Development of Federal Energy Efficiency Product Recommendations

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In this paper, we describe the formulation of the Federal Energy Management Program (FEMP) Product Recommendations and provide estimates of expected energy and cost savings attributable to the program. The Product Recommendations include specific energy efficiency levels and estimated energy costs for a wide variety of products. The energy efficiency levels and associated guidelines help to streamline the implementation of cost-effective purchasing by Federal buyers. The Product Recommendations apply to the entire Federal sector, which is the world's single largest purchaser of energy-using equipment.

Focusing on the Residential Equipment and Appliance Product Groups, we show the results of detailed market compression analyses and the application of a set of screening criteria across product categories. Based on the statistical analyses as well as other technical guidance, we chose recommended energy efficiency levels for each product. We also determined the best available products, and compared the cost-effectiveness of purchasing at the recommended levels with the typical or standard energy efficiency level for each product category. The Recommendations are expected to save a considerable amount of taxpayer money, as well as providing environmental benefits and improved services.

INTRODUCTION

Energy efficiency is an important goal for the Federal sector as a means of reducing the cost of government and improving the environment. Federal energy expenditures in buildings, facilities, and process applications are roughly 4.5 billion $/year. A substantial fraction of this annual expenditure could be saved through cost-effective investment in energy efficiency. Further, energy efficiency investments continue to save the government money over the entire lifetime of the product, just as money in the bank earns interest every year. In addition to the potential for energy and cost savings, the Federal government, as the world's largest customer, can serve as a force to ‘‘pull’’ the overall commercial market towards greater energy efficiency.

The Federal Energy Management Program (FEMP) has developed a number of initiatives to support energy-efficient purchasing by the federal government. One of these initiatives is the Energy Efficiency and Resource Conservation Challenge. The purpose of the Challenge is to help agencies comply with Federal mandates, specifically Section 161 of the Energy Policy Act of 1992 (EPAct) and Executive Order 12902, issued March 1994. EPAct directs federal agencies to purchase energy-efficient products based on minimum life-cycle cost criteria. The Executive Order directs agencies to purchase products in the upper 25% of energy and water efficiency for comparable products, or at least 10% more efficient than U.S. DOE national standards.

The FEMP *Product Recommendations* are intended to help Federal buyers select energy-efficient products that comply with the Executive Order and the goals of EPAct. For a given product, the goal of our analysis was to develop energy efficiency guidelines consistent with these two directives by identifying the upper 25% of the market for energy performance. The *Recommendations* present these guidelines in an easy-to-use format for Federal procurement officials and product specifiers. Participating agencies who use these guidelines to buy efficient products can realize significant energy savings and operating cost reductions and thereby save taxpayers' money. In addition, the combined participation of all the agencies generates substantial buying power with the potential to expand the market and lower the costs for highly efficient products through increased competition and economies-of-scale.

The items covered under the *Recommendations* are expected to eventually include about sixty different types of products, spanning several different product groupings In this paper, we consider two product groups, Residential Appliances and Residential Equipment, and present the analysis and recommendations for eight different products. Residential Appliances includes room air conditioners, refrigerator-freezers, dishwashers and clothes washers. Residential

Equipment includes central air conditioners and heat pumps, gas furnaces, electric water heaters, and gas water heaters.

DATA AND METHODOLOGY

We used the most recent and reliable product databases from government agencies and trade organizations. Government agencies included the California Energy Commission (CEC), the New York State Energy and Research Development Authority (NYSERDA), and the Federal Trade Commission (FTC) in the U.S. Department of Commerce. Trade organizations included the Association of Home Appliance Manufacturers (AHAM), Gas Appliance Manufacturer Association (GAMA), and the Air Conditioning and Refrigeration Institute (ARI). The data include energy and performance characteristics of models available for sale, based on widely accepted testing methods. We rely on model data rather than sales data because it is readily available and non-proprietary. Even where sales data is available, it is generally aggregated and lacks sufficient detail for this type of analysis.

In all cases, the energy performance metrics are based on the standard DOE test procedure applicable to the product and product category (10 CFR 430, 1995). Where there were several different measures of energy performance, we chose the measure that appears on FTC ENERGYGUIDE labels so as to ensure that buyers would have sufficient information to make an informed decision. Actual energy consumption will of course vary for any product according to usage level and other behavioral factors.

