipment Efficiencies for 2010)	3 Product Classes for PTAC and PTHP each respectively (6 total product classes). Individual product classes based on (1) equipment type (either PTAC or PTHP) and (2) product size (ranges from standard size units at 9000 and 12000 Btuh to non-standard size units at 11000 Btuh). Each Product Class is further divided by six efficiency levels (Baseline plus five higher efficiency levels). The total number of unique combinations of equipment configurations and specifications is equal to: 6 Product Classes * 6 Efficiency Levels = 36 unique combinations. Selection of the pre and standards case levels for each of the six distinct product class-size combination determines the Pre-Case and Post-Case product class market distributions that are provided on a per year basis from 2012 through 2046. For the purposes of this analysis years 2005 through 2012 are backcasted. DOE's basecase EER's (unit efficiencies) are based on ASHRAE/IESNA Standard 90.1-1999. Market shifts are calculated post 2012 for standard size units and post 2010 for non-standard size units to reflect the impact of federal standards (reference "energy conservation standards" from Buildings		Council Data Source: PC-HVACEQUIP-6P-D7 workbook, DOE Data Source: PTAC/PTHP NIA workbook, Chapter 7 of the PTAC & PTHP NIA TSD: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ptac_pthp_tsd/chapter_7.pdf
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes, different from DOE				
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, different from DOE				
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Yes, different from DOE				

					Technologies Office for Packaged Terminal Air Conditioners and Heat Pumps).		
	Appliance Saturation	Saturation rate of Commercial PTAC & PTHP units in the NW region	Yes, different from DOE	Council estimates vary by vintage and building type.	Not Applicable	Final results in the BPA analysis to be adjusted via Council regional appliance saturation numbers by building type.	
Stock Model	Historical Replacement Units Shipment in 2005	Number of commercial PTAC & PTHP units shipped to region in 2005	Yes, different from DOE	Data based on historical and projected Commercial Floor space	Historical shipments from ARI's shipment data were broken out by specific PTAC and PTHP equipment classes for 10 years (1997-2006) and used to calibrate DOE's shipments model (based on a survival function) to the existing market. The 2001 Ducker Worldwide market study was also used to supplement the ARI shipments data.		Council Data Source: PC-HVACEQUIP-6P-D7 workbook, DOE Data Source: PTAC/PTHP NIA workbook, Chapter 10 of the PTAC & PTHP NIA TSD: https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ptac_pthp_tsd/chapter_10.pdf
	New Construction forecast	New construction forecast from 2005-2030	Yes, different from DOE		Generally, new construction shipments are based off projected floor space construction after the year 2003 from AEO 2006.	Final results in the BPA analysis are scaled via regional Council commercial floor space projections.	
	Product Lifetime	Commercial PTAC & PTHP lifetimes	Yes, different from DOE	Varies based on building type. Range from 20 to 30 years.	10	Based on discussions with industry experts and available literature reviews, DOE used a typical (Note: Average) equipment life of 10 years for their shipments analysis (maximum life of 20 years). DOE noted that available information suggested that the initial existing stock of equipment is assumed to have an average age of five years, based on the ten-	

						year lifetime of a unit of equipment, and annual replacements going back 10 years.	
	Turnover assumption	Product retirement rate	Yes, different from DOE	1/lifetime	Equipment stock flows as a function of year and age. No coupling is assumed between equipment categories (i.e. DOE found no evidence of equipment switching between equipment classes for PTAC and PTHP's). DOE also believes that changing PTAC sleeve sizes generally does not happen and thus replacements are assumed to be the same size as the equipment they replace.		

