Miscellaneous Residential Electrical End Uses: U.S. Historical Growth and Regional Differences

Daniel P. Nore and Michael R. Roberts, Regional Economic Research, Inc.

This paper documents key drivers of sales growth over the last ten years and explores regional differences for nine census regions. The study provides insights into the growth of miscellaneous appliance sales and expands earlier empirical work to the regional level (Rainer, Greenberg, and Meier, 1992). Many forecasters expect growth in the miscellaneous end-use category to maintain or drive increases in national sales-per-household levels. Average sales-per-household levels have increased steadily over the last ten years, from 8,880 to 9,800 kWh. Approximately 60% of this growth occurred in the miscellaneous end-use category. Increases in the saturation and use of color televisions, microwave ovens, and home electronic appliances accounted for a significant share of the growth. Historical trends, regional differences, and methodologies presented in the paper establish a foundation for utility forecasters using residential end-use models.

Introduction

Estimated at between 13 and 20% of residential sales in 1990, miscellaneous electric appliances account for a significant percentage of residential electricity sales. Growth in the miscellaneous end-use category is projected to substantially offset sales declines achieved by federal appliance efficiency standards. Often miscellaneous forecasting assumptions are inadequately documented and skeptically viewed by senior utility management and regulatory commission staff. Documentation of historical growth trends and the appliance composition of the miscellaneous end-use category is critical for establishing and understanding future residential electric sales forecasts.

Research Approach

Miscellaneous end-use sales were derived using a two-step process. First, a top-down approach was used to develop aggregate national and regional miscellaneous end-use energy estimates. Historical sales-per-household estimates for the period 1980 through 1990 were derived from the Energy Information Administration's (EIA) Monthly Energy Review Residential Energy Consumption Survey (RECS), and household estimates published by the Census Bureau.

These estimates were then decomposed by end-use using EPRI's Residential End-Use Energy Planning System (REEPS). Major end-uses consisted of space conditioning, water heating, refrigerators, freezers, ranges and ovens, dishwashers, clothes washers, clothes dryers, and lighting. Major end-use electricity consumption was then subtracted from total residential sales to provide a residual estimate of miscellaneous electric appliance consumption.

The second step allocated the residual miscellaneous sales estimate to specific household appliances through the use of a bottom-up approach. Energy consumption for eleven appliances (color televisions, black and white televisions, microwave ovens, waterbed heaters, pool pumps, spa pumps, well pumps, attic fans, evaporative coolers, dehumidifiers, and home computers) was estimated using conditional demand analysis (CDA) and data from the 1990 RECS. The CDA approach related variations in household economic and demographic characteristics to differences in appliance-specific consumption levels. Cross-regional differences in income and family size, for instance, were related by the technique to resultant variations in appliance-specific energy consumption. Seven additional appliances were estimated using a engineering framework and information from prior studies.[1]

Miscellaneous Electric Sales Growth

A review of recent national forecasts emphasizes the historical and expected future role of the residential miscellaneous electric sales category. Figure 1 presents historical and forecasted sales-per-household estimates from recent U.S. residential forecasts completed by the EIA, the

