Market Research Report

ENERGY EFFICIENT LIGHTING IN NEW CONSTRUCTION

prepared by

Ecos Consulting

report #02-100

May, 2002

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Residential New Construction Lighting Program
Market Research Summary Report

March 21, 2002

Prepared By:

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Making a World of Difference

EXECUTIVE SUMMARY

This Report summarizes the background research funded by the Northwest Energy Efficiency Alliance (the Alliance) in support of the design and development of a Residential New Construction Program for the Pacific NW.[1] This innovative program will focus entirely on increasing the use of energy efficient lighting in residential construction, and is an extension of the successful NW Residential Lighting Program.

To assist in a successful program design, the background research was intended to identify the following elements:

- The status of residential construction in the Northwest,
- A baseline for lighting energy use in residential new construction,
- The principal barriers to efforts aimed at increasing the use of energy efficient fixtures in new residential construction.

To match the above elements, our research was focused in three main categories: Residential Construction, Residential Lighting Energy Use, and Barriers to Market Transformation. Major findings from these categories are briefly summarized below.

I. Residential Construction

The results from our research indicate that residential construction in the Pacific Northwest generally follows the national trends, including increasing square footage, concentration around urban areas, and the preponderance of single-family homes. The most important finding, with the potential to significantly affect the program, is the fact that energy efficient lighting fixtures commonly cost 1.5 – 2.5 times that for conventional ones. This fact confirms the need for a designed energy-efficient lighting system, which may reduce the number of fixtures required, rather than a one-to-one exchange of fixtures.

The findings also provided a number of NW specific data points. Most significant is the fact that the average house size is growing more quickly in the Northwest region than in the nation. Specifically, the average new home size in the region exceeds the national average by approximately 10%, with the exception of Idaho, where the houses are 20% smaller than the national average. Other important findings include:

- 70,000+ new residential units are constructed in the Northwest annually, accounting for 5% of the nation's new housing stock.

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[1] The program development team consists of:

- Ecos Consulting staff (currently the Alliance's ENERGY STAR® Residential Lighting Program implementer);
- Jim Benya and staff from Benya Lighting Design; and
- Robert Sardinsky and staff from Rising Sun Enterprises.

- Almost two-thirds of the new construction is single-family homes, one-third multi family, and the remainder manufactured ("mobile") housing.

- New construction increases the existing Northwest housing inventory by approximately 2% each year.

- A little more than half of all new residential construction in the region is occurring in Washington, one-quarter in Oregon, 15% in Idaho, and 4% in Montana.

- The average number of hardwire fixtures per home varies widely by scale and type of residence (single family, multi family, or manufactured), ranging from 10 to over 30.

- The average valuation for new homes in the region ranges from around $120,000 to $140,000 for single-family homes and $40,000 - $80,000 for units in multi family properties. Presuming a "lighting budget" of 2% of construction costs, this allows $1,200 to $2,700 for the lighting package.

II. Residential Lighting Energy Use

Our research into residential lighting energy use yielded little new information than has been reported by other researchers in this area. In fact, the whole "body of knowledge" about residential lighting energy use has been pieced together from a handful of limited studies. Nevertheless, assembling the information from these studies helped to identify areas in the home where lights may be on the longest, and provided a number of significant insights regarding residential lighting energy use, which are summarized below.

- The average annual household energy use for lighting is estimated to range from 940 kWh to 2,517 kWh, with the highest consumption being in the Northwest.

- Approximately half of all household lighting energy is used for illuminating the kitchen, living room, exterior, and bathroom.

- In practice, one-quarter of the lamps installed in household fixtures account for three-quarters of the lighting energy use.

- Incandescent sources dominate lighting in all rooms. Fluorescent lighting has only made inroads in the kitchen, and garage areas.

- Approximately one-fifth of all lighting energy consumption is drawn by portable, plug in fixtures.

III. Barriers to Market Transformation

Our research confirms that the design and use of energy-efficient lighting in the new residential construction market represents a largely untapped promise for long-term energy savings to date. While there have been many residential energy-efficient lighting programs thus far, most which are or were geared toward promoting the substitution of standard incandescent fixtures for fluorescent ones. These programs primarily address the price differential of energy-efficient fixtures, with varying degrees of success. Incentives range from token amounts for a handful of fixtures, to those that cover a significant portion of the marginal cost for energy efficient fixtures installed in high use and common areas.

While the price differential is a major barrier to the adoption of residential energy-efficient lighting in new construction, our research indicates that it is not the only major barrier. Others include:

- At least 11 different parties may be involved in the design or specification of lighting for new homes. The most likely players to be involved vary depending on type of construction -- tract home, semi custom home, custom home, or multi-family. Few of these parties have significant lighting design expertise and virtually none have expertise in energy efficient residential lighting

- Once energy efficient lighting options are specified for new residential construction, they may be procured through multiple channels. The most likely include electrical distributors, home improvement centers, and lighting showrooms. As in the above case, few of these parties have significant lighting design expertise and virtually none have expertise in energy efficient residential lighting.

- There are thousands of energy efficient lighting products available that are suitable for residential applications. Approximately 2700 of these are Energy Star listed. Many of these fixtures are attractive, well built, and provide high quality lighting, but numerous products compromise on at least one of these concerns.

- Most new residential construction energy efficiency programs are comprehensive in that they are concerned with whole house efficiency (HVAC, windows, etc.) and incorporate a lighting component, but they have not addressed optimal selection of light sources and enhanced architecture for day lighting.

- New residential construction energy efficiency programs exist in several places across the country. All are located in regions where strong market transformation efforts are underway, such as California, Wisconsin, and New England. The Pacific Northwest also has programs that provide opportunities for cooperative efforts. With few exceptions, efficient lighting design has not been a strong component of these efforts, most likely due to lack of fixture availability, lack of acceptance by construction market actors, cost, reliability, and/or lack of education.

- ❖ Proven energy saving auxiliary technologies, such as dimmers and occupancy sensors, are available but underutilized in residential construction.

IV. Next Steps

The preliminary findings from our research argue for a comprehensive approach to energy-efficient residential lighting. A program emphasizing the design element, and integrating other successful components, including education, marketing as well as cooperative efforts with key market players is needed to address the above barriers.

The design element will be an important one in our program design: our research found that although installed energy-efficient residential lighting systems have the potential to "capture" long-term savings, these savings are dependent upon consumers' satisfaction levels with the aesthetics of the lighting. If they are not, there is a good chance that it will be replaced. Therefore, the installation of non energy-efficient lighting options during new home construction creates lost opportunities; households who are satisfied with the conventional lighting specifications in their new home are unlikely to make any changes. The emphasis on integrated design is further underlined by the fact that building and decorating trends in the new construction market influence the practices found in updating older housing.

Other findings from our research that may help steer the direction of a comprehensive energy-efficient lighting program, and confirm the need and timeliness for such a program aimed at the new residential construction market include the following:

- ❖ The new home market accounts for over one-third of all residential hardwire fixture sales annually. This jumps to around fifty-percent, over 50 million fixtures, when renovations and additions are included. The balance is sold into the replacement market.

- ❖ Homebuyers rank lighting style and aesthetics as their greatest concern while home builders are more concerned with the first cost and availability of lighting fixtures.

- ❖ Some rooms in new houses impress homebuyers more than others. The kitchen overwhelmingly ranks as number one.

- ❖ The EPA ENERGY STAR program is developing tools to assist utility and market transformation groups implement residential new construction lighting programs.

- ❖ The more that energy efficient lighting is designed to be attractive and aesthetic, the more marketable and permanent it will be, even if this means giving up some potential energy savings to insure consumer satisfaction.

- ❖ The Pacific Northwest National Lab's (PNNL) compact fluorescent recessed can technology procurement initiative and the Program for Evaluation and Analysis of

Residential Lighting Products (PEARL) intend to improve the performance of energy efficient lighting fixtures, bring their costs down, and to verify manufacturers performance claims.

- Innovative research on a "systems" approach rather than a one for one fixture approach to energy efficient lighting is being conducted for use in kitchen applications.

RESIDENTIAL NEW CONSTRUCTION LIGHTING PROGRAM

Market Research

Developing a successful residential new construction lighting program that responds to the diverse needs and characteristics of the Northwest residential marketplace and ensures long term energy savings requires that one investigate and answer the following questions:

- Where is new construction occurring in the Pacific Northwest?
- What are the characteristics of new construction?
- What is standard practice for lighting in new conventional construction?
- How much energy does conventional lighting use?
- How is conventional lighting specified and procured?
- What concerns does the marketplace have about residential lighting?
- What energy saving lighting products and technologies are available?
- What lighting energy efficiency programs or initiatives are underway that we can learn from or lever?

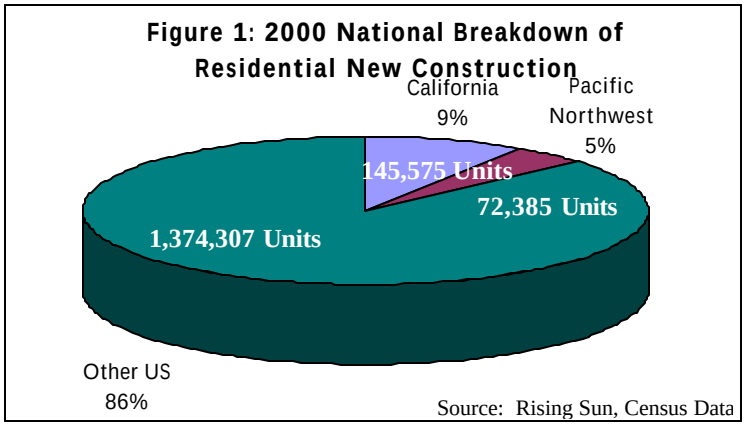
The Northwest Energy Efficiency Alliance (the Alliance) has funded the development of a Residential New Construction Program that focuses entirely on increased use of energy efficient lighting in residential construction. The program team, comprised of Ecos Consulting staff (currently the Alliance Residential Lighting Program implementer), Jim Benya from Benya Lighting Design, and Robert Sardinsky from Rising Sun Enterprises, determined that before launching into a program design, significant research was required to understand this regions' construction trends and trends in building codes and policy. In addition, to develop a successful program, we investigated lighting components of other regional programs across the country. We hoped to learn what aspects of their program design was successful and what areas contained significant barriers that hindered program success.