Commercial Clothes Washer Commercial Sector

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Regional Data Source	DOE Data Source
Usage	Cycles per Year	Average annual washing cycle	Only DOE value available	2190 (Laundromat); 141 (Multi-Family Not in Unit)	2190	DOE Commercial Clotheswashers NIA, assumption for laundromat	NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA
	Washer Capacity	Average clothes washer size	Commercial washer size available in the MF sector	2.83 cu.ft	2.83 cu.ft	DOE Commercial Clotheswashers NIA	NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA

	Water Heating Fuel Share	DHW heating market share by fuel type	Yes, different from DOE	64% electric (Laundromat); 95% electric (Multi-Family Not in Unit)	20% electric	Regional water heating fuel share is used	NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA
	Clothes Dryer Fuel Share	Clothes dryer market share by fuel type	Yes, different from DOE	82% electric (Laundromat); 99% (Multi-Family Not in Unit)	40% electric	Regional water heating fuel share is used	NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA
	6P Baseline device efficiency	Sixth Plan device efficiency tiers	Commercial washer efficiency tiers available in the MF sector	2 efficiency levels; 1.04 MEF 2005-2006; 1.26 MEF 2007-2030	5 efficiency levels for front loading, and three levels for top loading	DOE has more efficiency tiers and product classes	6th Power Plan model code write-up sent to Navigant from the NW Council in 2013.	DOE Commercial Clotheswashers NIA
	Standard device efficiency	Device efficiency after standard took effect	Commercial washer efficiency tiers available in the MF sector	N/A	2.0 MEF front loading; 1.6 MEF top loading	current values are up to date; the 2012 standard was not included in the Council's forecast	N/A	DOE Commercial Clotheswashers NIA
Market	Basecase product class distribution	Number of product class(s) and distribution if standard did not exist	Yes, different from DOE	1 product class with the same MEF	2 product classes with different MEF's ; 30% Front Loading and 70% Top loading		N/A	DOE Commercial Clotheswashers NIA
	Standard case product class distribution	Number of product class(s) and distribution factoring in the effective standard	Yes, different from DOE	Not applicable since the 2012 was not included in the 6P baseline	2 product classes with different MEF's; 30% Front Loading and 70% Top loading		N/A	DOE Commercial Clotheswashers NIA

	Basecase efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Yes, different from DOE	100% at 1.04 MEF 2005-2006; 100% at 1.26 MEF 2007-2030	70% at 2012 standard efficiency level for front loading; 2% at 2012 standard efficiency level for top loading		N/A	DOE Commercial Clotheswashers NIA
	Standard case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Only DOE analysis available	Not applicable since the product was not included in the commercial sector	100% at standard level	100% compliance at standard effective year	N/A	DOE Commercial Clotheswashers NIA
	Appliance Saturation	Saturation rate of CCW in the NW region	Yes	15% (Laundromat); 43% (Multi-Family Not in Unit)	N/A		RBSA 2012 14.7% of multi-family units do not have access to in-building or in-unit washing machines	CBSA 2009 Final Report; DOE Commercial Clotheswashers NIA
Stock Model	Historical Replacement Units Shipment in 2005	Number of CCW shipped to region in 2005	Yes, different from DOE	Data from Supply Curve, MF sector	Not applicable		PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook	DOE Commercial Clotheswashers NIA
	New Construction forecast	New construction forecast from 2005-2030	Only DOE analysis available	Data from Supply Curve, MF sector	Not applicable		PNW Residential Sector Load Forecast Copied from PNWResSectorSupplyCurveUnits_6th_Fnl workbook	DOE Commercial Clotheswashers NIA
	Product Lifetime	CCW product lifetime	Yes, different from DOE	14	7.13	Using DOE lifetime because it is more robust	NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA
	Turnover Assumption	Retirement Rate	Yes, different from DOE	1/lifetime	Survival curve based on Weibull distribution		NW Council Supply Curve: EStarWasher_DryerComLaundry_FY09v1_0	DOE Commercial Clotheswashers NIA
	Abandon Rate	Retired units not replaced	Yes, different	0%	12%	The Council's baseline did not account for	N/A	DOE Commercial Clotheswashers NIA