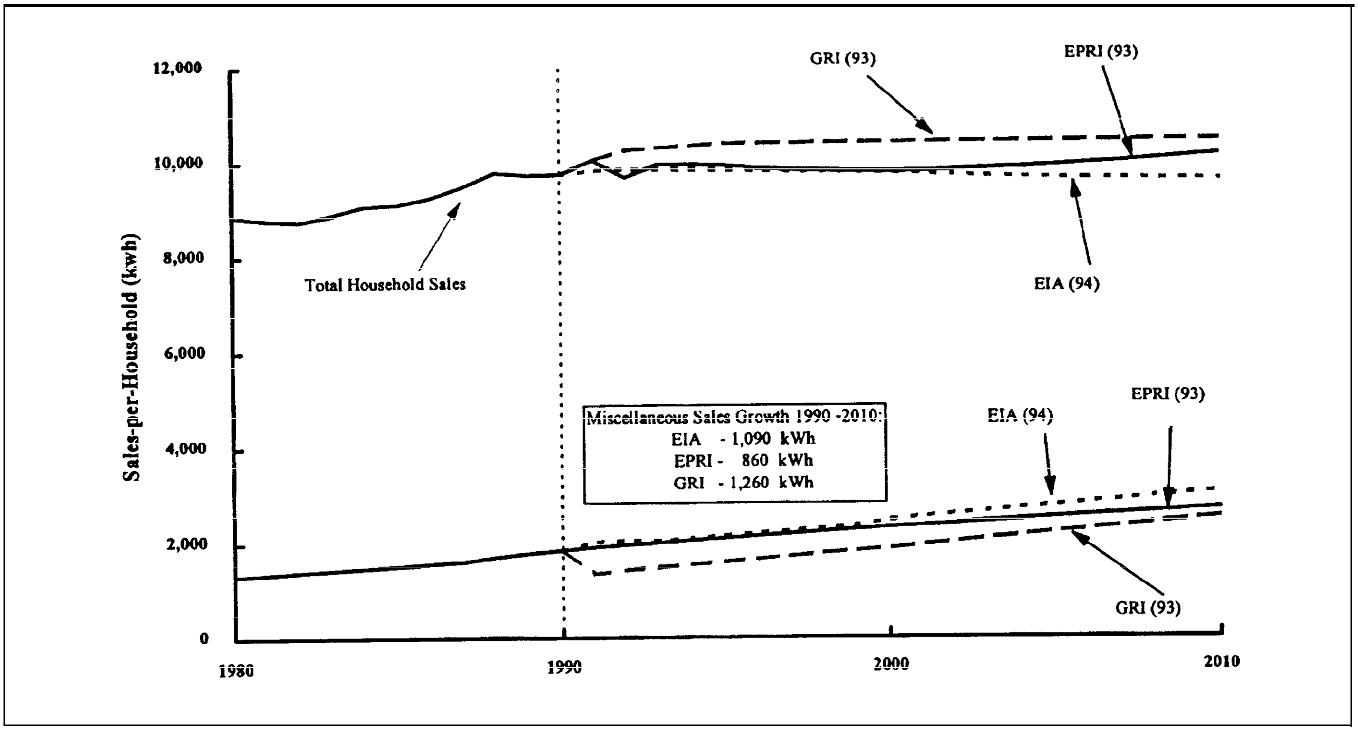

Figure 1. Sales-Per-Household: Total and Miscellaneous Electrlc

Electric Power Research Institute (EPRI), and the Gas Research Institute (GRI).[2] The outlook for sales-per-household growth ranges from a slight decline to moderate increase. The expected 1990 to 2010 change in average sales-per-household for the three forecasts is -190, 390 and 840 kWh respectively. Starting with a 1990 value of 9,750 kWh, these projections represent annual growth rates of -0.1 %, 0.2%, and 0.4%. As a reference, during the period 1980 to 1990 sales-per-household grew by 870 kWh or 0.9% annually. The three forecasts are consistent with the expectation that residential sales-per-household growth in the next two decades will be significantly lower than the previous decade.

Miscellaneous electric sales-per-household grew at a 3.3% annual rate during the period 1980 to 1990, increasing from 1,320 to 1,840 kWh for a net increase of 520 kWh. This indicates that miscellaneous electric sales growth accounted for 60% of total sales-per-household growth in the last decade. As of 1990, miscellaneous electric sales represented 19% of total sales-per-household. [3]

All three forecasts project continued miscellaneous electric sales growth over the next twenty years. On a sales-per-household basis, these forecasts suggest that miscellaneous electric sales will increase by 860 to 1,260 kWh between 1990 and 2010. This growth translates into an annual gain of approximately 40 to 60 kWh and represents a continuation of the 50 kWh annual growth pace experienced during the 1980's. In the EPRI and GRI forecasts, growth in the miscellaneous end-use category offsets energy savings derived from efficiency standards and conservation. Unlike the 1980's however, miscellaneous sales increases represent the primary source of future growth and, as a result, its share of total household consumption is projected to increase from 19% to over 24%.

Miscellaneous Electric UEC Decomposition

Table 1 provides an appliance breakdown of the miscellaneous electric unit energy consumption (UEC). A review of Table 1 indicates that in 1990, 18 appliances accounted for 77% of our estimated miscellaneous UEC of 1,840 kWh. These 18 appliances are are significant since they account for large share of the current UEC total or are expected to impact to future sales growth.

An earlier study of miscellaneous end-uses (Rainer, Greenberg, and Meier, 1990) evaluated a total of 32 appliances. They estimated a 1987 miscellaneous UEC of 1,500 kWh. Our miscellaneous end-use definition incorporates 31 of their 32 appliances, but excludes furnace fans. Consumption related to non-listed appliances like aquarium pumps, clocks, toasters, and electric blankets are included in the "other plug load" line item at the end of Table 1. The difference between our UEC estimate and the Rainer, Greenberg, and Meier estimate is attributed to miscellaneous end-use growth between 1987 and 1990 and our use of a top-down approach.

Table 1. 1990 Miscellaneous Electric UEC Decomposition

Description	Household Shares 1980	Household Shares 1990	UEC	Weighted UEC	% of Total UEC
Color TV's	82.0	96.0	694	666	36.2
Waterbed Heaters	5.0[a]	15.0	1,013	152	8.3
Microwave Oven	14.0	79.0	178	141	7.6
Pool Pumps	6.0[a]	5.0	1,916	96	5.2
Hair Dryers	53.0[a]	87.0	80	70	3.8
Well Pumps	15.0[a]	15.0	399	60	3.3
Dehumidifiers	9.0	12.0	349	42	2.3
Coffee Makers	44.0[a]	73.0	50	37	2.0
VCR	5.5[a]	72.0	40	29	1.6
Spa Pumps	3.0[a]	4.0	634	25	1.4
Home Computers	6.0[a]	16.0	121	19	1.1
CD Players	0.0	28.0	60	17	0.9
Evap. Coolers	4.0[a]	4.0	372	15	0.8
Attic Fans	7.0[a]	10.0	129	13	0.7
Phone Answering	2.0[a]	43.0	30	13	0.7
B/W TV's	51.0	31.0	26	8	0.4
Cordless phones	0.0	19.0[a]	30	6	0.3
Home Security Systems	0.0[a]	15.0	30	5	0.2
Other Plug Load				428	23.3
Total Miscellaneous 1990				1,840	

(a) Estimated based on 82 RECS, 84 RECS, and Appliance Magazine saturations and shipments.