The following report details the research findings from this portion of the Alliance's program development.

I. Residential Construction

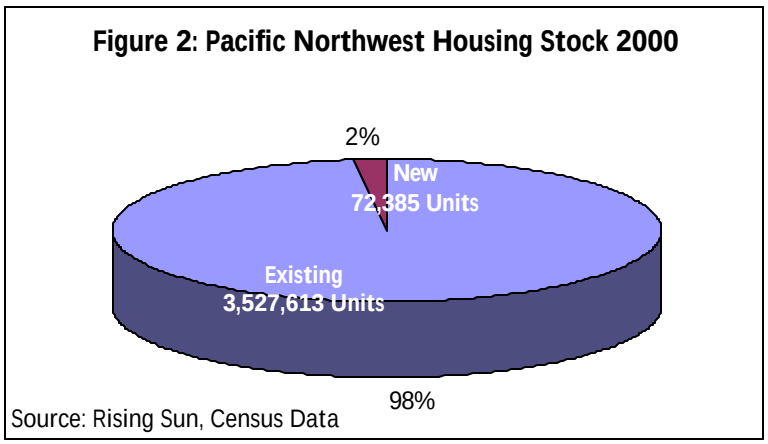
To assess the location, type, and extent of new construction throughout the Pacific Northwest, we gathered the most recent data from the Census Bureau (year 2000) and the Alliance commissioned studies: "Baseline Characteristics Of The Residential Sector: Idaho, Montana, Oregon And Washington" and "Baseline Characteristics Of The Multi-Family Sector: Oregon and Washington". Both studies were completed by the Ecotope group in October 2001, and primarily draw on data gathered in 1998. While the Ecotope studies provide detailed information on residential construction demographics, characteristics, and thermal energy performance, no data was gathered on lighting characteristics or energy usage.

Figure 1 illustrates the extent of new residential construction in the Northwest compared to the nation. In 2000, seventy-two thousand new housing starts were completed in this region, accounting for 5% of all construction nationally. Adding California to the grouping raises the tally to 218,000 units and 14% respectively.



This regional outlook is important from a market transformation perspective because of the potential for standardizing on energy codes across state lines and increasing demand and buying power for more energy efficient lighting products.

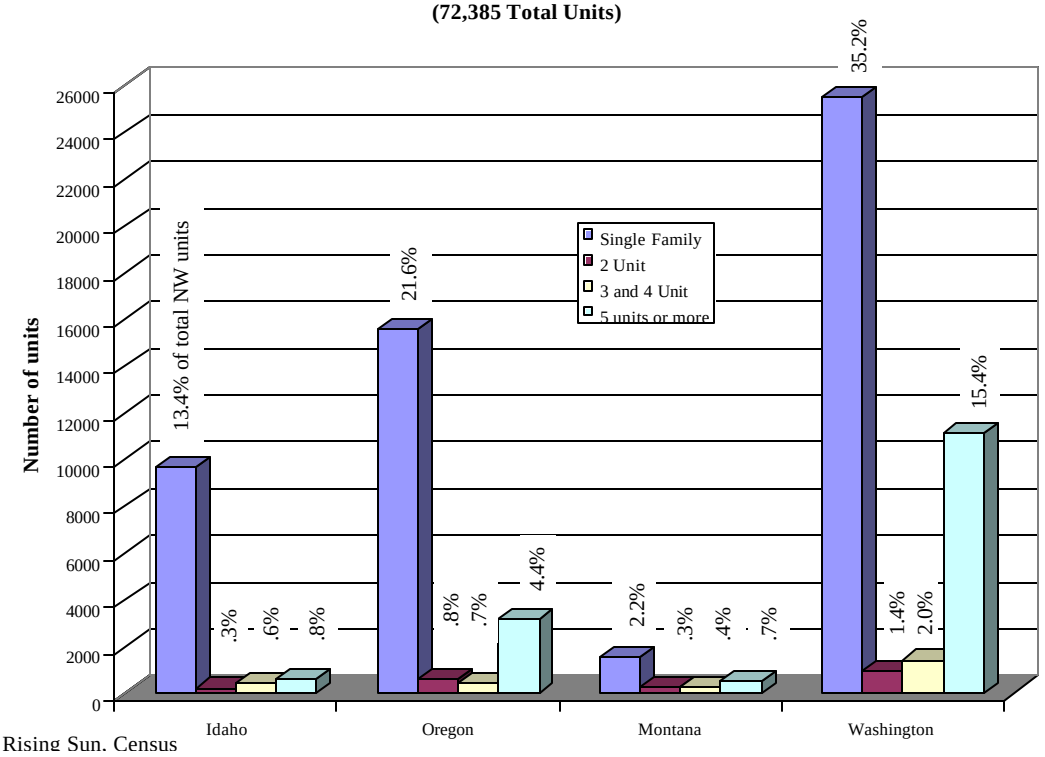
In comparison, the Pacific Northwest new housing starts are a small fraction of the region's total available housing stock. Figure 2 compares the magnitude of the new residential construction to that of existing housing stock. It shows that new construction increased the regions' 3.5 million housing units by 2% in 2000. This comparison offers perspective on the scope of the market for lighting in new residential construction verses existing housing.



Many opportunities for "new" residential lighting are represented by the significant after-markets for remodel projects, additions, and replacements. This points to the need for continued emphasis on the after-market channel of distribution and consumer education that are covered under the existing Alliance Residential Lighting Program scope of work.

Of the new housing starts in the region, much can be learned from further understanding where the starts occur and the type of construction they represent. Figure 3 slices the housing start data by state and by type: single family or multi family. In 2000, approximately 54% of all new residential construction in the region occurred in Washington, 28% in Oregon, 15% in Idaho, and 4% in Montana. Understanding where new construction is occurring and the nature of the construction allows the program to effectively target high impact areas and to account for the construction trends and variety in the region.

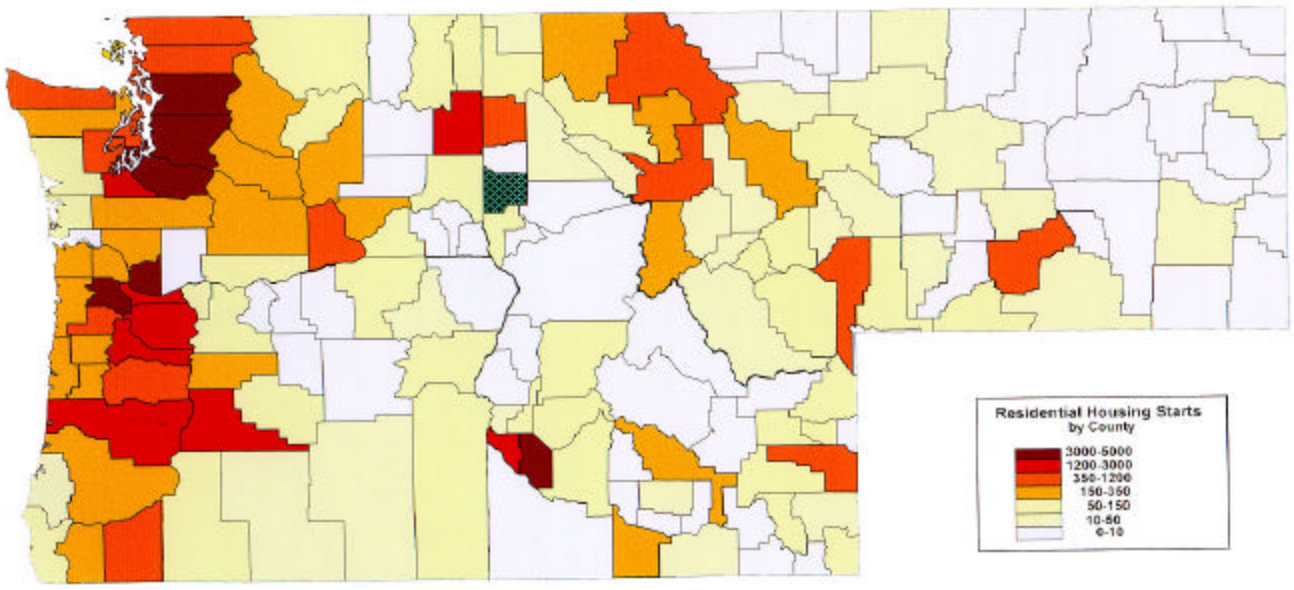
Figure 3: Pacific Northwest Permitted Housing Units Year 2000 (72,385 Total Units)



Source: Rising Sun, Census

Figure 4 illustrates the density of new housing starts throughout the region on a county-by-county basis. Most new construction is concentrated around urban areas. Per Ecotope's findings, "in Idaho, the counties immediately around Boise account for 69% of residential construction. In Oregon, the Portland area accounts for 53%; in Washington, the Seattle area accounts for 63 percent. Only Montana lacks a single urban area accounting for more than 20% of residential construction." This valuable data helps identify areas of focus for the program development and implementation team.