			from DOE			abandon rate		

Commercial Refrigeration

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	6P Pre-Case	Efficiency level in the 6P	Yes	The 6P Supply curve used the 2010 and 2012 standards as the baseline for the CRE products. However, the Council assumed TSL 4 for Beverage Vending Machine products as the standard while the final rule is TSL 6 for Class A vending machines and TSL 3 for Class B machines.	N/A	See workbook for details	PC_Packaged_Refrig_Equipment.xls
	5P Pre-Case device efficiency	Efficiency level at 2005	No	TSL level 1	TSL level 1	No difference	DOE NIA Commercial Refrigeration Product workbook
	2010 standard	minimum standard	No	See Standards tab; UEC weighted by shipment	See std tab; UEC weighted by shipment	No difference	DOE NIA Commercial Refrigeration Product workbook
	2012 standard	minimum standard	Yes	Final beverage vending machine standard level is different; same otherwise	See std tab		DOE NIA Commercial Refrigeration Product workbook
	Refrigerator and Freezer Volume	Refrigerator and freezer volume in cu.ft. Affects 2010 refrigerator and freezer products	Yes	updated with RTF 2012 analysis data: 31.3 cu.ft	N/A		RTF 2012 ComFreezer_v3 workbook; ComRefrigerator_v3 workbook

	Number of product classes	Number of product classes	No	4 groups of refrigeration products, (1) ref &frz- 6 product classes ; (2) non-hybrid ref-frez- 15 product classes (3) ice-maker- 3 product classes (4) beverage vending machine- 1 product classes	Same	See product classes tab	PC_Packaged_Refrig_Equipment.xls; DOE NIA workbook
	Shipment for non-hybrid products	Shipment by year for replacement and new units	No	Shipment of refrigeration products by Freedonia, Uses ARI 2005 shipment data to break out market shares of each product class, shipment number scaled to 4% for regional value	Shipment of refrigeration products by Freedonia, Uses ARI 2005 shipment data to break out market shares of each product class, shipment number scaled to 4% for regional value. Shipment model includes lifetime of CRE stock, replacement and new shipments. The distribution of stock in year t is a function of age of the equipment to year t+1		DOE TSD Chapter 10 shipment model; CRE_Final_Rule_NIA_Workbook
	Shipment for ref and frz products	Equipment shipment by year	N/A	No regional value, use 2008 appliance magazine value and scale to region with 4%	N/A		PC_Packaged_Refrig_Equipment.xls;
Market	Shipment for ice-maker and beverage machines	Equipment shipment by year	N/A	No regional value, use ACEEE 2002 data on approximate annual sales	N/A		PC_Packaged_Refrig_Equipment.xls;
Stock Model	Shipment Growth Rate	Shipment growth rate based on forecast	No	6P uses NIA analysis, therefore all shipment assumptions are the same	New equipment is driven by construction of new floor space and replacement units are replaced on a one-for-one basis		DOE TSD Chapter 10 shipment model; CRE_Final_Rule_NIA_Workbook

	Lifetime	Product Lifetime	N/A	Since the shipment units used in the supply curve is the same as the numbers from the NIA, the lifetime is the same for the shipment model. The documented lifetime is 10years on average.	Average to be 10 years in large grocery chains, and 15 years in small stores; Using an average of 10 years to be consistent with the 6P.		DOE TSD Chapter 10 shipment model; CRE_Final_Rule_NIA_Workbook

Commercial/Industrial Liquid-Immersed and Dry-Type Distribution Transformers

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	6P Baseline device efficiency	Sixth Plan baseline device efficiency tiers	Only DOE Data Currently Available	Only DOE Data Currently Available	DOE Assumes least efficient transformer available on the market pre-standards case. Baseline Efficiency levels for Liquid-Immersed Transformers are approximately 98.91% to 99.42% (TSL-1). Baseline Low-Voltage Dry-Type Transformer efficiencies are approximately 98% to 98.6% (TSL-2). Baseline Medium-Voltage Dry-Type Transformer efficiencies are approximately 98.63% to 99.22% (TSL-2).	Distribution Transformers not highlighted in DEE or DESTD. Therefore, code write-up does not reflect the baseline used although we could potentially use the % savings from the Industrial tool to see if the baseline is consistent with DOE as the % savings in the industrial tool is documented as sourced from DOE rulemaking.	PNW Industrial Tool Supply Curves (Section Updated 2009), DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf

	Standard device efficiency	Device efficiency after standard took effect	No	1.5% Savings for RET (Retrofit), 0.4% Savings for NEW (Replacements). Industrial tool workbook does not document TSL efficiency levels used to generate savings results.	TSL-1 for Liquid-Immersed and TSL-2 for Dry-Type Transformers. Standard case Efficiency levels for Liquid-Immersed Transformers are approximately 98.95% to 99.49% (TSL-1). Standard case Low-Voltage Dry-Type Transformer efficiencies are approximately 98% to 99.02% (TSL-2). Standard case Medium-Voltage Dry-Type Transformer efficiencies are approximately 98.69% to 99.37% (TSL-2).	Industrial tool documentation shows that the savings are consistent as per U.S. DOE Rulemaking. DOE has more efficiency tiers and product classes.	PNW Industrial Tool Supply Curves (Section Updated 2009), DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf
Market	Pre-Case & Post-Case product class distribution	Number of product class(s) and distribution for both cases of No Standard and Standard in Effect	Only DOE Data Currently Available	Only DOE Data Currently Available, Industrial Tool does not outline the breakouts by product classes. No documentation found in Industrial tool.	HVOLT 2001 Market Share estimates used to distinguish between different equipment classes and size categories within each equipment class. Trends in electricity consumption from EIA national retail sales data to project market share trends for liquid-immersed and dry-type transformers. Updated with regional electricity sales forecast.	Key DOE assumption behind market share methodology is that transformer capacity market shares follow the relative electricity consumption of the end users of the electricity that passes through the transformers. DOE also assumed that the relative market share within each transformer type (liquid-immersed or dry-type) will be constant over time.	DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf
Market	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	Only DOE Data Currently Available	Only DOE Data Currently Available, Industrial Tool does not outline the breakouts by product classes. Only % Savings for RET & NEW Scenarios	DOE Assumes least efficient transformer available on the market pre-standards case.	Baseline established by DOE 2007 rule for liquid-type and medium voltage dry-type transformers. EPACT 2005 establishes the baseline for low-	DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf

				which is documented as per DOE rulemaking. No documentation found in industrial tool.		voltage dry-type transformers.	
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	Only DOE Data Currently Available	Only DOE Data Currently Available, Industrial Tool does not outline the breakouts by product classes. Only % Savings for RET & NEW Scenarios which is documented as per DOE rulemaking. No documentation found in industrial tool.	100% at standard level for in-service transformers from the Basecase and Standard Case product class distribution that are purchased in or after the year the standard has taken effect.	DOE 100% compliance at standard effective year for units purchased in or after the year the standard has taken effect.	DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf
Stock Model	Shipments Data	Estimated shipments in MVA/year broken out by Liquid-Immersed and Dry-Type Distribution Transformers	Only DOE Data Currently Available	Only DOE Data Currently Available	From NIA, 2001 & 2009 years established from HVOLT (contractor) estimates of shipments. Backcast generated from BEA. Forecast generated from EIA & AEO 2011 US Electricity Sales and Revenue data (Utility). Updated with regional electricity sales forecast.	Can update with regional C/I incremental sales data (historic and projected) if available.	DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf
	Product Lifetime (NEW)	Lifetime of Product (non-early replacement, new capacity)	Yes	10	Variable	DOE assumes that the transformers shipments growth is equal to the forecasted growth in electricity consumption (Incremental C&I Sales) from EIA & AEO 2011 US Electricity Sales and Revenue data (Utility) <- we	PNW Industrial Tool Supply Curves (Section Updated 2009), DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf

						can update this if we have regional sales data.	
	Product Lifetime (RET)	Lifetime of Product (early replacement)	No	32	32	Industrial Supply tool follows U.S. DOE Rulemaking with 32-year average transformer lifetime.	PNW Industrial Tool Supply Curves (Section Updated 2009), DOE Distribution Transformers NIA (2010), http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdch9.pdf
	Turnover assumption	Product retirement rate	Yes	1/lifetime	Survival & Retirement functions (Weibull Curve adjusted to fit 32 year average lifetime assumption with maximum vintage of 60 years)	The 1/lifetime assumption is consistent with the Council's modeling practice. However, we can consider using survival and retirement functions.	PNW Industrial Tool Supply Curves (Section Updated 2009), DOE Distribution Transformers NIA (2010)