The analysis for each product followed essentially the same series of steps. First, we determined a set of distinct product categories for analysis, based on relevant product characteristics such as capacity or distinguishing features. These product categories were closely related to the product classes used for national appliance standards under the National Appliance Energy Conservation Act (NAECA). In some cases, there are efficiency differences across product categories, and such distinctions are necessary to ensure that our recommended energy efficiency levels do not conflict with proper sizing or buyer preferences for specific features.

Second, for each product category with a reasonable number of models (generally at least 50 models), we tabulated model counts across the relevant range of energy performance. We included only those models that met or exceeded existing national standards. From this data, we developed histograms and cumulative frequency distributions. We identified the energy efficiency level nearest to a cumulative frequency of 75% (from worst to best), which is equivalent to the upper 25% of the market, as called for in the Executive Order.

Third, where appropriate, we adjusted this level to coordinate with other federal programs and to consider purchasing patterns of the central supply agencies. Such programs include the Environmental Protection Agency's ENERGY STAR[SM] program and the Department of Energy's ENERGY SAVER program. The central supply agencies include the General Services Administration (GSA) and the Defense Logistics Agency (DLA).

Fourth, for each product category, we determined the number of manufacturers represented in the model selection before and after applying the energy efficiency criteria. In order to insure competitiveness in federal purchasing, a minimum of three manufacturers had to be represented in the reduced set of models that meet the criteria (unless the total number of manufacturers is less). We interpreted brands and manufacturers equivalently in this case, because it is often not possible to distinguish them. Furthermore, since buyers often identify with particular brands and subsidiaries can in many cases act independently, there should be sufficient distinction from an overall market perspective.

Finally, where the recommended energy efficiency levels did not differ significantly across two or more product categories, they were combined in order to simplify the recommendations. Also, recommendations were not made for those categories and products for which the results of the analysis were inconclusive or for which availability was constrained. Consequently, the final set of product categories for the Recommendations necessarily differed in some cases from the set of product categories at the start of the analysis, as well as from the NAECA product classes.

PRODUCT ANALYSES

In the next section, by way of example, we have illustrated the basic methodology graphically for one of the products, room air conditioners. Due to space limitations, graphs for the other products are omitted, although they are available on request from the authors. The graphics resulting from the analysis are similar for all products, although of course the categorization and the measure of energy performance differs. We have summarized in tabular form the analysis of efficiency distributions for the other products and the resulting energy efficiency recommendations for the relevant product categories.

Room Air Conditioners

The Energy Efficiency Ratio (EER) for room air conditioners is correlated with cooling capacity, presence of louvered sides, and reverse cycle (heat pump) capability. Consequently, NAECA distinguishes twelve product classes based on size (cooling capacity), including six for those with louvered sides and six for those without louvered sides (those appropriate for through-the-wall installation). The

category and the non-louvered categories into one category, resulting in a more simplified and reasonable set of Recommendations, as summarized in Table 1.

Refrigerator-Freezers

The energy consumption of refrigerator-freezers is affected by several features and design options, including automatic defrost, the configuration of the compartments, and presence of through-the-door ice (TTD-ice) features. Among the different NAECA product classes, top-mount freezer models (TF-A) and side-by-side models with automatic defrost (SS-A) are by far the most common, representing over 90% of the models in the AHAM database (AHAM 1995b). We

use more energy, other things being equal, and the NAECA standards differ for models with ice. However, a number of new efficient models with ice have been introduced on the market in recent years. Consequently, in some size categories, models with ice have lower energy consumption on average than those without ice. As a result, there appeared to be no systematic bias against models with ice when we considered them together for a given size category.

In determining product categories, we used the ENERGY-GUIDE size bins, each of which spans 2 cubic feet in total volume. We developed recommendations for a total of ten product categories, as shown in Table 2, These included

Table 1. *Room Air Conditioner Summary*

Cooling Capacity (Btu/hour)	Louvered Sides?	Number of Models	Worst (EER)	Recommended (EER)	Best (EER)
< 20,000	Yes	586	8.0	10.0	12.0
= or > 20,000	Yes	215	8.2	9.0	10.0
All	No	320	8.0	9.0	9.6

Source: Association of Home Appliance Manufacturers (AHAM), October 1995.