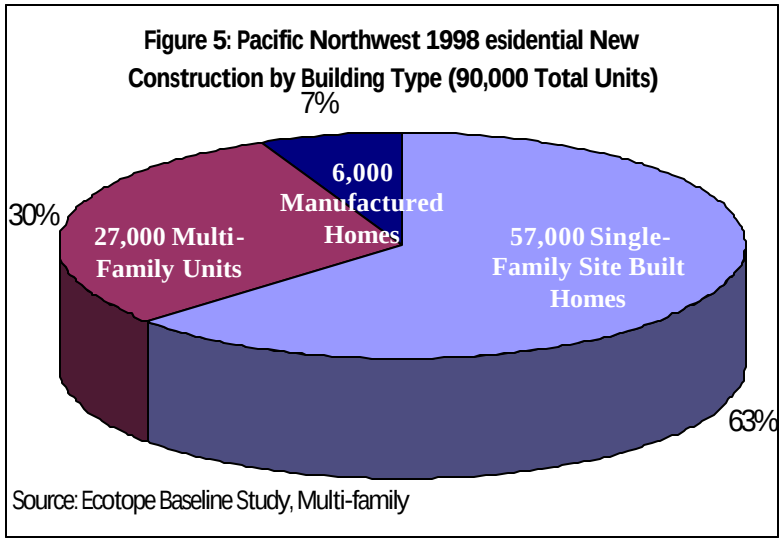
Figure 4: 1998 Residential Housing Starts for the Pacific Northwest



Source: Ecotope Base Line Study - Single Family Homes

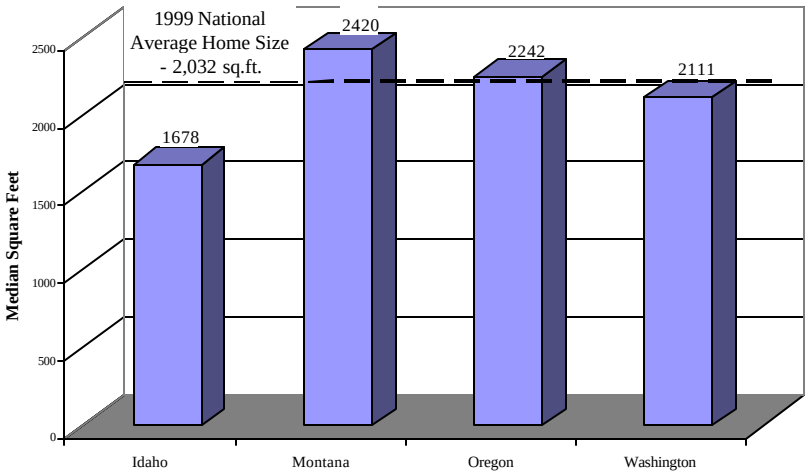
Figure 5 provides greater detail regarding the 3 different types of new housing starts in the region by construction: single-family, multi-family, and manufactured ("mobile home"). It is important to distinguish between these because each type commonly has:

1. Different players involved in the specification of lighting;
2. Different lighting aesthetic and operational concerns based on ownership (owner occupied verses rental unit);
3. Different building codes or standards.



Further analysis of the regional data shows that with the exception of Idaho, average home sizes in the Pacific Northwest exceed national averages. Figure 6 shows the median square footage size for new single family housing in the region by state. Though there is little data to substantiate the relationship between new house size and fixture quantity, in general the larger the house the greater the quantity of fixtures. A general assumption is to allow for one hardwired fixture per every 100 square feet of "budget" housing, 50 square feet of "standard" housing, and 30 square feet of "custom" housing.

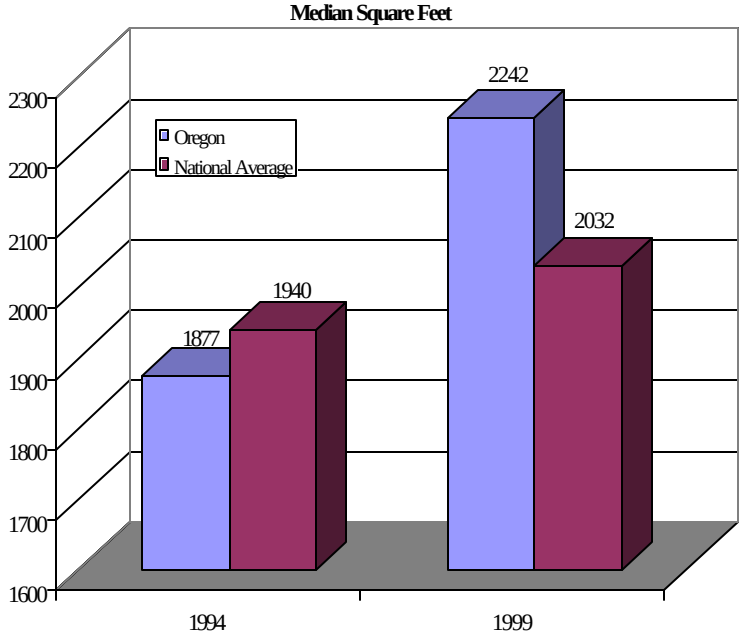
Figure 6: Pacific Northwest 1999 Home Size
Median Square Feet



Source: Rising Sun, Census, Ecotope Baseline Study

Figure 7 shows the growth in the average size of new single-family homes in Oregon and across the U.S. during 1994 and 1999. It indicates that home size is increasing more rapidly and to a greater extent in the region than the nation. Though we assume that larger homes represent more affluent consumers and are outfitted with greater numbers of lighting fixtures than smaller homes, the most significant factors impacting per capita lighting energy consumption is the number of people per household and household income, not house size. As average household size shrinks, lighting electricity use per person rises. Lighting energy use also rises with household income.

Figure 7: Oregon Home Size vs National Average
1994 & 1999
Median Square Feet



Source: Rising Sun, Census, Ecotope Baseline Study

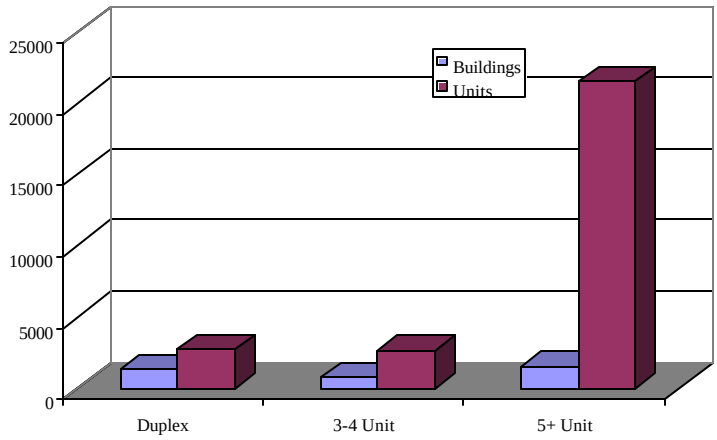
Figure 8 shows the average number of lighting fixtures found in a sampling of 1255 existing California residences. Though this data spans homes constructed over the past 50+ years throughout the State, it is informative to see that the average number of fixtures ranges from 10 to 33 depending on type of residence, with an average range of 11 in apartments, 11 – 18 in multi family attached dwellings, 12-18 in mobile homes, and 20 – 32 in single family homes.

Figure 8: California Statewide Lighting & Appliance Saturation Study 2000
Average Number of Fixtures / Lamps by Type of Residence

Type of Residence	Fixtures	Lamps	Sample Size
Overall	19.72	33.82	1255
Apartment (1 or 2 stories)	11.43	18.89	281
Apartment (3 or more stories)	10.49	16.37	51
Duplex - Triplex - or Quadplex	10.92	16.19	82
Mobile Home - Double Wide	18.21	29.28	21
Mobile Home .0 Single Wide	12.81	19.14	6
Modular / Prefabricated	20.16	37.42	7
Other	20.64	36.80	4
Single Family - Unattached - < 2 stories	32.67	51.51	14
Single Family - Unattached - 1 story	20.37	35.23	544
Single Family - Unattached - 2 story	31.10	55.03	210
Townhouse or Rowhouse	18.36	30.83	35

Figure 9 compares the breakdown of new multi-family buildings verses the average number of units per building. It shows that 80% of all new multi-family units are in buildings containing five or more units, that is, "apartment" type buildings versus low-rise duplex, triplex, and quads. This distinction is important to be aware of because: 1) units in apartment buildings not only encompass residential spaces but also common public areas (e.g., hallways, lobby, stairwells, laundries, parking, etc.) which tend to be treated more as commercial projects than residential ones; 2) because these buildings often fall under different building codes; and 3) because the identical fixture

Figure 9: Pacific Northwest 1998 New Multi-family Construction Breakdown
Buildings vs Units

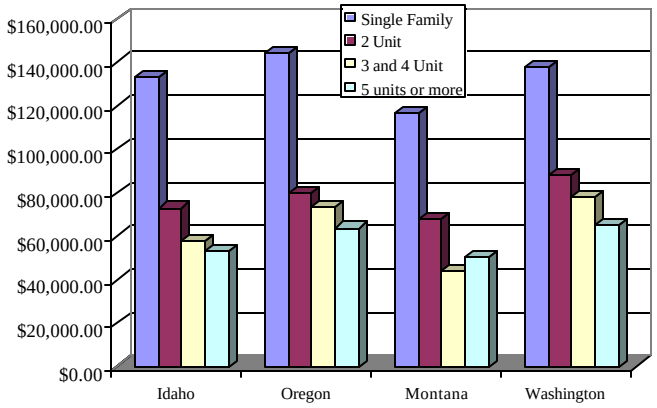


Source: Rising Sun, Ecotope Baseline Study

package is more likely to be duplicated throughout the building.

Next, we investigated the average valuation of construction for each of the Pacific Northwest states. Figure 10 charts the average cost for new residential construction by building type for Idaho, Oregon, Montana, and Washington. Being cognizant of the valuation for new housing provides a budgetary context within which to examine lighting first costs.

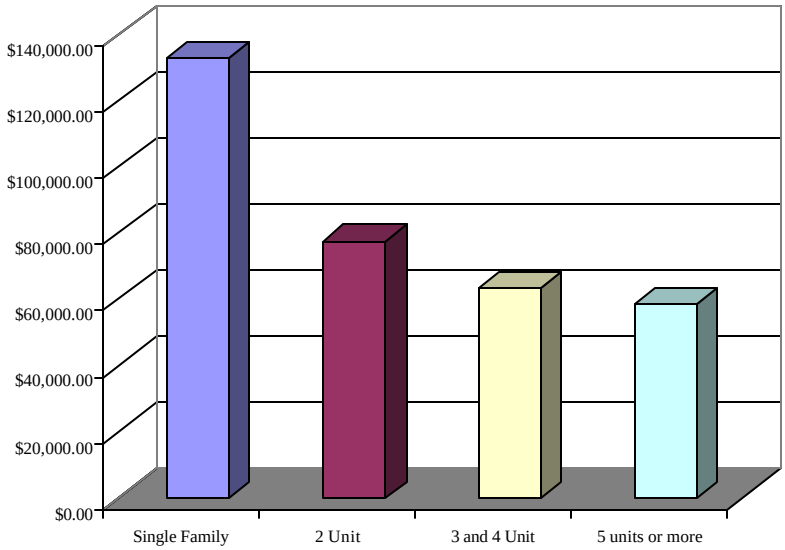
Figure 10: Pacific Northwest
Valuation per Unit of Permitted Housing Year 2000



Source: Rising Sun, Census

Figure 11 compares the average regional valuation for new residential construction and outlines a hypothetical "lighting budget" for fixtures presuming different "allowances" based on 1% - 3% of total construction cost. In reality, this percentage may be higher or lower and is complicated by the fact that the "lighting budget" may be buried in with the overall electrical budget, may refer only to decorative fixtures or to all fixtures (decorative, recessed, and utility), and may or may not include light switches, dimmers, and/or other control devices.