Historical Drivers of Growth (1980-1990)

Growth in the miscellaneous end-use UEC has been largely driven by increases in the number of households which own a specific appliance and/or increases in the number of specific appliances owned by each household. For example, the share of households with color televisions increased from 82 to 96% between 1980 and 1990, a net share increase of 14%. During this same time period the average number of color televisions sets owned by those households with color televisions increased from approximately 1.3 to 1.8 sets. Other end uses like microwave ovens have experienced dramatic increases in ownership shares but units per household have remained constant.

It is estimated that color televisions, waterbed heaters, and microwave ovens accounted for approximately 70% of the miscellaneous sales growth in the last ten years. Based on the color television ownership changes discussed above, it is estimated that color televisions accounted for at least 28% of the increase in miscellaneous end-use sales. The calculation of this growth estimate is as follows:

UEC Chg = [Share Increase x per unit UEC] +
[% Increase intensity x per unit UEC x
2nd television utilization factor x
% household ownership share]

The increase in microwave oven and waterbed heater ownership is estimated to account for another 42% for a total of 70% (28% + 42%).

Miscellaneous electric appliances can be designated as either maturing, emerging or obsolete technologies. This classification scheme is derived from the product "life cycle" model used in the product marketing field. The life cycle model is useful for explaining and evaluating miscellaneous electric sales trends. Emerging technologies drive sales growth, obsolete technologies lead to sales declines, and maturing technologies only marginally influence sales trends.

Mature technologies are defined as appliances that have reached a stable saturation level (i.e., shipments are equal to replacements). Given the dramatic increase in ownership rates of color televisions, microwave ovens and VCRs, these appliances could now be considered mature technologies. Figure 2 presents shipments data for color televisions, microwave ovens and VCRs. Between 1980 and 1988, annual color television shipments increased from 10.8 million to 20.0 million units per year. Since 1988 shipments have leveled off at rate of 20.0 to 21.0 million units per year. This level of shipments is only slightly above an estimated 19.2 million annual replacement level. The annual rate of 19.2 million assumes a eight year average life and a existing stock of 150 million. Microwave shipment levels peaked in 1987 at 12.6 million units per year and have since declined to 8.1 million per year. The microwave shipments level is also slightly above an estimated replacement level of 7.4 million units per year. This assumes a ten year average life and an existing stock of 74.0 million.

Mature technologies are unlikely candidates of future growth in the miscellaneous end-use category. Growth derived from mature technologies will be primarily determined by increases in appliance usage or size. For example, a change in household preferences toward large screen televisions or an increase in the number of hours watched could still cause the color television UEC to increase. The expected gain, however, will be a fraction of the gain driven by increased saturations witnessed over the past ten years.

Future Drivers of Miscellaneous Growth

Future miscellaneous electric sales are expected to be influenced by increased saturations of recently introduced technologies and the appearance of entirely new technologies. These appliances are classified as emerging technologies. Home computers, CD players, telephone answering machines, cordless phones, home security systems, and similar electronic appliances will drive future of miscellaneous sales growth. It is estimated that these emerging technologies contributed 50 kWh or 10% of the total miscellaneous UEC growth during the 80's.

A large number of emerging technologies require the use of a power transformer. Meier, Greenberg, and Rainer (1992) estimated that the average home contained at least three external transformers drawing 1-9 watts on a continuous basis. External transformers are required for most phone answering machines, cordless phones, and video games. Other electronic appliances have built in transformers and are less apparent. In general, each transformer adds 50 kWh to annual household consumption.

It is estimated that existing technologies listed in Table 1 will generate 30 to 40% of the miscellaneous growth projected by the three sales forecasts discussed earlier. The miscellaneous UEC can be expected to increase 350 kWh on the basis of these technologies. This estimate assumes increases in ownership shares for emerging appliances like phone answering machines and moderate increases in maturing technologies like color televisions and

