ENERGY STAR ® Labeling Potential for Freezers

March 20, 2002

Executive Summary

Household freezers consume about 37.4 TWh (0.40 QBtu primary) of electricity each year, similar to the energy consumed nationally by furnace fans or cooking equipment. The average unit energy consumption (UEC) is about 1,100 kWh per year with approximately 36 million units of freezer stock in the United States today. Using AHAM's weighted average volume for current freezer shipments of 21 ft^3 per unit, the current federal energy standards for the three primary freezer configurations are:

- Upright-Manual Defrost: 417 kWh/year
- Upright-Automatic Defrost: 587 kWh/year
- Chest-Manual Defrost: 351 kWh/year

Using AHAM's weighted average volume again and assuming an ENERGY STAR level of 10 percent less than the current federal standard, the proposed ENERGY STAR label energy levels would be:

- Upright-Manual Defrost: 375 kWh/year
- Upright-Automatic Defrost: 528 kWh/year
- Chest-Manual Defrost: 316 kWh/year

If the ENERGY STAR labeled freezers (at a proposed 10% reduction from the current federal standard) were to make a 10 percent market penetration in the first year of availability, the aggregate, national energy savings would be 9.0 GWh/year (0.098 TBtu primary) of electricity. This energy savings assumes freezer manufacturers will be able and willing to manufacture freezers with energy efficiencies 10 percent better than today's levels without a related cost increase that would limit market penetration.

Market

The freezer market is comprised of two main players, Frigidaire and WC Wood, comprising over 99% of all shipments. Together, these manufacturers ship about two million units a year. Three configurations of freezer are available: chest, upright manual defrost and upright automatic defrost. Chest freezers represent just over half of all freezer shipments and are available in manual defrost only. Upright freezer shipments are nearly split between manual and automatic defrost with automatic defrost units gradually gaining in popularity. Frigidaire produces freezers for Sears/Kenmore and GE. W.C. Wood produces freezers for Whirlpool and Maytag/Amana. Frigidaire is the dominant player in the market at 75 percent market share; W.C. Wood makes up the remainder.

In the last two years, freezer sales have increased about 15 percent each year. Anecdotal evidence suggests that in poor economic times consumers eat at home more often requiring better food storage. The freezer market more typically follows economic

growth with sales increases of 3 to 4 percent a year. Another suspected factor for increased freezer sales is the purchase of more side-by-side configured refrigerators/freezers. Many consumers perceive the freezer in these units to be too small. Consumers may make up for this by purchasing freezers.

Below are two tables summarizing marketing information for freezers.

Freezers—Market Data		
Type of Freezer	Shipments (01)*	Stock Units**
Chest***	1,178,000	22,000,000
Upright-Manual Defrost	427,000	7,500,000
Upright-Automatic Defrost	463,000	6,500,000
Total	2,068,000	36,000,000

Notes: * AHAM (01) totals, last quarter estimated
** RECS 97 data
***Chest freezers only available in manual defrost

Freezers—Market Participants*			
Manufacturer	Market Share		OEM Agreements/Distributors
	Upright Freezer	Chest Freezers	
Frigidaire	80%	65%	Sears/Kenmore, GE
W.C. Wood	20%	35%	Whirlpool, Maytag/Amana

*These two manufacturers supply 99% of the freezer market

Engineering Considerations

Much like refrigerators, freezer manufacturers have made tremendous strides in energy efficiency over the years. In 1980, freezers typically consumed 880 kWh per year (AHAM) of electricity. Today, a typical freezer consumes about 470 kWh (AHAM) per year, nearly a 50 percent improvement. Many technological advances have enabled this performance improvement, including improved compressors, better and thicker insulation, improved door seals, and improved heat transfer surfaces and configurations.

About two-thirds of the energy consumed by a freezer is expended through the cabinet walls. Any improvements to the walls result in a two-fold improvement: reduced heat loss, as well as reduced compressor operation. Manufacturers are actively pursuing improved insulation. A major insulation issue facing freezer manufacturers is the use of HCFC blown insulation. Recently, CFC blown insulation was outlawed and replaced with HCFC blown insulation. HCFC blown insulation will be outlawed in 2004. Manufacturers are seeking new, better types of insulation anticipating this upcoming change. Some European manufacturers are experimenting with cyclopentane blowing agents. Drawbacks of this blowing agent are increased volatile organic compound (VOC)

emission and flammability, however insulation performance is comparable to current HCFC blown insulating agents. Other materials being investigated are vacuum power and gas filled panels.