Table 2. *Refrigerator-Freezer Model Summary*

Type (Product Class)	Total Volume (cubic ft.)	Number of Models	Worst (kWh/yr)	Recommended (kWh/yr)	Best (kWh/yr)
SS-A	18.5-20.4	166	935	760	702
SS-A	20.5-22.4	251	967	760	561
SS-A	22.5-24.4	108	1008	843	750
SS-A	24.5-26.4	115	1040	843	641
TF-A	12.5-14.4	119	624	526	496
TF-A	14.5-16.4	186	653	616	514
TF-A	16.5-18.4	586	769	655	518
TF-A	18.5-20.4	215	732	655	533
TF-A	20.5-22.4	320	840	727	555
Compact	(< 7.75)	105	457	329	270

Source: Association of Home Appliance Manufacturers (AHAM), June 1995.

tors. A separate category for compacts (defined as < 7.75 cubic feet) was justified because they are important in the federal sector due to their use in military installations. The other size bins have an insufficient number of models to permit identification of a reasonable breaking point near the 75th percentile. Furthermore, based on a review of current GSA buying practices, all but a few of the refrigerator-freezers currently purchased fall into one of the selected categories.

In some cases, the same efficiency level was recommended for two adjacent size categories. For SS-A, the 18.5-20.4 and 20.5-22.4 cu.ft. categories would have been 760 and 759 kWh/year, respectively, but obviously a single level of 760 kWh/year is appropriate. Similarly, the 22.5-24.4 and 24.5-26.4 categories have the same recommended level of 843 kWh/year even though the 75th percentile for 24.5-26.4 actually fell at 828 kWh/year. It would also be somewhat illogical to call for lower energy use for the larger volumes.

In the case of TF-A models, the 75th percentile fell at 653 kWh/year for 16.5-18.4 cu.ft., which is close enough to 655 to combine the two categories.

While necessary to provide buyers with information in a recognizable format, use of the ENERGYGUIDE size bins does require some interpretation. First, the grouping of models in bins of 2 cubic feet means that units with the same annual energy consumption within a given bin may have slightly different levels of performance. Second, the size bins are defined by total volume rather than adjusted volume. Since energy performance is correlated to adjusted volume, variations in energy performance occur because freezer volume is not a fixed proportion of total volume, but varies according to model design. In spite of these shortcomings, we still find it preferable to provide a recommendation that is easier to use and interpret rather than a recommendation that is technically superior but requires buyers to interpret information not readily available to them.

Dishwashers

The measured energy consumption of dishwashers includes the heating of water and boosting for the wash cycle, heated drying via the electric resistance element (and sometimes fan operation), and electricity for the motor to turn the spray arm and pumper. The largest source of energy consumption is the heating of hot water, often accounting for 75% of the total energy consumption. The Energy Factor (EF) for a dishwasher is equal to the reciprocal of the energy used in one complete operation of the dishwasher, and annual energy consumption is the energy consumed in 322 cycles per year.

The data used for this analysis were based on the California Energy Commission (CEC) database as well as information gathered during 1995 by the Federal Trade Commission for updates to the ENERGYGUIDE labels. Although NAECA has two product classes, standard and compact capacity, we considered only standard models, which make up over 90% of the market. There were 420 models that met or exceeded the 1994 standards, with 25 different manufacturers or brands represented. The 75th percentile falls at an annual energy consumption of 619 kWh, which corresponds to an energy factor of 0.52. There are 102 models that meet or exceed this recommended level, with 14 manufacturers or brands represented. At the upper end of the market, the best available dishwasher has an annual energy consumption of 474 kWh or an energy factor of 0.68.

Clothes Washers

Water heating accounts for about 90% of a clothes washer's total energy consumption on average, with the remaining energy consumption due to electricity for mechanical operation of the motor and the drain pump. Strategies to reduce energy consumption therefore focus on hot water use, including both simple user-controlled features as well as design changes. If the complete laundry cycle is considered (washer and dryer), then one of the most effective energy-saving strategies is to increase the washer spin speed. This is because the mechanical spinning process of the washer is more efficient at removing the initial moisture content of the clothes than is the thermal cycle of a dryer. Unfortunately, there was insufficient data available at this time to include dryers in the analysis, although we expect that future analyses will consider the complete laundry cycle.