Electric Motors

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	Suggested Value	Notes	Data Source
Usage	Standard Effective Year	Year when standard comes into effect	N/A	N/A	2010	In 2010, the EISA standards update became effective; there are two parts to the standards savings (1) For motors not regulated by EPAct-92 to go to EPAct-92; (2) For all motors to go to 2010 standard level	DOE 10 CFR 431.25

	Product Classes	Number and distribution of product classes	Yes	For the commercial analysis, motors classes were not explicit. In the industrial tool, motor rewinds are distributed by product classes used in this analysis.	6 product classes in total; 1-5 HP; 6-20 HP; 21-50HP; 51-100 HP; 101-200 HP; 201-500 HP		Nadel, Steven. Energy-Efficient Motor Systems: A handbook on technology, program, and policy Opportunities. Second Edition
	Pre-Case efficiency level	Pre-standard efficiency level	N/A	Values were not explicit	Pre-Case efficiency developed for each product class, average Pre-Case shipment weighted UEC is 16,845 kWh		Nadel, Steven. Energy-Efficient Motor Systems: A handbook on technology, program, and policy Opportunities. Second Edition
	Post-Case efficiency level	Post-standard efficiency level	N/A	Values were not explicit	Post-Case efficiency developed for each product class, average Post-Case shipment weighted UEC is 16,486 kWh		Nadel, Steven. Energy-Efficient Motor Systems: A handbook on technology, program, and policy Opportunities. Second Edition
Market	Market Distribution by Sector	Electric Motors were shipped to commercial, industrial, and agricultural end-uses	N/A	Values were not explicit	According to the DOE Electric Motors Rulemaking; the distribution of electric motors averages to be 72% to commercial use and 28% to industrial use (excluding agricultural use)		DOE Electric Motors Rulemaking; http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/em_preanalysis_tsdch09.pdf
	Shipment by Product Class	Motor shipments by HP class	N/A	N/A	Shipment estimates developed using US Census data; MA 335H (03) and MA 335H (02); shipment data available from 2001-2003; shipment forecasted to 2005 using NEMA sales index		US Census, MA 335H(03) and MA 335H(02)
	Shipment Growth Rate	Sales Growth Estimate	N/A	N/A	1.40%		http://www.nema.org/News/Pages/Motors-Shipments-Improved-in-Fourth-Quarter-of-2012.aspx

	% Sales Applicable to Standards	Percentage of motor sales affected by the standard	N/A	N/A	Not all motors are subjected to the 2010 standards; the expanded motor regulation applies to 25% of the motors and the efficiency upgrade component of the standard applies to 65% of motors	HP 200-500 HP not regulated by the EISA 2010 update	ACEEE: Impact of Proposed Increases to Motor Efficiency Performance Standards, October 2007
Stock Model	Lifetime	Product lifetime	Yes	18 years for commercial ECM for VAV	Varies by motor classes; range from 17 years to 29 years	Since the different product classes have different lifetime values, each product class has its own stock model	Nadel, Steven. Energy-Efficient Motor Systems: A handbook on technology, program, and policy Opportunities. Second Edition
	Product Turnover Assumption	Stock-Turnover Rate	Yes	N/A	1/lifetime	1/lifetime turnover assumption to be consistent with other products (and for the lack of data)	Engineering Assumption

Illuminated Exit Signs

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Operating hours per year	24/7 operation	N/A	8760 hours/year	N/A	Used in supply curve, found in several resources including DOE 2008 Report	Supply Curve (PC_Exit_Sign_6P_D2.xls); http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_october2008.pdf
	Number of faces	Number of sides of the exit sign	N/A	2	N/A	Supply curve assumes all signs are double sided.	Supply Curve (PC_Exit_Sign_6P_D2.xls)