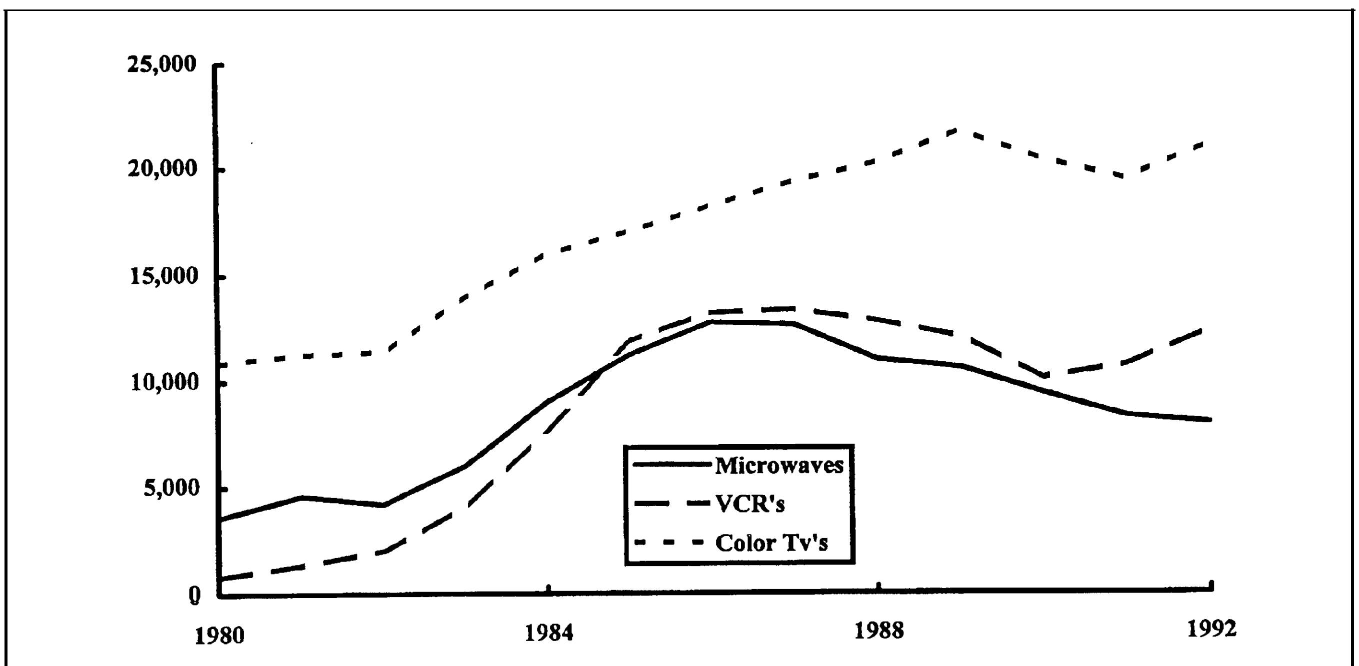

Figure 2. Maturing Technologies (National Shipments in 1000's)

microwave ovens. Figure 3 indicates that increased saturations of emerging technologies are forth coming. Between 1980 and 1992, annual shipments of phone answering machines jumped from 0.6 to 15.5 million units, cordless phones from .2 to 17.7 million, and video games from 6.5 to 12.9 million. Much of this growth occurred in the last five years.

It is anticipated that the remaining miscellaneous UEC growth will be driven by the introduction of entirely new technologies. As discussed earlier; the total miscellaneous UEC is projected to grow between 860 to 1,260 kWh by 2010 (actual sales through 1993 suggest 160 kWh of growth has already occurred). Existing and emerging technologies will account for 350 kWh of the expected growth. New technologies will account for the remainder. A review of the previous decade indicates that growth of this magnitude can result from a single technology like color televisions or through a combination of appliances like phone answering machines and home computers.

The development of new technologies for home entertainment will be the most likely source of miscellaneous sales growth. Applications of virtual reality research is a strong contender. Smart home technology is another potential source.

Future Offsets–Obsolete Technologies and Efficiency Improvements

The decline of obsolete technologies and pending miscellaneous appliance efficiency improvements will offset growth in the miscellaneous UEC. Often emerging technologies provide substitute services for existing miscellaneous appliances. Figure 4 presents shipments data for three obsolete technologies. The appliances depicted in Figure 4 have been replaced by a substitute technology. For example, turntable shipments declined as the CD player gained in popularity. Since the energy consumption of CD players is similar to turntables, the decreased contribution of turntables to the miscellaneous UEC is largely offset by CD players. The decline in black and white televisions, in contrast, has led to increased miscellaneous electric sales. The introduction and increased popularity of color televisions has caused the decline of black and white televisions. Color televisions, however, are larger and consume considerably more electricity than the black and white units they replace.

As significant efficiency improvement goals are achieved with the major residential end uses, focus is likely to shift to the miscellaneous appliance group. Color televisions are one of the 13 appliances covered by the National Appliance Energy Conservation Act (NAECA), but efficiency standards have not yet been established. Earlier efficiency analysis completed by the Department of Energy indicates that efficiency standards for color televisions could reduce consumption by 26% (DOE Technical Support Document DOE/CE-0239, 1988). The incorporation of microprocessors in appliances is another commonly cited efficiency trend. Personal computer and peripheral sleeper chip technology provides a good example. Sleeper chips are design to shut down equipment after a set period of inactivity. The U.S. Environmental Protection Agency's