The Energy Factor (EF) for a clothes washer is equal to volume or capacity (ft3) divided by the energy consumption per cycle in kWh. ENERGYGUIDE labels give only the Annual energy consumption in kWh per year, which is equal to energy use per cycle times 416, the estimated number of cycles per year. This means that a buyer would have to know the volume as well as the DOE assumption for cycles/year (416), and then would have to calculate the energy factor. Furthermore, some manufacturers do not report energy factor at all because the ENERGYGUIDE program technically obligates them to report only kWh/year. So existing databases will in some cases only list annual energy consumption. Since buyers may therefore either not have the needed information on energy factor or have some difficulty to calculate it, we determined that the recommendations would need to refer to annual energy consumption rather than energy factor. Because the range in volume gives rise to a wide range in kWh/year for a given energy factor, a performance measure based on kWh/year will be biased towards smaller machines, other things being equal.

The analysis is based on information gathered during 1995 by the Federal Trade Commission for updates to the ENERGYGUIDE labels with some supplemental information from other sources such as the California Energy Commission (CEC) database. There were only a few compact models, and so we considered only Top-loading standard capacity ($>$ 1.6 ft3). There were 194 standard models that met or exceeded the 1994 standards, with 15 different manufacturers or brands represented. The 75th percentile falls at an annual energy consumption of 840. There are 49 models that meet or exceed this level, with 11 manufacturers or brands represented.

Table 3 summarizes the model analysis across different volumes, including the number of models and manufacturers before and after excluding the models with AEC greater than the recommended maximum of 840 kWh/year. As expected, very few of the large volume models meet this recommendation, and all but one manufacturer are eliminated at these volumes. In effect, the recommendation becomes that of buying a small or mid-size machine since 41 of the 49

Table 3. *Clothes Washer Model Analysis Summary*

Volume (ft3)	Model With Highest Energy Consumption (kWh/year)	Total Number of Models	Number of Models Under 840 kWh/year	Total Number of Manufacturers	Manufacturers With at Least One Model < 840 kWh
1.7	599	1	1	1	1
2.1	740	1	1	1	1
2.4	846	1	1	1	1
2.5	881	26	25	2	2
2.7	952	43	16	6	6
2.8	987	29	2	1	1
2.9	1022	26	0	2	0
3.0	1058	22	0	1	0
3.1	1093	29	2	5	1
3.2	1128	16	1	4	1

qualifying models are between 2.4 and 2.7. Buyers will potentially have no options at all between 2.8 and 3.0 cubic feet. In some cases, the 840 kWh/year recommendation will present an availability problem because retailers can only stock a limited number of models. A competitive conflict may arise as well, since there will not be three manufacturers available for large machines. Consequently, energy-efficient Federal purchasing for clothes washers will generally be constrained for large volume machines under these guidelines.

At the upper end of the market, the best available clothes washer has an annual energy consumption of 234 kWh/year. This model has a horizontal-axis design, and is somewhat smaller in volume than the typical vertical-axis machine. In a conventional machine, the tub must be filled with water so that all the clothes are kept wet as the agitator swirls the water around to clean the clothes. Conversely, in a horizontal-axis machine, the clothes are brought to the water, so to speak. The tub itself rotates and makes the clothes tumble into the water, an inherently more efficient process since all the clothes need not be immersed in water simultaneously. The horizontal-axis machines also use less detergent than vertical-axis machines, thereby lowering operating costs even further. Although horizontal-axis machines tend to be front-loading, there are also top-loading models. At the same time, some manufacturers have recently been focusing on more energy-efficient designs that are not based on horizontal-axis. The upshot is that the market for clothes washers is currently in flux with respect to energy-efficient designs to a greater extent than in the past, so that the direction of efficiency changes to be taken by manufacturers is rather uncertain.