Figure 11: Pacific Northwest (Idaho, Oregon, Montana, Washington)
Average Valuation per Unit of Permitted Housing Year 2000
&
"Lighting Budget"



"Lighting Budget"				
1%	$1,327	$773	$632	$581
2%	$2,653	$1,547	$1,265	$1,162
3%	$3,980	$2,320	$1,897	$1,743

Source: Rising Sun, Census

Figure 12: NEEA ENERGY STAR Residential Lighting Fixture Program: Market Report 1999 Baseline

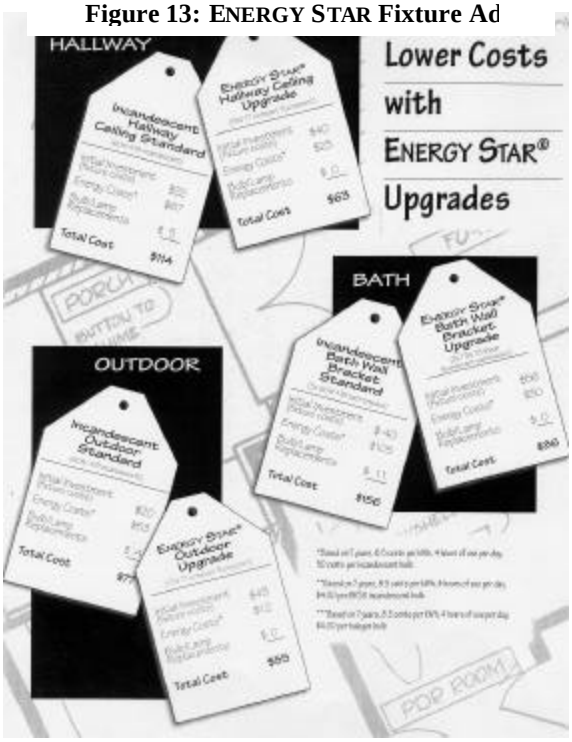
Indoor Fixture Type	Estimated Total Market	Average Incandescent Price	Average Energy Efficient Price	Watts Displaced
Vanity	55,000	$35.00	$60.00	40
Pendant	35,000	$39.99	$49.99	188
Strip lighting (per foot), 4' avg.	25,000	$29.99	$60.00	110
Fluorescent Torchieres	15,000	$20.00	$49.00	225
Wall Sconce	5,000	$34.99	$49.99	124
Ceiling Flush Mount				174
9" Decorative	225,000	$8.00	$18.00	
13" Decorative	100,000	$24.99	$39.99	
14" & 15" Decorative	50,000	$28.00	$41.99	

Outdoor Fixture Type	Estimated Total Market	Average Incandescent Price	Average Energy Efficient Price	Watts Displaced
Coaches / Lanterns	175,000	$35.00	$60.00	57
Porch	55,000	$17.99	$29.99	62
High-pressure Sodium	75,000	$49.99	No Data	
Flood	180,000			104
PAR (Incandescent)		$19.99	$29.99	
Halogen		$17.99	$29.99	

Source: NEEA Market Progress Evaluation Report, "Energy Star Residential Lighting Fixture Program No. 2 (8/99) #E99-035

Figure 12 shows the Alliance's 1999 internal assumptions regarding the average difference in cost between standard incandescent lighting fixtures and more energy efficient alternatives that could be promoted through its ENERGY STAR Residential Lighting Fixture Program. Since first cost is one of the greatest hurdles in new residential construction it is important to be aware that the incremental cost to upgrade from conventional to more energy efficient lighting can increase fixture cost by 1.5x to 2.5x. Figure 13 illustrates these differences in an ENERGY STAR promotion that was laid out to emphasize the difference in life cycle costs (including not only first cost but also energy and maintenance costs) rather than purchase price. This distinction is important because most consumers are not aware of the significant difference between the two.

Figure 13: ENERGY STAR Fixture Ad



II. Residential Lighting Energy Use

Designing a residential new construction lighting program that maximizes energy savings requires that we understand the extent to which energy is used for lighting throughout the home.

Unfortunately, little work has been carried out in this area and the focus of most of it has been on quantifying the opportunity to replace incandescent lamps with compact fluorescent ones or on assessing the saturation of different lighting technologies in the home. Virtually all of the research we identified examined existing housing, not new construction. The only data we uncovered for new construction was completed by LBL in 2001, where the research team documented the number of recessed cans in 29 new residences as part of an initiative to develop more energy efficient lighting systems for California kitchens.

Figures 14 and 15 highlight the primary research conducted over the past decade on residential lighting and energy use. As indicated, most of this work was completed in the early through mid 1990's and are limited either by the relatively small sample size, lack of metered data, dependence on self-reported data, lack of comprehensive survey, lack of data on house size or age, and/or dependent on far-reaching extrapolation. Given that most of the data shown was collected in residences in Washington, Oregon, and California, this does, however offer a unique regional perspective. Interestingly, the data suggests that households in the Northwest use up to twice the lighting energy as the national average.

Figure 14: Comparison of Lighting Studies (Existing Home)
"Our Body of Knowledge"

Study	# of Fixtures with Loggers Installed	# of Homes (Site)	Fixtures per Home	Lamps per Home	Average Lamp Wattage	Rooms per Home	Lamps per Room	Fixtures per Room	Calculated Wattage per Room	Whole House Area (w/o Garage)	Calculated Watts per Square Foot	Usage Reporting Method	Lamp Daily Usage Hours
Free Lighting (1992)		7700		37.6	66.3		3.9		259			self-reported	
Grays Harbor (1992)	44	20	30.63	44.5	61.5	11.5	3.9	2.7	238	1594	1.385	loggers	2.52
PG&E (1991)		1009		29.7	71.6					1400	1.504	self-reported	
TPU (1994 - 1995)	3955	161	31	50.9	71.4	15	3.4	2	242	2000 - 2999	1.8 - 1.2	loggers	2.12
SCE (1993)	477	692	21	34.86	60.4	11.9	2.9	1.8	177	1496	1.408	self-reported	2.8
CA Saturation Study (12/99 - 3/00)		1258	20	35									

Source: *Residential Lighting: The Market to Date* - LBL, Rising Sun, TPU

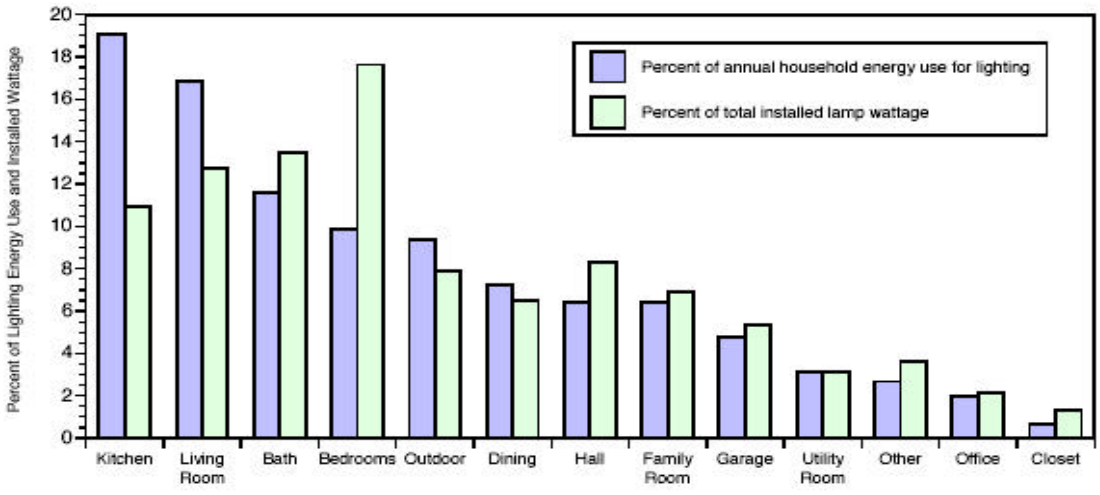
Figure 15: Estimates of Annual Household Energy Use for Lighting

Annual Household Energy Use for Lighting	Study Period	Notes
940 kWh	1993	Average for all US. households in 1992. Based on RECS (EIA's) national survey of 7000 households.
1313 kWh, for *incandescent* lamps only	1990	Average for all US. households in 1990. Based on metered wattage and lighting energy use data for the service territory of Pacific Gas & Electric.
1704 kWh (All) 2076 kWh (Single Family)	1997	Average for all households in California. Based on survey of homeowners regarding hours of use for 16,000 fixtures in 697 homes in Southern CA.
1818 kWh	1993 - 1995	Average for selected homes in Pacific Northwest. Based on metering of 161 single-family homes.
2418 kWh	1992	Average for selected homes in Yakima, WA. Based on surveys and metering of 53 homes.
2517 kWh	1991 - 1992	Average for selected homes in Grays Harbor County, Washington. Based on surveys of 20 homes.