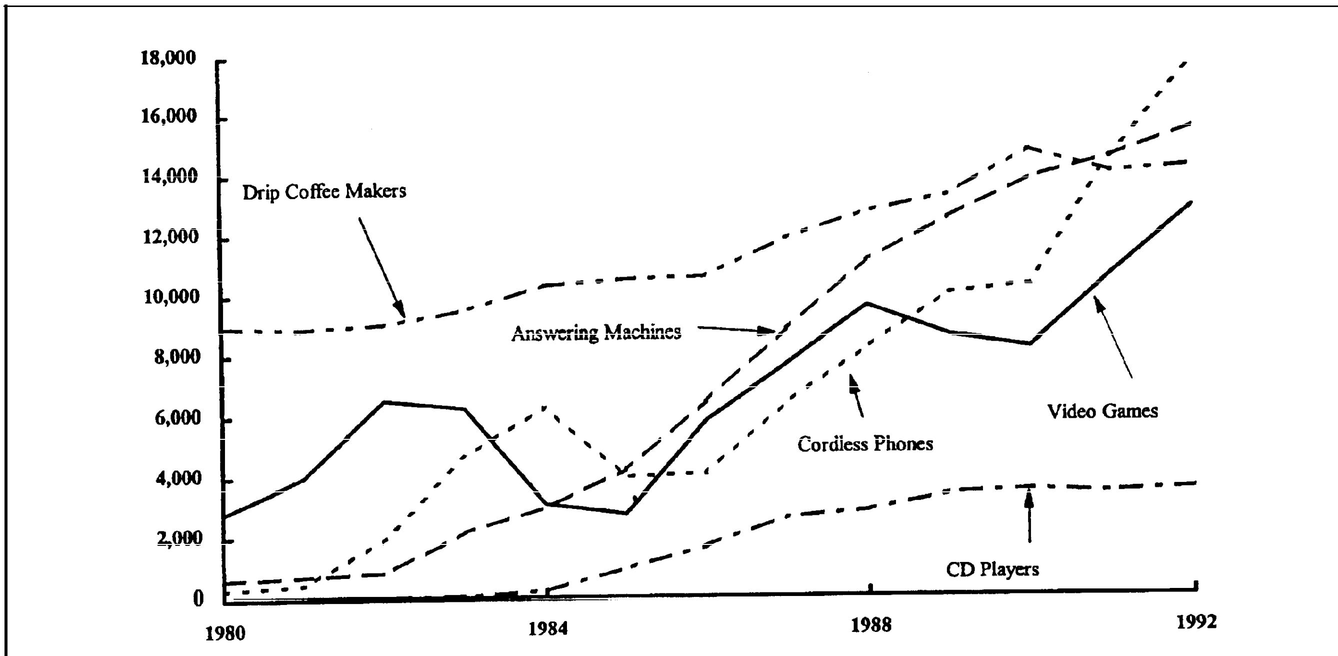

Figure 3. Emerging Technologies (National Shipments in 1000's)

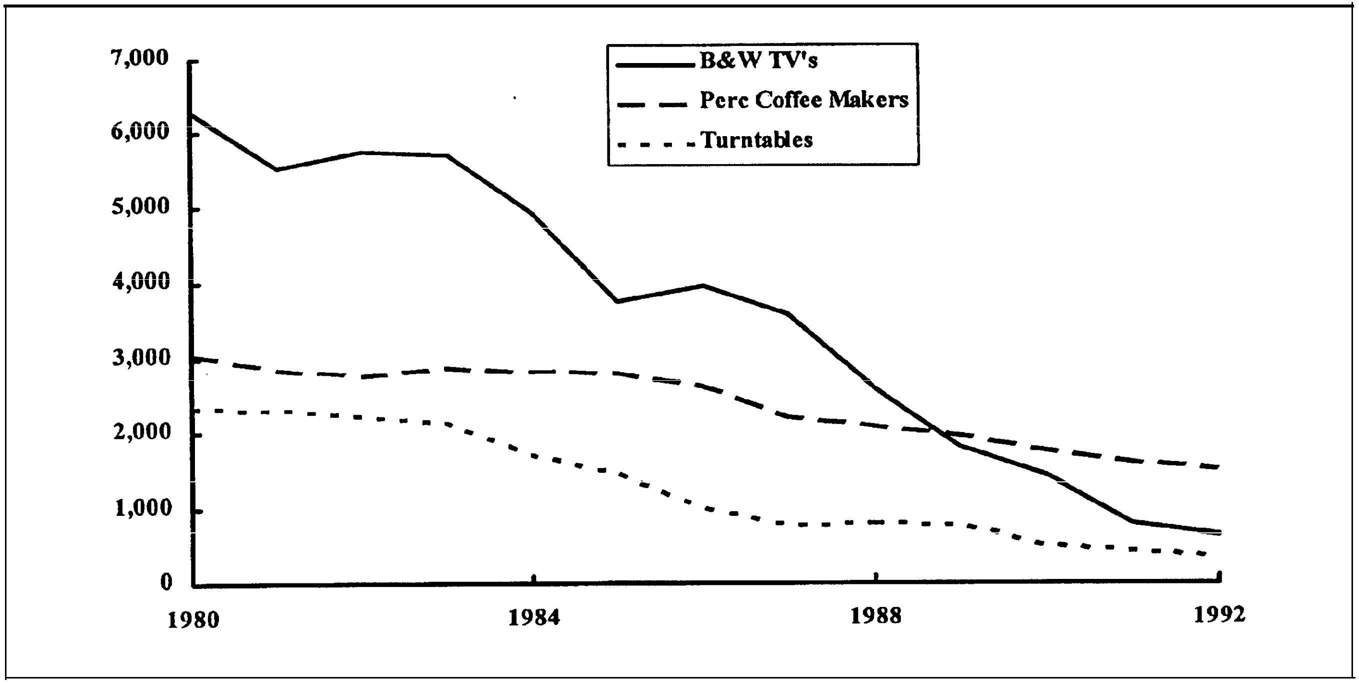

Figure 4. Obsolete Technologies (National Shipments in 1000's)

(EPA) Energy Star program is estimated to save 60% of the energy used by a standard monitor.