Based on many of the aforementioned factors, we ultimately determined that it was premature to establish a recommendation for clothes washers at this time, for several reasons. The first reason is the uncertainty in the data due to the reporting of annual energy consumption rather than energy factor and volume for many models. Efforts are underway to improve the tracking of energy factor as well as other characteristics such as water consumption for future analyses. A second reason is the difficulty in making a recommendation based on kWh with regard to consumer choice, given the limited availability of larger models that meet the ‘‘upper 25% criteria under this metric. Third, it may be more appropriate to develop a measure of performance that considers the whole laundry cycle, an approach that will become feasible as additional data such as remaining moisture content becomes available. Finally, we expect that once some of the changes in the clothes washer market are settled in the coming year, there will be a more sound basis for a set of FEMP Product Recommendations than there is now.

RESIDENTIAL EQUIPMENT ANALYSIS

Central Air Conditioners/Heat Pumps

The Air Conditioning and Refrigeration Institute's Unitary Directory (ARI 1995) provides information on current models available for central air conditioners and heat pump. Here we are concerned only with residential size systems (65 kBtuh or less in cooling capacity). We conducted separate analysis for each of the NAECA product classes, which are distinguished by capacity, heat pump capability, and system type: split system or single-package (SP), as given in table 3. Analysis of this data revealed that for split systems, the upper 25% of the market generally falls around SEER = 12.0. Since there is a heavy clustering of models at SEER = 12.0, a higher level would be rather stringent in terms of model availability. The availability of single-package models is more constrained than for split-systems, but the upper 25% of the market still fell fairly close to an SEER = 12.0

Since the Environmental Protection Agency's (EPA) ENERGY STAR CAC/HP level is also SEER = 12.0 for both system types, this energy efficiency level appears to be the logical breaking point for the Federal purchasing recommendation. Use of a single level for all system types also greatly simplifies the ability of buyers to implement the recommendations. At the same time, consistency with EPA ENERGY STAR reinforces the ‘‘market-pull’’ value of the recommendations by sending a clear signal to manufacturers and buyers about where the market is headed.

On the heating side, we also adopted the ENERGY STAR level for HSPF of 7.0 (not shown in the table). We did not explicitly analyze the heat pump model distributions by HSPF in the same manner as for SEER, for three reasons. First, our preliminary analyses showed that over 99% of available heat pump models with SEER $>=$ 12.0 also had an HSPF $>=$ 7.0. Second, the cooling side is generally more important than the heating side for buyers and manufacturers of air-source heat pumps. Air-source heat pumps tend to be used for heating in milder climates because their performance degrades in colder regions where ambient temperatures can drop below freezing for a significant part of the year. Buyers tend to size the systems for cooling and manufacturers tend to optimize their designs for cooling for this reason. Third, there is little justification to depart from the ENERGY STAR level in the absence of other mitigating factors.

Gas Furnaces

The data used for this analysis was taken from the Gas Appliance Manufacturer Association's (GAMA) Directory

Table 4. *Central Air Conditioner Model Summary*

Cooling Capacity (kBtu/hour)	Product Type	Number of Models	Worst (SEER)	Recommended (SEER)	Best (SEER)
$<$ 39 kBtuh	CAC—Split	15743	10.0	12.0	16.4
39-65 kBtuh	CAC—Split	16226	10.0	12.0	17.0
$<$ 39 kBtuh	CAC—SP	1370	9.7	12.0	13.0
39-65 kBtuh	CAC—SP	2053	9.7	12.0	13.0
$<$ 39 kBtuh	HP—Split	15023	10.0	12.0	15.8
39-65 kBtuh	HP—Split	9461	10.0	12.0	16.0
$<$ 39 kBtuh	HP—SP	565	9.7	12.0	12.5
39-65 kBtuh	HP—SP	643	9.7	12.0	12.6

Source: Air Conditioning and Refrigeration Institute (ARI), April 1995.

of Residential Heating Equipment (GAMA 1995a). We grouped the data according to heating output (measured in kBtuh) in order to assure that the energy efficiency criteria could be applied without having a negative impact on size selection. The capacity groups are based on those used in the GAMA directory. The only difference from the GAMA grouping is that we collapsed the smallest ($<$ 43 kBtuh) and largest ($>$ 110 kBtuh) categories for ease of representation, since they represent smaller shares of the overall data set. The Annual Fuel Utilization Efficiency (AFUE) provides the appropriate measure of efficiency for gas furnaces.