Source: LBL Lighting Market Sourcebook

Figures 16 identifies the percentage of lighting energy use and power density throughout the typical house, by room type. This study by Tacoma Power provides direction on which areas of

Figure 16: Annual Lighting Energy Consumption and Installed Lamp Wattage in Households, by Room Type



Note: Data were obtained from TPU analysis of lighting energy use in 161 single-family homes in the Pacific Northwest between 1993 and 1995. Rooms are listed in order of decreasing energy consumption.
Source: Adapted from Jennings et al. (1996); TPU data updated based on Moezzi (1996-97)

the home to target for energy efficient lighting. The data suggests that kitchens, living rooms, bathrooms, bedrooms, and outdoor lighting are the top 5 areas of energy consumption for lighting in the home.

Figure 17 documents findings from studies reported on by the Natural Resources Defense Council (NRDC) and Lawrence Berkley Labs (LBL). These studies show the close correlation between California and Northwest households of the rooms that use the most lighting energy in the home. These include the kitchen, living room, bathroom and outdoor wall fixtures. This data closely matches the findings by Tacoma Power.

Figure 17: Dominant Residential Light Fixtures and Share of Total Household Lighting Energy Use, by Region

	California Households		Pacific Northwest Households	
Rank	Fixture Location, Type	Fraction of Lighting Energy	Fixture Location, Type	Fraction of Lighting Energy
1	Outdoor, wall-mounted	**10.6%**	Kitchen, closed ceiling	**8.0%**
2	Kitchen / dining room, suspended	**8.3%**	Living room, table lamp	**7.6%**
3	Living room, table lamp	**8.1%**	Bath, wall	**7.5%**
4	Kitchen / dining room, recessed	**7.6%**	Outdoor, wall	**6.9%**
5	Bath, wall	**7.3%**	Living room, floor lamp	**5.3%**
6	Kitchen / dining, surface	**6.3%**	Kitchen, recessed	**4.8%**
7			Dining room, chandeliers	**3.2%**
8			Garage, bare bulb	**3.4%**
9			Family room, table lamp	**1.9%**
10			Outdoor, bare bulb	**1.3%**
	TOTAL	**48.2%**		**49.9%**

Sources: NRDC - "Lighting the Way to Energy Savings"; LBL - Lighting Market Sourcebook
Hershong Mahone report to CEC, "Residential Lighting Baseline" Lighting Efficiency Technology Report 3/7/97

Reviewing these studies provides clear direction on how to achieve the biggest savings in residential lighting. Coupled with an understanding of which areas of the home consume the most energy for lighting, it is also worth understanding how the length of use affects energy consumption.

Figure 18 illustrates how the quantity of household lamps and the daily hours they are operated impact total lighting energy use. Lamps that operate for less than 2 hours per day account for 72% of all household lamps, but they only consume 24% of total lighting energy. These should not be the focus of a program design. Conversely, the remaining 28% of the total household lamps use 76% of total lighting energy! This provides clear direction that if we make those high usage fixtures more energy efficient, large impacts to energy savings can be made without developing a program that requires all lighting fixtures to be energy efficient. Looking even more closely at the data reveals that a very limited number (about 3.4%) of high use (greater than 10 hours per day) fixtures use 23% of the total energy. These are the “low hanging fruit” that should be pursued aggressively.

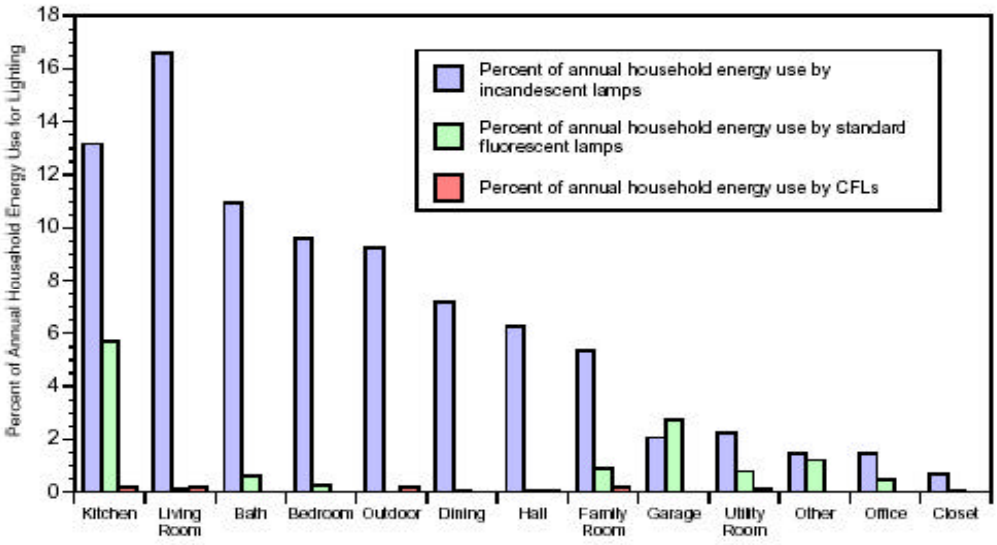
Figure 18: Percent of Household Lamps and Lighting Energy Use in Terms of Daily Hours of Use (TPU Study)

Hours of Use per Day	Percent of Household Lamps		Percent of Household Lighting Energy Use	
<1	53.2%	72%	9.9%	24%
1 - <2	18.6%		13.9%	
2 - <3	9.5%	28%	12.2%	76%
3 - <4	4.8%		8.2%	
4 - <5	3.8%		8.9%	
5 - <6	2.5%		7.0%	
6 - <7	1.6%		4.7%	
7 - <8	1.0%		4.2%	
8 - <9	0.9%		3.7%	
9 - <10	0.9%		4.0%	
>= 10	3.4%		23.3%	
TOTAL	100.0%		100.0%	

Source: LBL Lighting Market Sourcebook

Figure 19 illustrates the magnitude of energy use by incandescent versus fluorescent sources. It highlights the fact that the least efficient light sources, incandescent, consume most residential lighting energy use.

Figure 19: Annual Lighting Energy Consumption in Households, by Lamp and Room Type



Note: The data for incandescent lamps also includes other lamp types including quartz and some HID lamps; these "other" lamp types, however, account for less than 1% of the energy consumption represented by the "incandescent' category in the figure. Data were obtained from TPU analysis of lighting energy use in 161 single-family homes in the Pacific Northwest between 1993 and 1995. Rooms are listed in order of decreasing energy consumption.
Source: Adapted from Jennings et al. (1996); TPU data updated based on Moezzi (1996-97)

Figure 20 shows results from the Tacoma Power study that breaks down the specific lamp types found in each room. It confirms that energy efficient fluorescent lighting has made little inroads and that incandescent lighting dominates as the lighting source in virtually every room of the home, except for kitchens, garages, and utility rooms.

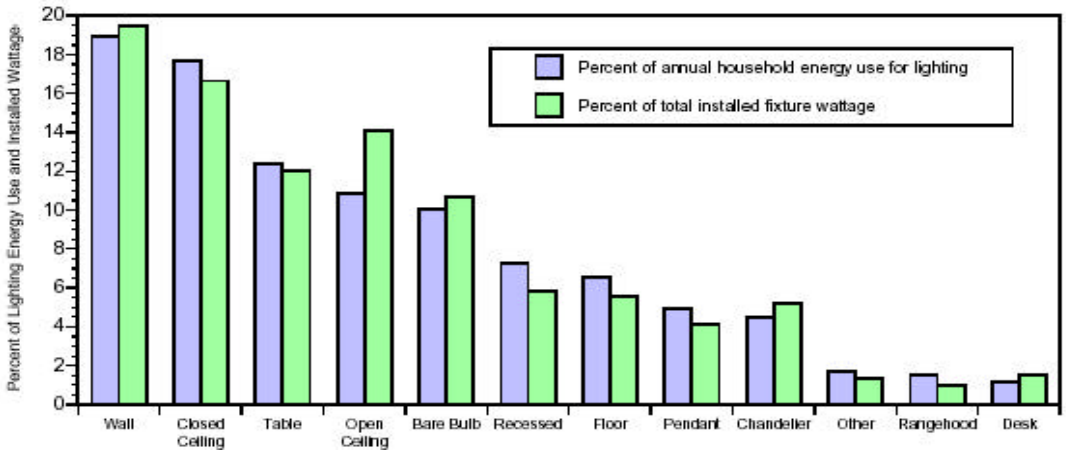
Figure 20: Percent of Homes with Lamp Type in Room (TPU Study)

Room Type	Standard Incandescent Lamps	Incandescent Reflector Lamps (non-Halogen)	Tungsten-Halogen Lamps (incl. Reflectors)	Tubular Fluorescents	CFLs	Other (incl. HID and quartz)
Kitchen	88%	24%	2%	52%	7%	1%
Bathroom	96%	17%	0%	12%	2%	<1%
Living Room	98%	9%	6%	4%	8%	1%
Family Room	50%	6%	3%	13%	4%	2%
Bedroom	100%	6%	2%	9%	5%	2%
Dining Room	80%	4%	0%	4%	0%	1%
Utility room	65%	3%	0%	16%	4%	<1%
Outdoor	80%	35%	7%	1%	5%	11%
Garage	49%	3%	1%	34%	1%	0%

Source: LBL Lighting Market Sourcebook

Figure 21 shows the degree to which lighting energy consumption and power density is attributed to the different fixture types. Approximately one-fifth of all lighting energy use is drawn by portable plug in type fixtures, i.e., table lamps, floor lamps, and desk lamps. The high consumption shown for wall type fixtures is due to the extended dusk to dawn operating hours for many exterior fixtures (e.g., flood lights, lanterns, security lights, etc.) and high wattage incandescent sources which proliferate bathroom vanity lighting.