Miscellaneous Electric Sales – Regional Perspective

This section presents the results of the regional miscellaneous UEC analysis performed on the 1990 RECS data. The 1990 RECS database has consumption data for 5,095 households distributed across nine census regions. The foundation for our miscellaneous UEC analysis was provided by a 1990 RECS CDA study completed by EIA. EIA completed CDA analyses of each of the last three RECS surveys (84,87, and 90). The EIA CDA studies separate whole house bills into heating, cooling, water heating and appliance UECs. In 1990, refrigerator and freezer UECs were estimated and separated from the appliance UEC estimate.

Our analysis used EIA's 1990 appliance UEC estimate, net of refrigerators and freezers, to calculate miscellaneous appliance UECs. UECs for major appliances like clothes dryers, clothes washers and dishwashers were estimated and subtracted from the EIA total to arrive at a beginning miscellaneous total. Miscellaneous UECs presented in this section are consistent with the miscellaneous end-use definition employed in the first half of the paper.

The results of the regional miscellaneous appliance UEC analysis is presented in Figure 5 and Table 4. These results indicate that both total miscellaneous UEC's (Figure 5) and miscellaneous appliance UEC's (Table 4) vary substantially by region. This variation is attributable to regional differences in the following drivers of electricity consumption:

- Demographics,
- Housing characteristics,
- Electric prices,
- Weather, and
- Appliance shares.

Demographics, Housing Characteristics, Electric Prices and Weather

Miscellaneous appliance UEC's are influenced by regional demographics, housing characteristics, electric prices, and weather. The RECS database contains detailed information on each of the households contained in the survey. Some of the key variables used in our CDA study are summarized in Table 2. Table 2 presents regional and national data on electric price, income, home size, family size, and weather.

As key drivers of miscellaneous end-use energy consumption, cross-regional differences in demographics help explain some of the regional UEC variation. Most regions have a combination of above average and below average values for the variables presented in Table 2. Outside of the expected differences found in the weather variables, there are several important distinctions to be noted from the Table 2.

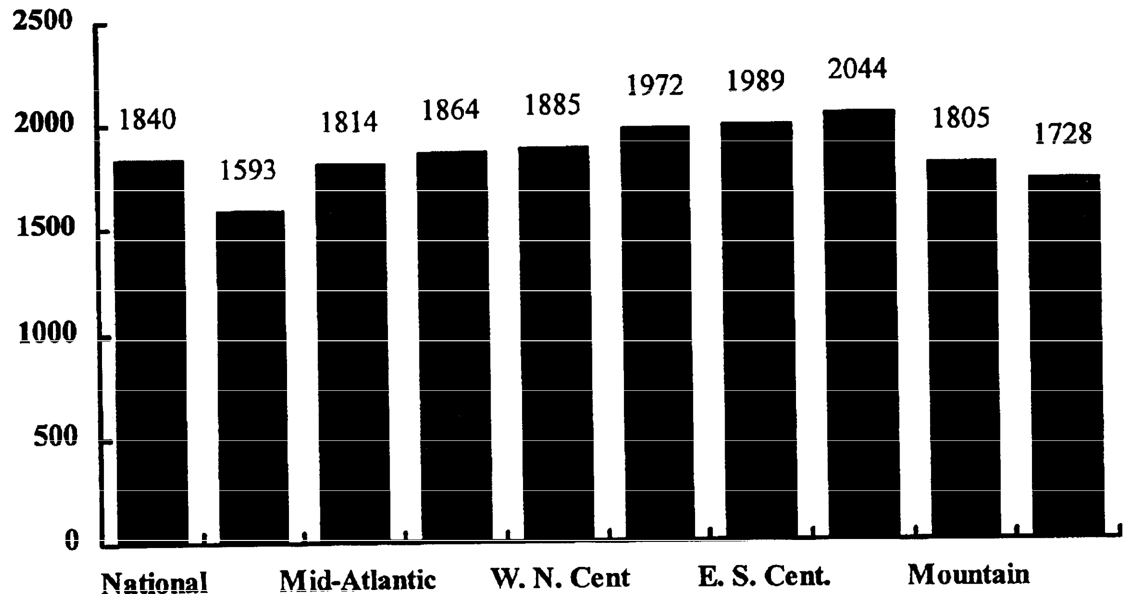

Figure 5. Total Miscellaneous End Use UEC's

Table 2. Regional Characteristics

Drivers	National	N.E.	Mid-Atlantic	E.N. Central	W.N. Central	South Atlantic	E.S. Central	W.S. Central	Mountain	Pacific
Avg. Price ($/kWh)	.083	.100	.109	.082	.074	.073	.058	.072	.071	.091
HH Inc.	29,278	30,956	28,542	29,892	29,777	29,026	26,920	29,833	32,201	28,576
House Size	1,800	2,046	2,115	2,032	2,041	1,607	1,675	1,618	1,614	1,489
HH Size	2.52	2.43	2.63	2.44	2.36	2.43	2.49	2.75	2.61	2.55
CDD (65)	1,386	626	832	761	1,088	2,202	1,787	1,599	1,770	1,020
HDD (65)	3,887	5,709	4,895	5,695	5,730	2,193	2,782	2,001	4,328	2,892