	5P Baseline Device Efficiency	5th Plan baseline device efficiency	N/A	Not included	N/A	N/A	N/A
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency	N/A	Incandescent 16 W/face, CFL 8.5 W/face, LED 3 W/face	N/A	Values for 2007	Supply Curve (PC_Exit_Sign_6P_D2.xls); http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_october2008.pdf
	2006 Standard Device Efficiency	Device efficiency after standard took effect	N/A	5 W/face	N/A	Regional standards never went into effect because of EPACT 2005	DOE (10 CFR 431 Subpart L)
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	N/A	85% LED, 10% CFL, 5% Incandescent in 2010	N/A		Supply Curve (PC_Exit_Sign_6P_D2.xls)
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	N/A	100% LED	N/A	Use frozen efficiency at EPACT level (5 W/face), which would be 100% LED	Supply Curve (PC_Exit_Sign_6P_D2.xls)
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	N/A	Incandescent 16 W/face, CFL 8.5 W/face, LED 3 W/face	N/A	Values for 2007	Supply Curve (PC_Exit_Sign_6P_D2.xls); http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_october2008.pdf
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	N/A	100% LED at 5 W/face	N/A	Use frozen efficiency at EPACT level (5 W/face)	DOE (10 CFR 431 Subpart L)
	Appliance Saturation	Saturation rate of exit signs in the NW region	N/A	1.5 million signs in 2010, scaled based on floor space for other years	N/A	Based on 2008 national value scaled to 2010 using 1.6% growth rate from 2008 report. Assumes 4% are in NW (from population?)	Supply Curve (PC_Exit_Sign_6P_D2.xls); http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_october2008.pdf

Stock Model	Historical Replacement Units Shipment in 2005	Number of exit signs shipped to region in 2005	N/A	Based on historical floor space calculations	N/A	Need to verify with Council that the pre-2010 values we selected are correct	Commercial Forecast 6P.xls
	New Construction forecast	New construction forecast from 2005-2030	N/A	Based on new floor space and 0.48 signs per 1000sf assumption. See Tab SC-NR cells B15:X18	N/A	Continue to use new floor space assumption, research signs per SF value	Supply Curve (PC_Exit_Sign_6P_D2.xls)
	Product Lifetime	Exit sign Product Lifetime	N/A	13.1 years (LED), 10 years (CFL and incandescent)	N/A	Commercial Master sheet says "Average of lighting system change rate weighted by type" and then calculates turnover rate as 1/13.1; Lifetime in supply curve listed as 13 years in MDataTestLED and MDataEquip tabs (but it is unclear if those tabs are relevant in this analysis)	Supply Curve (PC_Exit_Sign_6P_D2.xls); Commercial Master (Com_Master.xls); PC-ExitSigns-D1(Plan 5).xls
	Turnover assumption	Product retirement rate	N/A	1/lifetime	N/A	Commercial Master sheet says "Average of lighting system change rate weighted by type" and then calculates turnover rate as 1/13.1	Commercial Master (Com_Master.xls)
	Abandon Rate	Retired units not replaced	N/A	Not included	N/A	Assume it is 0% since exit signs are required for safety	N/A

Commercial Pre-Rinse Spray Valve

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Annual Days of Operation	Number of days per year spray valve is used	N/A	365.25 days per year	N/A	RTF file	Regional Technical Forum Workbook (ComCookingPreRinseSprayValv