Figure 21: Annual Lighting Energy Consumption and Installed Fixture Wattage in Households



Note: Data were obtained from TPU analysis of lighting energy use in 161 single-family homes in the Pacific Northwest between 1993 and 1995.
Source: Adapted from Jennings et al. (1996); TPU data updated based on Moezzi (1996-97)

III. Barriers to Market Transformation

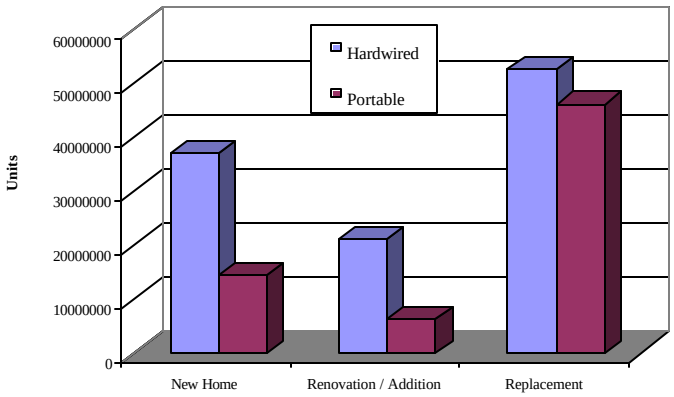
Knowing where new residential construction is being built and how energy for lighting is used in households highlights where the greatest savings opportunities lie. Capturing these is dependant on developing and implementing strategies that transform the market, that is, the demand for energy efficient lighting.

To date the Alliance residential lighting programs have focused on upgrading the light source in existing fixtures from screw-in incandescent to compact fluorescent, replacing standard existing incandescent hardwired fixtures with ENERGY STAR compact fluorescent ones, and replacing halogen torchieres with compact fluorescent alternatives. These ongoing efforts have targeted the replacement and renovation markets. The Alliance's new construction program is being designed to complement the existing programs and is aimed at "capturing" new residential sockets by promoting the design of lighting systems to meet the aesthetic and utilitarian needs of households in the most energy efficient manner practical.

Figure 22 shows the significance of fixture sales for each residential market nationally, including new home, renovation/addition, and replacement. In practice, the first two markets may be grouped together though there are differences between them. For example, since many new homes are built on speculation by developers there tends to be relatively more owner involvement in the renovation/addition market than in new construction. Nevertheless, "crossover" from transformation programs targeted at any of the three markets is a given and furthers the overall goal, to reduce residential lighting energy consumption.

Figure 22: Where's The Market?

Comparison of National Residential Fixture Sales by Market 1995



Source: NEEP Baseline Study of Northeastern Residential Lighting Market

Presuming that the average new Northwest home contains 25 hard-wired fixtures and that 72,000 new homes were built in the region in 2000, approximately 1.8 million new fixtures entered the lighting stream in that year alone. With 1.5 million housing starts nationally, this sum mushrooms to 38 million fixtures. Missing out on the installation of energy-saving lighting products in the new construction market creates lost opportunities; consumers who are satisfied with the lighting specifications in their new home are unlikely to make any changes, and therefore potential energy savings are "lost." New construction is also important because building and decorating trends in this market influence the practices found in the remodel market.

In our effort to reduce lighting energy consumption it is critical that residential new construction programs promote the use of good design practice and lighting technologies that will satisfy consumer needs and concerns. If not, there is a good chance that unacceptable energy efficient lighting products will be installed and that they may not satisfy the homeowner. Figure 23 illustrates this point by documenting why and when 175 households replaced some of their lighting in new homes. This data emphasizes that homeowners who have not participated in selection of the lighting fixtures for their new homes are likely to replace some of them soon after moving into their new residence.

Figure 23: The Importance of "Doing It Right the First Time"
(Source: NEEP Baseline Study of Northeastern Residential Lighting Market)

Why Fixture Replacements are Made		
	Indoor Fixtures	**Outdoor Fixtures**
n (sample size)	142	32
Style	51%	61%
Need more / less light	15%	2%
Fixture was broken	9%	8%
Other	26%	31%

When Fixture Replacements are Made		
	Indoor Fixtures	**Outdoor Fixtures**
n (sample size)	142	32
Within One month of moving in	33%	24%
One to three months	41%	35%
Four to six months	14%	23%
Seven to twelve months	6%	15%
One year or more after moving in	1%	3%

This study had some interesting findings:

1. Builders often spec the simplest fixtures at minimum cost, expecting them to be replaced.
2. One builder estimated that up to 75% of the fixtures he specified were replaced by the homeowner.
3. 32% of people interviewed in newly constructed homes replaced at least one indoor fixture.
4. 12% of people interviewed in newly constructed homes replaced at least one outdoor fixture.

Market Actors

Transforming the market for energy efficient residential lighting requires that we understand and influence who specifies the lighting selection as well as those who are positioned to supply the equipment. Figure 24 illustrates the diversity of players involved in product selection and how they differ between housing types.

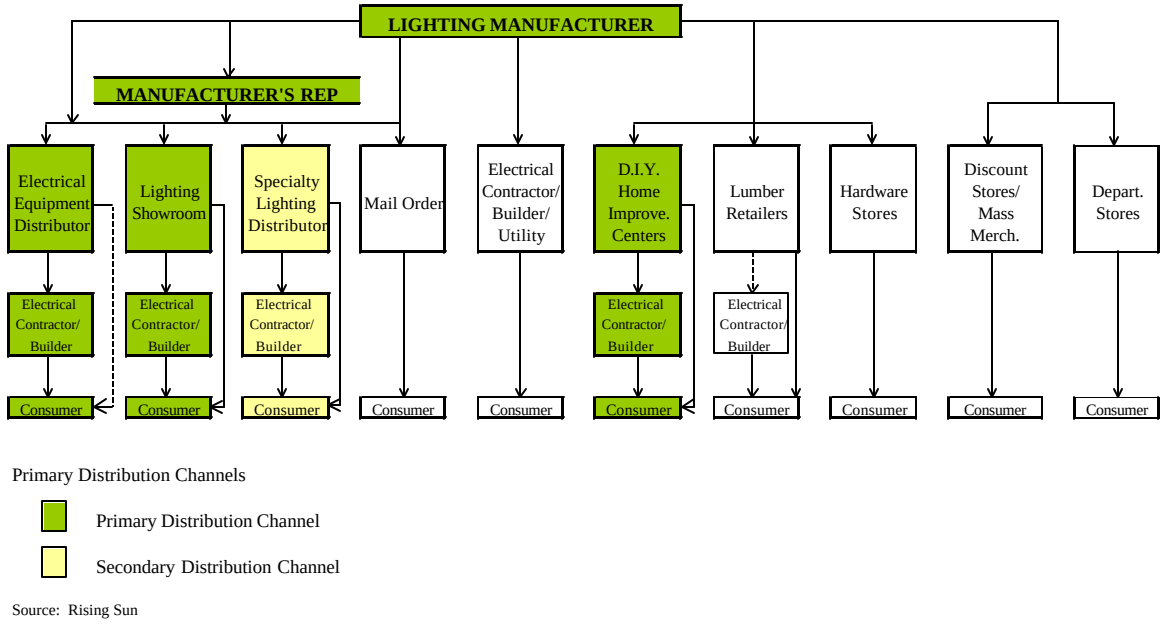
Figure 24: Who Specifies or Influences Hardwire Lighting for New Homes?

Specifier	Tract Home	Semi - Custom Tract Home	Custom Home	Multi-Family Housing
Commercial Architect	UnLikely	UnLikely	UnLikely	Likely
Residential Architect	Possibly	Possibly	Possibly	Possibly
Electrical Engineer	UnLikely	UnLikely	Possibly	Likely
Developer	Likely	Likely	Possibly	Possibly
General Contractor	UnLikely	UnLikely	UnLikely	UnLikely
Electrical Contractor	Likely	Likely	Possibly	Possibly
Electrical Distributor	Possibly	Possibly	UnLikely	Possibly
Lighting Showroom	Likely	Likely	Likely	Possibly
Homeowner	UnLikely	Possibly	Likely	UnLikely
Interior Decorator	UnLikely	Possibly	Likely	Possibly
Lighting Designer	UnLikely	Possibly	Likely	Possibly

Source: Rising Sun

Figure 25 illustrates the primary and secondary product distribution channels for hardwire fixtures into the new construction industry. This helps identify the intricacies of how market actors in this industry interact. As program designers, we must be able to identify the motivators and barriers each market actor is likely to experience and provide reasons as to why they should embrace this effort.

Figure 25: Residential Lighting Distribution Channels for New Construction Hardware Fixtures

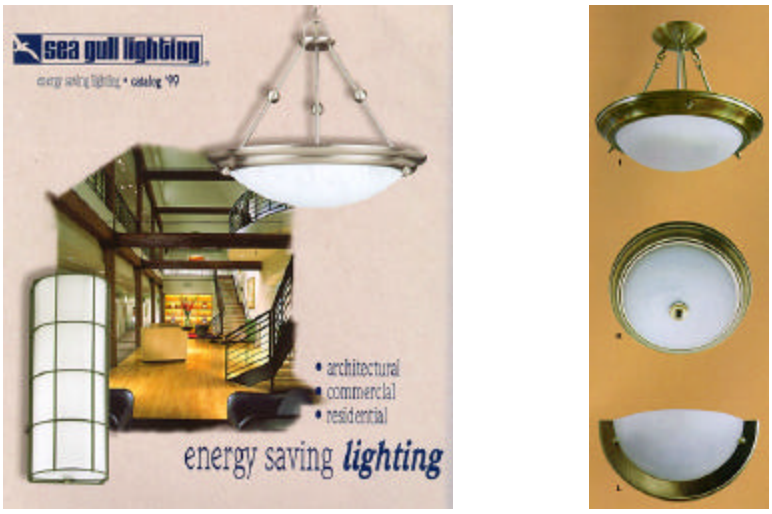


Source: Rising Sun

Based on research into the distribution channels for new residential construction in the Northeast, 42% of all fixtures there are sold through electrical distributors, 27% lighting showrooms, 25% direct retail, and 6% other. For reference, a phone directory search of the Northwest states lists approximately 150 lighting suppliers, which includes electrical/lighting distributors and lighting showrooms. A separate search of the American Lighting Association's membership lists 22 member showrooms in the region.

Once the market is convinced that energy efficient lighting is important it is critical that manufacturers develop products that meet consumers' expectations and needs, whether these be aesthetic or utilitarian. There are over 2500 ENERGY STAR listed light fixtures currently offered by 57 manufacturer allies, and many more energy efficient lighting products are available that are not ENERGY STAR branded. While many of the fixtures are attractive, well built, and provide high quality lighting, many are marginal. The ENERGY STAR label primarily insures that fixtures meet minimum efficiency performance standards. It does not address photometric performance, reliability, or aesthetics. With so many different energy efficient lighting fixtures to choose from, we must specify products carefully to insure consumer satisfaction.