- The East South Central and South Atlantic regions have sub-mean values for all three demographic variables.
- The Pacific region, while having a mean family size, falls below the average in terms of income and even further below in terms of house size.
- Differences in home size across regions can in part be attributed to the different distributions of housing types (i.e., the mix of single family, multi-family, and mobile homes).

Total miscellaneous UEC's ranged from 1,593 in New England to 2,044 in the West South Central region. Underlying the distributions found in Figure 5 is a distribution of average electricity prices. Regions with higher average prices generally have smaller UEC's and vice versa. In accordance with this correlation, regions such as New England and Pacific have low UEC's while the Southern regions (East South Central and West South Central) have higher UEC values.

Appliance Shares

Table 3 presents regional appliance shares for major end uses included in our miscellaneous end-use category.

From a regional perspective, appliance saturations are significantly different. While some regions are similar, each is unique in its end use composition. The different distributions of appliances play a large part in the variation exhibited by the total miscellaneous end use (see Figure 5 above).

In general, the more mature technologies (TV's and microwaves) have a relatively small variance across regions while the weather sensitive end uses (dehumidifiers, attic fans, and swamp coolers) vary quite significantly. The remaining end uses, with the exception of personal computers, display cross-regional variation as well. Specific regional differences are as follows:

- Mountain, Pacific and West South Central regions are similar in the low saturation of well pumps and dehumidifiers and the high concentrations of evaporative coolers.
- New England, the Mid-Atlantic, and the East North Central regions have more black & white televisions, well pumps, and dehumidifiers than the national average. Swamp coolers and spa pumps; however, are less prevalent.
- The South Atlantic and East South Central regions don't vary much from the national average with the exception of dehumidifiers.
- Similar to the Mountain and Pacific regions, the West South Central region differs in several end use categories. Most notably, well pumps, waterbed heaters, and dehumidifiers are well below average.

Regional UECs

The results presented in Table 4 are in large part driven by the demographic, price, weather, and appliance data previously discussed. As a result, one would expect the UEC's to exhibit similar variation to that found in these "explanatory" variables.

Upon close examination of Table 4, several inferences can be made.

- The more mature technologies, as previously defined, exhibit relatively small variation across regions. This implies that any variation exhibited in the drivers of usage are canceled out by one another.
- Weather sensitive end-uses vary significantly as a result of usage patterns dictated by weather.
- Appliance intensity must also be considered in explaining cross-regional variation. Water bed heater consumption in the Mid-Atlantic is considerably lower as a result of a relatively small intensity.

Conclusions

The miscellaneous end use is both an important and little understood component of residential electricity sales. The miscellaneous end-use category was responsible for 60%

Table 3. 1990 RECS Regional Appliance Saturations

End-Use	National	N.E.	Mid-Atlantic	E.N. Central	W.N. Central	South Atlantic	E.S. Central	W.S. Central	Mountain	Pacific
Color TV's	96%	99%	96%	96%	98%	95%	93%	97%	97%	95%
B/W TV's	31%	29%	31%	38%	31%	31%	32%	35%	29%	19%
Microwaves	79%	73%	70%	83%	87%	80%	79%	80%	84%	78%
Well Pumps	15%	20%	17%	23%	16%	22%	13%	4%	7%	6%
Dehumidifiers	12%	19%	18%	23%	22%	8%	7%	3%	2%	3%
Attic Fans	10%	5%	13%	8%	12%	12%	12%	14%	5%	6%
Waterbed Heaters	15%	10%	11%	17%	27%	13%	15%	10%	23%	13%
Personal Computers	16%	12%	17%	15%	12%	18%	12%	12%	18%	20%
Pool Pumps	5%	6%	8%	5%	2%	6%	4%	5%	2%	7%
Spa Pumps	4%	2%	2%	2%	2%	3%	5%	3%	3%	9%
Evap. Coolers	4%	0%	0%	0%	1%	0%	0%	7%	39%	7%