The striking feature about the distributions of gas furnaces is the fact that they essentially ''jump'' from an AFUE of 80-81 to 90. This jump is due to a significant difference in design. Models with an AFUE at or above 90 are condensing furnaces, which are designed to reclaim some of the heat lost in exhaust gases, including water vapor. Consequently, there are very few models in the range between 80 and 90 AFUE. With current national standards at an AFUE = 78%, this implies that any recommendation below 90% would have little impact on efficiency. A final reason for the choice of AFUE = 90 as the recommended efficiency level is that the EPA's ENERGY STAR program has chosen this level. Coordination with the EPA program will enhance the market-pull effect of the FEMP recommendation as well as simplify choices for Federal buyers.

Electric Water Heaters

The data for electric water heaters were taken from the Gas Appliance Manufacturer Association's (GAMA) Directory of Residential Water Heating Equipment (GAMA 1995b). The distributions with respect to energy factor (EF) were based on first hour rating in order to assure that the energy efficiency criteria could be applied without having a negative impact on size selection. The 75th percentile falls at or near an EF of 0.92 or 0.93 for the lower capacities. Availability of efficient models is most constrained for the larger water heaters, those with first hour rating above 86 gallons.

Another criterion is the energy efficiency of models available to Federal buyers through the Central Supply agencies, in this case the General Services Administration (GSA). GSA offers several models between 41 gallons and 82 gallons in first hour rating. Electric water heaters above 82 gallon capacity are rather uncommon outside of special applications with unusually high peak demand. Since GSA models are purchased with a life-cycle cost methodology, these models provide an additional refinement to the upper 25% criteria. In particular, electric water heaters up to 82 gallon FHR should have at least an energy factor of 0.92 since all GSA models are at this level or higher.

A third criterion is the simplicity with which buyers can implement the efficiency recommendations. Except for unusually large models, the groupings reveal that the efficiency distributions are not overly sensitive with respect to capacity, so that it might be feasible to set a few levels or even a single level for the recommended energy factor. Only at higher capacities is availability constrained, so we chose a single recommended energy factor of 0.92 for models under 87 gallons in first hour rating. For buyers interested in higher capacities, no explicit recommendation is made, and life-cycle cost analysis should be used in comparing models which otherwise meet the buyers' specifications.

Gas Water Heaters

The data used for this analysis are taken from the Gas Appliance Manufacturer Association's (GAMA) Directory of Residential Water Heating Equipment (GAMA 1995b). We grouped the data by first hour rating in order to assure that the energy efficiency criteria could be applied without having a negative impact on size selection. The capacity groups are based on those used in the GAMA directory, except that some of the less populated groups at the two ends of the capacity distribution have been collapsed to increase the sample size.

In light of the fact that the national standards are based on storage volume, our choice of first hour rating as the measure for capacity obviously creates some confusion. Some models will have the same storage volume, but different first hour rating, and vice-versa. Since the standards are based on storage volume, some models with almost the same first hour rating could be impacted differently by the standards. Furthermore, first hour rating is itself correlated with efficiency, even more so than storage volume, so that it is not possible to independently specify both first hour rating and efficiency. However, since the groupings are used in the ENERGYGUIDE labels, buyers should be somewhat immune to this dilemma. Once the peak demand is estimated and size is determined through choice of a category (grouping), a buyer need only compare the efficiency of models that fall in the same grouping with respect to first hour rating.

The 75th percentile falls between an energy factor of 0.60 and 0.61 for most capacity ranges. Since the efficiency distribution of models is not overly sensitive with respect to first hour rating, it might be feasible to set a few levels or even a single level for the recommended energy factor rather than a linear function as is the case for the national standard. From the perspective of a buyer, this would greatly simplify application of the criteria in particular circumstances. Availability of efficient models is most constrained for the larger water heaters, those with first hour rating above 86 gallons.

GSA offers one model with a first hour rating of 52 and energy factor of 0.61, and another with a first hour rating of 61, and energy factor of 0.63. Consequently, a minimum energy factor of 0.61 is warranted even if such a level falls above the 75th percentile, since Federal buyers can simply purchase the GSA models. Since no GSA models are available above 61 gallon FHR, the question then becomes at what capacity does an energy efficiency recommendation of 0.61 become untenable due to availability constraints?