Figure 26: Sample Energy Efficient Fixtures Available



Promoting greater use of energy efficient lighting in new residential construction is admirable, however it is but one of many concerns which homebuyers and homebuilders may have regarding lighting. In fact, energy efficiency ranks low on the marketplaces' priority list. Energy efficient lighting products must be developed that respond to the needs of the marketplace well beyond energy savings.

The greatest barriers to increasing the penetration of energy efficient lighting in new residential construction include the following: a lack of awareness or concern by the homebuyer and homebuilder, lack of interest by specifiers and suppliers, lack of ready availability of modestly priced, attractive fixtures, lack of information on good applications for energy efficient lighting, concerns regarding "fluorescent" lighting quality, concerns regarding lack of wattage interchangeability (can't change bulb for different light outputs), concerns regarding reliability of product, and concerns regarding lack of significant candlepower for accent lighting or "point source sparkle" for select decorative applications.

Figure 27: Program Success is Dependant on Responding to the Marketplace

Homeowner

Style or aesthetics is the most important factor for consumers buying indoor lighting. For outdoor lighting, safety security, and durability are most important.

- Style
- Appearance
- Ambiance
- Light Output
- Functionality
- Safety
- Price
- Control
- Durability
- Frequency
- Energy Efficiency

Builder / Contractor

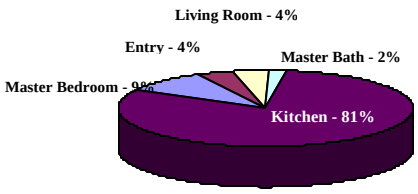
Builders and contractors are overwhelmingly influenced by first cost. They perceive that consume rs value other factors such as square footage, floor plan, kitchen appliances, etc. above energy efficiency.

- Price
- Availability
- Function
- Style
- Reliability

Source: NEEP Baseline Study of the Northeastern Residential Lighting Market, 1998

During program development, extra care must be paid to those areas around new homes that make the greatest impression on the marketplace. The lighting in these areas must enhance the home otherwise it will compromise the marketability not only of energy efficient lighting but more profoundly the sale of new homes. Figure 28 illustrates the need to consider those areas of the home that make the greatest impressions and to be certain that efficient lighting does not compromise those impressions.

Figure 28: Going for the Gold!
Be Sensitive To What Makes The Biggest Impressions In a Home



Make Sure Your Energy Efficient Lighting
Doesn't Compromise It

Source: Professional Builder New Home Survey

Strategically, perhaps the most critical new construction program design focus that must be determined is whether to take a simplistic one-for-one upgrade approach or a more comprehensive energy efficient lighting design tract. In the first scenario, the program simply aims to get ENERGY STAR fixtures substituted for conventional inefficient fixtures wherever possible, whether or not the fixture selection, layout, and control is optimal. In the second, the lighting is looked at systematically and it is designed to maximize performance and value given each application. The former is far simpler to implement but doesn't necessarily maximize energy savings or insure consumer satisfaction. If well executed, the latter maximizes consumer benefits and insures long-term savings. Figure 29 illustrates the holistic approach this program development team believes is essential to assure success. We believe that integrated energy efficient lighting design will achieve greater levels of customer satisfaction.

Figure 29: Environmentally Responsible Lighting Design

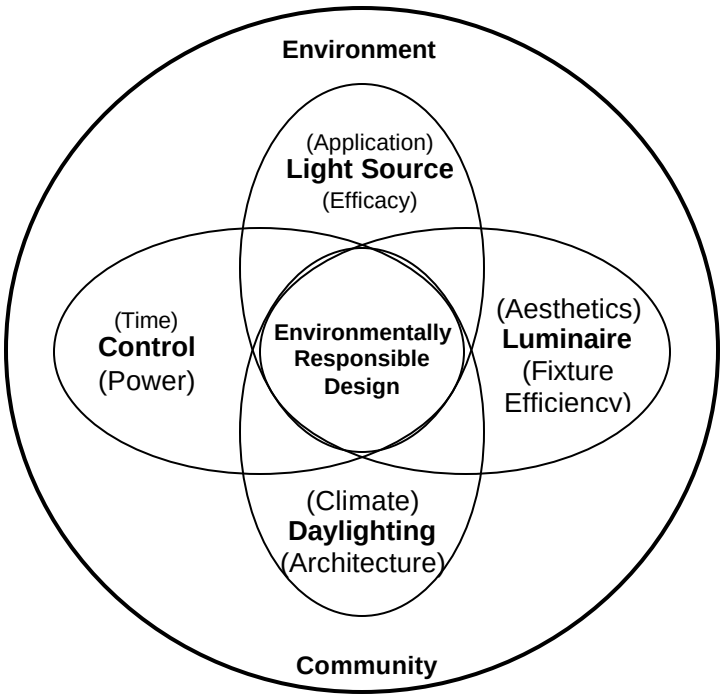
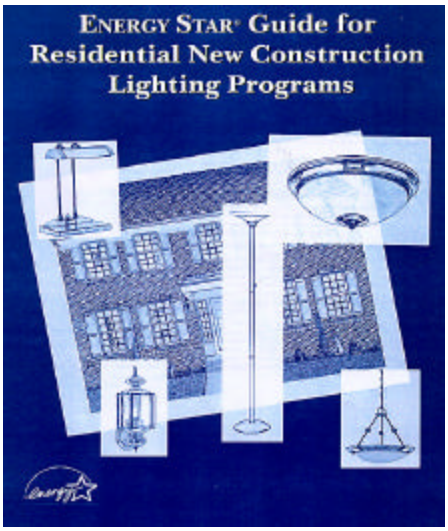


Figure 29 emphasizes the fact that maximizing residential lighting energy savings not only involves specifying efficient fixtures, but also selecting the most appropriate light source given the application, selecting controls to effectively regulate time of use or light levels, and integrating day lighting features into the architecture to minimize electric lighting needs during the daytime. Note, while most residential energy efficiency programs rightly emphasize fluorescent sources, there are some applications where halogen sources provide the desired illumination more efficiently and aesthetically.

A number of new residential construction energy efficiency programs have been implemented across the country. Most are comprehensive and incorporate lighting components. While each promotes and provides incentives to use hardwire fluorescent fixtures, most simply emphasize the one-for-one upgrade of conventional lighting to higher efficiency options. Figure 30 highlights the EPA's recommendations for developing successful residential new construction lighting programs. The Alliance program development team referenced this publication in developing its program design guidelines.

Figure 30: Notable Initiatives!



Overview of the Residential New Construction Lighting Industry

1. Market Actors
2. Design Practices
3. Budget Issues

Designing Effective Residential New Construction Lighting Programs

1. Establish Credibility with Market Players and Consumers
2. Research and ID Target Builders, Key Distributors & Manufacturers
3. Determine the Distribution Product Channels & Purchasing Influencers
4. Review Standard Lighting Packages and Design Practice
4. Consider the Use of Incentives
6. Educate the Consumer
7. Create and Implement the Sales Plan
8. Monitor Builder and Consumer Satisfaction and Refine Program as Necessary

Regional Program Review

As part of the Alliance's development team's research, we investigated other new construction programs already in place across the country. Our intent was to learn about the lighting component of these other programs and to glean relevant knowledge of the successes and barriers teams experienced elsewhere. Below is a brief overview of how some new construction programs incorporate lighting.

Seattle City Lights Build Smart Program

The Build Smart Program (formerly *Super Good Cents*) is a multi-family housing program that provides rebates to builders for efficient lighting and appliances. Lighting incentives of $25 are provided for interior and exterior energy-efficient fixtures in common areas and for up to three fixtures per multi-family unit. Fixtures must be hardwired and utilize high power factor ballasts to qualify for rebates. For more information visit www.cityofseattle.net/light/conserve/resident.

Portland General Electric's (PGE's) Earth Advantage Program

The Earth Advantage Program is a comprehensive builder program that encourages builders to construct homes that exceed the 1993 Model Energy Code (MEC) for efficiency by 20-30 percent. In addition, Earth Advantage requires homes to score between 87-91 on the Home Energy Rating System (HERS) scale exceeding the ENERGY STAR target of 86. Currently, more

than 30 builders participate in Earth Advantage. The Program requires that three (3) hardwire fixtures be installed, *or* builders may use two (2) hardwired fixtures if two (2) screw-in CFLs are installed in high-use areas. For more information visit www.earthadvantage.com.

Vermont ENERGY STAR Homes

In 2002, Efficiency Vermont's program combined with Vermont Gas Systems' HomeBase New Construction program to become Vermont ENERGY STAR Homes Program. This combined program contains a strong lighting component where builders must install at least four (4) hard-wired efficient lighting fixtures in moderate to high-use locations. In addition, $25 rebates are provided for each efficient recessed can, and $15 for other efficient lighting fixtures, up to a maximum of twenty (20) fixtures per home. Achieving all the efficiency targets outlined for the new program, participants are eligible to receive rebates of up to $1800 from the program. For more information visit www.vtenergystarhomes.com.

Sacramento Municipal Utility District (SMUD) New Home Lighting Efficiency Program

SMUD's current program (through December 2002) encourages builders and contractors to install energy efficient lighting systems in new homes. Lighting incentives are limited to 50 percent of the fixture cost up to a maximum of $10 rebate per fixture. The maximum lighting incentive per home is $100 and a maximum of $20,000 per builder application. For more information visit www.smud.com/adv_home/energy.html

New England ENERGY STAR Homes

Sponsored by electric utilities in Massachusetts, Rhode Island, and New Hampshire, this program offers up to $900 in rebates for ENERGY STAR products per home – limit of $200 per refrigerator and $100 per dishwasher. Rebates for the full purchase price of ENERGY STAR lighting fixtures is applied after the home receives ENERGY STAR certification. In Massachusetts alone, more than 2000 homes received ENERGY STAR certification in 2000. For more information visit www.energystarhomes.com.