Table 4. Regional Miscellaneous UEC's

End-Use	National	N.E.	Mid-Atlantic	E.N. Central	W.N. Central	South Atlantic	E.S. Central	W.S. Central	Mountain	Pacific
Color TV's	694	636	781	670	633	683	697	705	635	702
B/W TV's	26	23	20	33	30	31	32	11	12	29
Microwaves	178	177	163	181	186	187	169	161	183	186
Well Pumps	399	389	411	397	408	400	391	392	393	376
Dehumidifiers	349	248	292	273	370	592	584	906	301	191
Attic Fans	129	48	95	91	105	132	122	202	145	184
Waterbed Heaters	1,013	1,010	898	1,028	1,045	1,031	1,045	1,089	1,008	981
Personal Computers	121	136	107	130	109	129	101	101	117	134
Pool Pumps	1,916	1,566	1,844	1,865	2,277	2,069	1,802	1,386	2,267	1,719
Spa Pumps	631	633	632	637	628	627	635	632	626	631
Evap. Coolers	372	None	439	450	410	449	422	359	353	404
Other	428	307	358	424	405	538	645	755	360	350
Total Miscellaneous	1,840	1,593	1,814	1,864	1,885	1,972	1,989	2,044	1,805	1,728

of the growth in sales-per-household during the 1980's and experienced a 3.3% compounded annual growth rate. The future role of this end use is expected to be even greater as both current technologies become more prevalent and new technologies enter the market. The impact of pending efficiency standards on specific appliances within the miscellaneous category is only partially known at this time. Current regional differences among miscellaneous energy consumption were also found to exist, although not dramatic. This is due mainly to a difference in the appliance composition of the miscellaneous end use category and the difference in electric prices. Different technologies offset one another resulting in a relatively even distribution of energy consumption.

Endnotes

1. Prior evaluation of the miscellaneous electric end-use category has been conducted by Alan K. Meier, Steve E. Greenberg, and Leo I. Rainer. These researchers utilized a bottom-up approach based on engineering estimates, metering studies and utility CDA studies. Study references are listed below. The miscellaneous end-use has also been evaluated by EIA as part of the RECS analysis. This paper expands on these efforts by evaluating historical trends, regional differences, and future expectations.

2. Three recent national residential sales forecasts provialed a end-use decomposition. The EPRI and GRI forecasts employed a comparable miscellaneous end use definition. The EIA study differed from the EPRI and GRI definition by incorporating clothes washers and dishwashers in the miscellaneous sales category. References for the three forecasts are listed below.

3. In studies completed by Meier, Rainer, and Greenberg, the sales contribution of the miscellaneous end-use category was estimated at 17 to 18% of total sales.

4. Estimates of miscellaneous end use sales varied among the three forecasts (EIA, EPRI, and GRI). A single historical estimate is depicted in Figure 1 and corresponds to the EPRI forecast estimate. The 1990 miscellaneous UEC estimates for EIA, EPRI and GRI are 1,979, 1,840 and 1,257 kWh, respectively.

References

Appliance Magazine, "Statistical Review." *Appliance Magazine,* 50(4): April 1993.

Appliance Magazine, "The Saturation Picture." *Appliance Magazine,* 50(9): September 1993.

Appliance Magazine, "U. S. Small Appliance Growth." *Appliance Magazine,* 50(11): November 1993.

Energy Information Administration. 1994. *Annual Energy Outlook 1994 with Projections to 2010.* DOE/EIA-0383(94), U.S. Department of Energy, Washington, D.C.

Gas Research Institute. 1993. GRI *Baseline Projection Data Book: GRI Baseline Projection of U.S. Energy Supply and Demand to 2010.* Volume II. Gas Research Institute. Washington, D.C.

Meier, A. K., Greenberg, S. E., and Rainer, L. I., "Emerging Miscellaneous Uses of Electricity in Homes." Residential Performance: Analysis and Measurement - *Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings,* Volume 4, pp. 4.141-4.143. American Council for an Energy-Efficient Economy, Washington, D.C.

Meier, A. K., Rainer L. I., and Greenberg, S. E., "Miscellaneous Electrical Energy Use in Homes." *Energy,* 17(5): 509-518.

Nadel, B., "The Green Machine." *PC Magazine,* pp. 110-145, May 25, 1993.

Rainer L. I., Greenberg, S. E., and Meier, A. K., "The Miscellaneous Electrical Energy Use in Homes." Residential Data, Design, and Technologies: Analysis and Measurement - *Proceedings from the ACEEE 1990 Summer Study on Energy Efficiency in Buildings*, Volume 9, pp. 9.263-9.271. American Council for an Energy-Efficient Economy, Washington, D.C.

Regional Economic Research, Inc. and Barakat & Chamberlain, Inc. *Drivers of Electricity Growth and the Role of Utility Demand-Side Management.* Electric Power Research Institute Report No. TR-102639. Research Project 2863-01.

Sanders, M., "Interfacing with the Home of the Future." *Appliance Magazine,* 50(4): April 1993.

U.S. Department of Energy, Conservation and Renewable Energy, Building Equipment Division. *Technical Support Document: Energy Conservation Standards for Customer Products:* Washington, D.C., DOE/CE-0239: Refrigerators, Furnaces and TVs.

U.S. Department of Energy. *Housing Characteristics 1990.* DOE/EIA-0314(90). Energy Information Administration. Office of Energy Markets and End Use, Department of Energy. Washington, D.C.

U.S. Department of Energy. Household Energy *Consumption and Expenditures 1990.* DOE/EIA-0321(90). Energy Information Administration. Office of Energy Markets and End Use, Department of Energy. Washington, D.C.