A fairly ''natural'' breakpoint falls for gas water heaters at an FHR of 87 gallons. Above an FHR of 86 gallons, there do exist some models with energy factor at or above 0.61, but there are very few manufacturers. In the case of models above 98 gallons, there is only one manufacturer. Given this clear breaking point, we believe that a recommended energy factor of 0.61 should apply under 87 gallons in FHR. Above these capacities, no recommendation is made and the buyer must make the decision based on life-cycle cost and availability. In fact, models of such large capacities are generally neither appropriate nor common since most applications tend not to have such high peak hot water demands. The more efficient larger models may actually be intended for combined water and space heating, and so should be considered independently of this analysis anyway. A single energy factor criteria of 0.61 greatly simplifies the gas water heater recommendation without significantly impacting the availability of models.

COST-EFFECTIVENESS AND SAVINGS

Table 7 summarizes the energy performance characteristics, recommended levels, and cost savings for a representative category for each product. Annual energy use is based on the standard DOE test procedure. Lifetime cost savings is based on standard FEMP assumptions for discount and escalation factors over the expected lifetime of the products. Electricity and gas prices are based on the 1994 commercial averages of 7.79¢/kWh and 54.8¢/therm, respectively. As expected, lifetime savings are quite substantial for the space conditioning and water heating products, since these are major components of residential energy use. For appliances, savings are smaller, although it should be noted that other sources of savings are not included here, such as water, detergent, or usage impacts.

There are of course many other factors that impact cost-effectiveness such as energy prices and climate. At the same time, the performance metrics themselves may be impacted by location and climate, especially for the space conditioning products. While there are always application-specific differences that impact energy consumption, overall the figures provide a reasonable rule-of-thumb for comparison purposes. Buyers can compare the expected lifetime savings with the incremental purchase cost for the more efficient appliance to ascertain cost-effectiveness. We have made no

Table 5. *Cost-Effectiveness Examples for Product Recommendations*

Product	Capacity and/or Category	Energy Perform. Metric	Recom-mended Level	Annual Energy Use	Annual Energy Cost	Lifetime Cost Savings
Room Air	10000 Btuh	EER	10.0	750 kWh	$50	$80
Refrig/Freezer	TF-A, 19.5 ft^3	kWh/yr	655	655 kWh	$51	$76
Dishwasher	standard	kWh/yr	619	619 kWh	$48	$69
Clotheswasher	standard	kWh/yr	840	840 kWh	$65	$96
CAC/HP	Split, 36 kBtuh	SEER	12.0	3000 kWh	$234	$578
Gas Furnace	60 kBtuh	AFUE	90%	693 therms	$380	$875
Elec. Water Ht.	50gal. FHR	EF	0.92	4773 kWh	$370	$283
Gas Water Ht.	42 gal. FHR	EF	0.61	246 therms	$135	$243

Annual Energy use in kWh/year for electricity; therms for Gas
Lifetime energy savings based on comparison with standard level using FEMP discount factors.

attempt to include purchase cost in the calculation since these vary widely with the pricing strategies of manufacturers and retailers, as well as due to geographical location.

IMPLEMENTATION ISSUES

We have outlined seven sets of FEMP Product Recommendations for residential equipment and appliances as well as one product that was analyzed for which no recommendation will be made at this time (clothes washers). Federal agencies should use these Product Recommendations to purchase energy-efficient equipment and appliances in compliance with Executive Order 12902 and section 161 of EPAct. Once other agency-specific selection needs are identified, the agency should choose a product which meets or exceeds the recommended energy efficiency level for that product category. Where energy prices differ significantly from the national average, the agency may wish to conduct a detailed analysis of lifetime energy costs for several different models of varying energy efficiency within the same product category.

The same recommended energy-efficiency levels may be used to develop or update product specifications or Commercial Item Descriptions, and in establishing other performance requirements for procurement, supply, and construction or service contracts. These Product Recommendations will be used by the Federal supply agencies (General Services Administration and Defense Logistics Agency) in designating energy-efficient products in their catalogs, on-line data bases, and other publications, and in directing vendors to designate such products in published or on-line schedules. DOE will encourage the supply agencies to identify such products with a common symbol and to make such products widely available through the Federal supply system.

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