Wisconsin ENERGY STAR Homes

Wisconsin's new construction program focuses on efficient home design and construction. Although lighting is not a specific component of the program, participants are eligible for the existing consumer rebate program that offers $10 rebates for ENERGY STAR fixtures, $15 for ENERGY STAR ceiling fans, and $20 for ENERGY STAR Torchieres. For more information on Wisconsin's ENERGY STAR Homes program and lighting rebates visit www.weccusa.org/wesh/ and www.weccusa.org/energystar/rewards.html#rewards.

New Jersey ENERGY STAR Homes

The statewide New Jersey ENERGY STAR Homes program is sponsored by the electric and gas utilities of New Jersey. This program utilizes the nationally recognized Home Energy Rating System (HERS) to determine program compliance. Because HERS does not include efficient

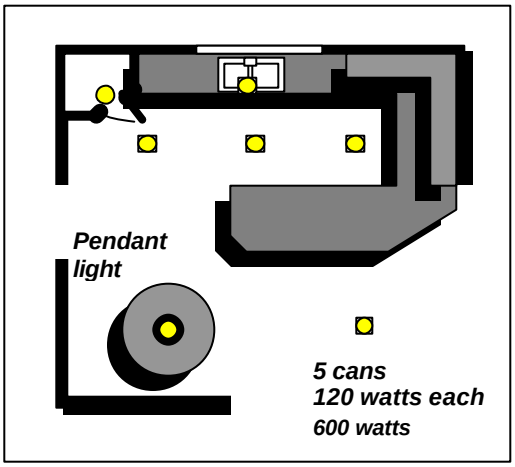
lighting, the NJ program encourages ENERGY STAR fixtures through supplemental incentive -- $30 per ENERGY STAR recessed can; $20 for each other ENERGY STAR fixtures used in high-use locations. For additional information please visit www.njenergystarhomes.com/index.html.

Regional Program Summary

There are significant regional and national efforts incorporating ENERGY STAR into new construction. With few exceptions, efficient lighting has not been a strong component of these efforts; most likely due to lack of fixture availability, lack of acceptance by construction market actors, cost, reliability and/or lack of education.

Holistic Lighting Design Approach

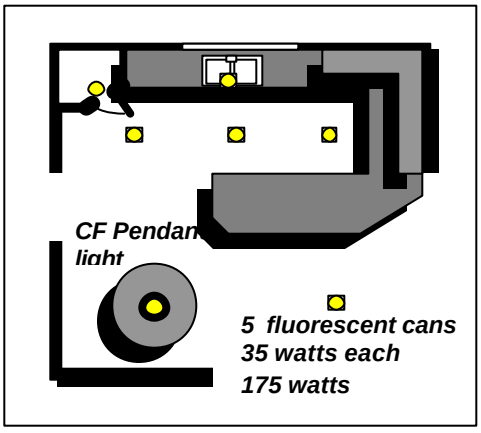
Figure 31: Basic SHERIDAN Kitchen



Statistics
750 watts
225 sf
3.33 w/sf

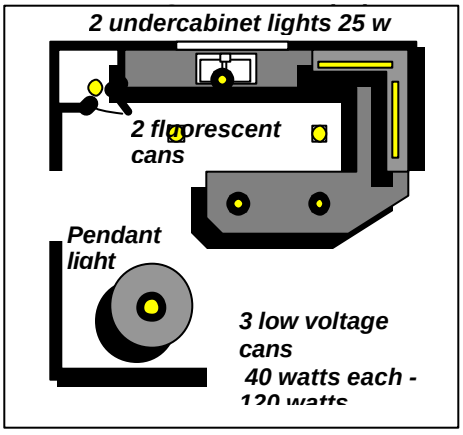
The Alliance is advocating a more sophisticated approach than those outlined above, by marrying improved lighting design practice with more energy efficient hardware. This concept is illustrated in figures 31 – 33. Figure 31 shows the standard lighting package for the kitchen in a new representative Pacific Northwest tract house. Figure 32 represents a one-for-one energy efficiency upgrade package, which reduces energy consumption by 70%. In contrast, figure 33 illustrates an upgraded alternative that features a more effective lighting design, and uses two additional fixture types. This alternate design enhances lighting quality and flexibility while reducing energy consumption up to 62% compared to the standard practice. Though the upgraded alternative uses a little more energy than the one-for-one upgrade it provides a much more attractive and marketable lighting scheme.

Figure 32: Efficient SHERIDAN Kitchen



Statistics
220 watts
225 sf
0.97 w/sf

Figure 33: Efficient Upgrade -



Statistics
285 watts
225 sf
1.27 w/sf

Barriers, Controls, and Policy

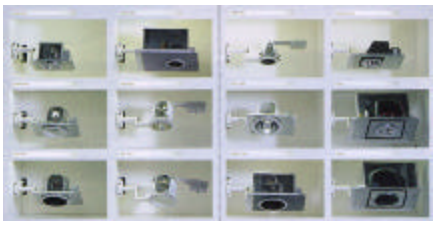
A number of technical barriers exist that limit the use of energy efficient lighting in some applications; most notably compact fluorescent recessed cans for insulated ceilings. Over 20 million recessed cans were sold in the year 2000, with ~75% being I.C. (insulated ceiling) rated. Existing compact fluorescent technology has not proven to be reliable in this application, limiting prospective energy savings in a number of heavy use areas such as kitchens. Several initiatives are underway to overcome this barrier. Figure 34 summarizes two (2) of the more significant initiatives, including a compact fluorescent recessed can technology procurement competition being overseen by the Pacific Northwest National Labs (PNNL) and an energy-efficient down lights for California Kitchen program being collaboratively undertaken by Lawrence Berkley Labs (LBL), the Natural Resources Defense Council (NRDC), Sacramento Municipal Utility District (SMUD), and Lithonia lighting.

Figure 34: Notable Initiatives - Can Crazy

CFL Recessed Can Technology Procurement Competition

(DOE - PNNL)

Challenge Industry to Develop a:
- Cost-effective
- High Reliability
- Residential Grade I.C. Airtight
- 65-watt BR40 Lamp equivalent
- Minimum 900 Initial Lumens



Energy-Efficient Downlights for California Kitchens

Integrated Kitchen Lighting System

(LBL, NRDC, SMUD, Lithonia)

- Central Linear fluorescent Luminaire "Mothership"
- CFL Ballasts Located in Central Fixture for Remote Downlights
- Modular Plug and Play Interconnects
- System Provides Layered Lighting (Ambient, Task, and Accent)

These initiatives are important because:

- There were 21 million residential recessed cans sold in 2000
- 10 – 40 recessed cans were found per house in a sampling of 29 new homes throughout the state of California.
- Less than ½% utilized energy efficient CFL technology
- The average fixture efficiency is only about 55% (ranging between 30% - 80%)

In other applications, proven energy saving technologies exist but are under-utilized because of lack of consumer awareness or price premium. Two examples of these are occupancy sensors and dimmer switches. They not only save energy but also provide households with convenience and control over their environment, both highly marketable attributes. Figure 35 shows sample lighting control devices that could be utilized to reduce wasted energy use.

Figure 35: "Hidden Opportunities" - No-Brainer Motion Sensor Savings

Laundry and Garage Areas - Mode 1

Automatic-on
Automatic-off after 15 minute time delay
Light level sensing

Bedrooms - Mode 2

Manual-on
Automatic-off after 10 minute time delay

Closets, pantries, hallways - Mode 3

Automatic-on
Automatic-off after 3 minute time delay

High / Low:
Dim From Dusk to Dawn
Bright When Motion Occurs

Figure 36 illustrates the energy savings achieved by utilizing dimming controls. Dimmers actually work by turning the lights on and off very rapidly. The more a light bulb is dimmed, the more the light is in the "off" state and the less electricity is being used. This results in greater energy savings. A second benefit of dimming is that a dimmed lamp generates less heat, which extends the life of the filament in the light bulb. Unfortunately, less than two dimmer switches are installed in the average new home.

Figure 36: "Hidden Opportunities" - Dimmers Save Electircity and Increase Lamp Life!

Dimmers Pay For Themselves		
Dimming the Lights	**Saves Electricity**	**Makes incandescent bulbs last longer**
10%	10%	2 times longer
25%	20%	4 times longer
50%	40%	20 times longer
75%	60%	>20 times longer

No matter what the desirable benefits of improved lighting design and energy efficient lighting, certain portions of the marketplace will not respond until forced to. Implementing more rigorous energy codes is one of the fastest ways to expedite change and the only way to raise the minimum acceptable performance for "bottom draggers". Residential energy codes differ from non-residential codes in many ways. For instance, while non-residential energy codes are required to meet or exceed ASHRAE/IESNA 90.1-89 to comply with EPACT, residential codes are required to meet or exceed the 1992 Model Energy Code (MEC). Following is a summary of the current regional energy codes for residences in the Pacific Northwest:

- Washington's code exceeds the 1995 MEC for electrically heated buildings, but not for non-electrically heated buildings.
- Oregon's code exceeds the 1995 MEC by 20-30%.
- The Idaho Residential Energy Standards (IRES) code is less stringent than the 1992 MEC
- Montana employs the 1993 MEC with state amendments, but it is only required for state jurisdictions that adopt codes, which is only a portion of the state

A concluding observation is that currently, there are no energy efficiency requirements for new residential lighting in the Northwest, except that "IC" airtight recessed can housings be used in Oregon and Washington residences when installed in ceilings below unconditioned spaces. This leads the program development team to conclude that there is opportunity to work with state energy code policy makers to make efficient lighting a component of residential construction, but we have to recognize that this is a long-term undertaking.

The only state residential code to have lighting requirements is California's Title 24. Title 24 presently requires hardwired high efficacy lighting for some of the lighting systems in the kitchen and bath. Title 24 is currently being reviewed for possible changes. Proposed revisions being considered in 2003 call for hardwired high efficacy lighting in utility spaces, garages, and exterior lighting. In addition, a proposal to restrict recessed lighting wattage is being reviewed for the 2003 revisions. The Alliance program development team looks towards California as a model of how to incorporate efficient lighting into the residential energy code.

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