							e_v2_0 available at http://rtf.nwcouncil.org/measures/
	Daily Hours of Use	Number of hours per day spray valve is used	N/A	0.63 hrs/day	N/A	From RTF file; Supply curve assumed 1.29 hours per day for 5th plan, 0.8 for food service hours Pre-Case, 1 for food service hours Post-Case, 0.1 for grocery service hours Pre-Case, 0.14 for grocery service hours Post-Case	Regional Technical Forum Workbook (ComCookingPreRinseSprayValve_v2_0 available at http://rtf.nwcouncil.org/measures/
	Change in water Temperature	Change in water temperature from source to fully heated	N/A	36.3F	N/A	From RTF file; 41.8F for food service and 30.3F for grocery service in supply curves	Regional Technical Forum Workbook (ComCookingPreRinseSprayValve_v2_0 available at http://rtf.nwcouncil.org/measures/
	Water Heating Efficiency	Efficiency of heating water used in spray valve	N/A	93% for electric	N/A	Water sense report uses 0.90 for electricity and 0.60 for natural gas http://www.epa.gov/WaterSense/docs/prsv_field_study_report_033111v2_508.pdf).	Supply Curve (C_Spray_Head_6P_D1.xls)
	5P Baseline Device Efficiency	5th Plan baseline device efficiency	N/A	Calculate based on 5500 kWh/head of savings from 5th plan	N/A		Supply Curve (C_Spray_Head_6P_D1.xls)
	6P Baseline Device Efficiency	Sixth Plan baseline device efficiency	N/A	1.6 gpm	N/A		Supply Curve (C_Spray_Head_6P_D1.xls)
	2006 Standard Device	Device efficiency after standard took effect	N/A	Flow rate of not more than 1.6 gpm	N/A		DOE (10 CFR 431 Subpart O)

	Efficiency							
Market	Pre-Case product class distribution	Number of product class(s) and distribution if standard did not exist	N/A	No product classes	N/A	RTF assumptions include all building types (food service, grocery, etc.)	Regional Technical Forum Workbook (ComCookingPreRinseSprayValve_v1_1) available at http://rtf.nwcouncil.org/measures/
	Post-Case case product class distribution	Number of product class(s) and distribution factoring in the effective standard	N/A	No product classes	N/A	RTF assumptions include all building types (food service, grocery, etc.)	Regional Technical Forum Workbook (ComCookingPreRinseSprayValve_v1_1) available at http://rtf.nwcouncil.org/measures/
	Pre-Case efficiency level distribution	Efficiency distribution of each product class if standard did not exist	N/A	100% at plan device efficiency levels	N/A	Use frozen efficiency at EPACT level from 2006 and later	DOE (10 CFR 431 Subpart O)
	Post-Case efficiency level distribution	Efficiency distribution of each product class factoring in the effective standard	N/A	Same as Pre-Case since standards were captured in 5P and 6P	N/A	Use frozen efficiency at EPACT level from 2006 and later	DOE (10 CFR 431 Subpart O)
	Appliance Saturation	Saturation rate of spray valves in the NW region	N/A	17,000 in 2010, scaled to other years using population growth rate	N/A	EPA Water Sense specifies 1.35 million nationally (http://www.epa.gov/WaterSense/docs/prsv_field_study_report_033111v2_508.pdf)	Supply Curve (C_Spray_Head_6P_D1.xls)
Stock Model	Historical Replacement Units Shipment in 2005	Number of spray valves shipped to region in 2005	N/A	Based on population and population growth rate calculations	N/A		Commercial Forecast 6P.xls
	New Construction forecast	New construction forecast from 2005-2030	N/A	Based on population growth rate	N/A		Supply Curve (C_Spray_Head_6P_D1.xls)
	Product	Product Lifetime	N/A	5 years	N/A		Supply Curve

	Lifetime						(C_Spray_Head_6P_D1.xls); Commercial Master (Com_Master.xls)
	Turnover assumption	Product retirement rate	N/A	1/lifetime	N/A		Commercial Master (Com_Master.xls)
	Abandon Rate	Retired units not replaced	N/A	Not included	N/A		N/A

Walk-in Coolers and Freezers

	Input	Description	Regional Value Different from DOE NIA?	Regional Value	DOE Value	Notes	Data Source
Usage	Standard Effective Year	Year when standard comes into effect	N/A	N/A	2009 (EISA); 2015 Standard Level built in but not executed		
	Product Classes	There are a total of 36 product classes. Each WICF have two components- (1) refrigeration system (2) envelope that includes the panel and the display doors. For specific details, refer to product class tab.	N/A	N/A	A WICF includes a (1) refrigeration system and (2) the envelope. The refrigerator system could be classified as multiplex/dedicated; low/med temperature; indoors/outdoors. Three size classes were evaluated (small, medium, and large). The envelope includes panels and doors. There is a total of 36 combinations between the refrigeration system and the envelope	See product class tab for details	DOE NIA Walk-in Coolers and Freezers NIA Preliminary Analysis Workbook
	Pre-Case efficiency	Efficiency level at pre-EISA (TSL -1) level.	N/A	N/A	Annual electricity use for each ref/envelope combination according to specifications in the DOE TSD.		DOE NIA Walk-in Coolers and Freezers NIA Workbook; 2015 Standards Rulemaking
	Post-Case efficiency	Efficiency level at EISA (TSL 0)	N/A	N/A	Annual electricity use for each ref/envelope combination according to specifications in the DOE TSD at EISA level.		DOE NIA Walk-in Coolers and Freezers NIA Workbook; 2015 Standards Rulemaking

Market	Shipment Data	Shipment data of each of the ref/box combination	N/A	CBSA has very sparse data on WICF, not sufficient for a robust analysis	Shipment data are collected from the WICF shipment model developed for the preliminary TSD. The refrigerator system and the boxes have different life times. Shipment models were developed for the following scenarios: (1) old ref system and old box; (2) new ref and old box (3) old ref and new box (4) new ref new box. Estimates were developed by the CBECS 2007 survey data and the U.S. Census Bureau Current Industrial Reports data,		DOE NIA Walk-in Coolers and Freezers preliminary analysis
	Pre-Case efficiency distribution	Pre-standard efficiency distribution	N/A	N/A	100% at pre-EISA efficiency level		Efficiency level sourced from DOE NIA Walk-in Coolers and Freezers Workbook; 2015 Rulemaking. Simplified assumptions for 100% pre-EISA level
	Post-Case efficiency distribution	Post-standard efficiency distribution	N/A	N/A	100% at EISA efficiency level	The 2015 standard (TSL 4 efficiency level) is built into the workbook but not executed	Efficiency level sourced from DOE NIA Walk-in Coolers and Freezers Workbook; 2015 Rulemaking. Simplified assumptions for 100% EISA level
	Shipment Growth Rate	Shipment growth rate of walk-in coolers distinguished by display and non-display coolers	N/A	N/A	Growth rate is estimated sourcing from CBECS data where market shares of display and non-display cooler was collected for five building types- grocery, food service, C-store, industry, and others.	Growth rate drives shipment in the model	DOE NIA Walk-in Coolers and Freezers preliminary analysis
Stock Model	HVAC Interaction Factor	Heat output from a walk-in interacts with the functioning of the HVAC systems in its building. Walk-ins of greater efficiency may produce slightly less heat, altering the interaction.	N/A	N/A	1 (no significant impact)	Most walk-ins are cooled by outdoor compressors, which reject their waste heat outside the building rather than	DOE Preliminary TSD; Chapter 10 .3.1.3

						inside. The interaction has no measureable effect	
	Scalar	Scale national analysis to regional analysis	N/A	N/A	Walk-in Cooler and Freezers- 6P Refrigeration end-use EUI is used as the baseline. Due to the lack of data granularity of the refrigeration end-use from CBSA 2009, the regional distribution of commercial refrigeration equipment type cannot be determined. The savings percentage from the walk-in Cooler and Freezer standard impact analysis is applied to the baseline refrigeration EUI based on 6P. Walk-in Cooler and Freezers are not included in the 6P Supply curve; therefore there is no baseline adjustment.	Consistent with other workbooks	Engineering Assumption
	Lifetime	Lifetime is defined as when a refrigeration system or a component fails or needed replacement	N/A	N/A	Envelope: 15 years, Refrigeration System 12 years, Doors: 14 years	Lifetime of WICF averages to be 15 years.	DOE WICF NOPR_TSD Chapter 9
	Lifetime Turnover Assumptions	Rate of replacement	N/A	N/A	Weibull 3.5 scale, 14 shape, 3 delay; ref weibull 3.5 scale, 7 shape, 1 delay; door weibull scale 2; shape=5; delay 1	See distribution parameter tab for details	DOE WICF NOPR_TSD Chapter 9

BONNEVILLE POWER ADMINISTRATION

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