Improvements to compressor/motor performance represent the most promise for improved freezer performance. Energy efficiency ratios (EER) for small compressors (<400 Btu/h) are about 3.0 and range up to about 5.5 for large compressors (>700 Btu/h). Research indicates that improved lubrication, reduced suction gas heating, and reduced mechanical losses could improve compressor performance further. Careful, holistic consideration must be given when combining the performance improvement of both the compressor and insulation for a freezer. As the insulation improves, the cooling load decreases requiring a smaller, less efficient compressor. The performance improvement of the insulation may be canceled or diluted by the reduced performance of the small compressor. Improvements in small compressor performance are one of the keys to improved performance in freezers. Other potential improvements to freezer performance include the application of linear compressors or Stirling gas-cycle cooler technology. These applications are largely in the laboratory stage or available for specialty applications.

Another possible way to improve the performance of a freezer is using electronically commutated motors (ECM) on the evaporator fans. An ECM would allow the fan to vary its airflow over the evaporator. These fans would be carefully controlled delivering the proper amount of airflow over the evaporator based on the refrigerative demand.

Manufacturers are also considering adding *smart* features to freezers. Since many utilities charge variable rates throughout the day, controls are being developed enabling a freezer to cycle its compressor on only during the off-peak hours. Food stored in a freezer takes a long time to thaw, especially if the food remains in the closed freezer. A long period of no cooling provided by the freezer is tolerable. Manufacturers propose to develop controls cycling the compressor only during off-peak hours passing on savings to the owner. This feature is not yet available, but may be in the near future.

Manual Defrost Only

Manual defrost units may suffer a performance penalty when sufficient ice builds inside the unit. Industry experts estimate the performance of an upright or chest manual defrost freezer may degrade 5 to 10% when the ice builds to a thickness of approximately 1” because of reduced heat transfer. Typically, consumers defrost their units when ice levels become 0.5” to 1” thick (about every six months). However, some may never defrost unless significant freezer volume is lost. If the ice accumulation continues, energy performance may suffer tremendously. Estimates are difficult to make, but energy levels may approach those of an automatic freezer. As soon as the ice is removed, the performance of the unit is restored. Automatic defrost units are becoming more popular, despite their poorer energy performance. Additionally, new automatic defrost units are

closing the energy performance gap with manual defrost units with better defrost schemes.

Energy Consumption and Potential Savings

Using AHAM's weighted average volume for freezer shipments, a simple model of the potential energy consumption and savings of ENERGY STAR labeled freezers may be created. Placing the weighted average volume for a freezer of 21.0 ft^3 into the equations for federal minimum energy standards per *10 CFR 430, Energy Conservation Program for Consumer Products, Standards for Refrigerators and Freezers,* minimum energy levels are calculated. Next, those levels are reduced by 10 percent, the proposed ENERGY STAR level. These new, lower energy consumption levels are used to calculate the potential savings of the sale of one year's worth of ENERGY STAR labeled freezer sales. Below is a table summarizing the energy performance of freezers and the energy saving potential of ENERGY STAR labeled freezers.

Freezers—Energy Consumption

	Type of Freezer			Weighted Averages/ Totals
	Upright w/manual defrost	Upright w/automatic defrost	Chest	
Current federal maximum annual energy consumption (10 CFR 430—1997, kWh/yr)*	417	587	351	472
ENERGY STAR Proposed maximum, annual energy Consumption (kWh/yr, 10% < current federal maximum)*	375	528	316	406
Current Aggregate Consumption (TWh/yr)	7.79	6.75	22.4	37.4**
Estimated Annual ENERGY STAR labeled Freezer Shipments, 10% market penetration	117,800	42,700	46,300	206,800
Aggregate Annual National Energy Savings with ENERGY STAR labeled Freezers (GWh/yr)	4.9	2.5	1.6	13.6

Notes: *uses average adjusted volume for 1997 from AHAM-2001, 21.0 ft^3
** RECS 1997

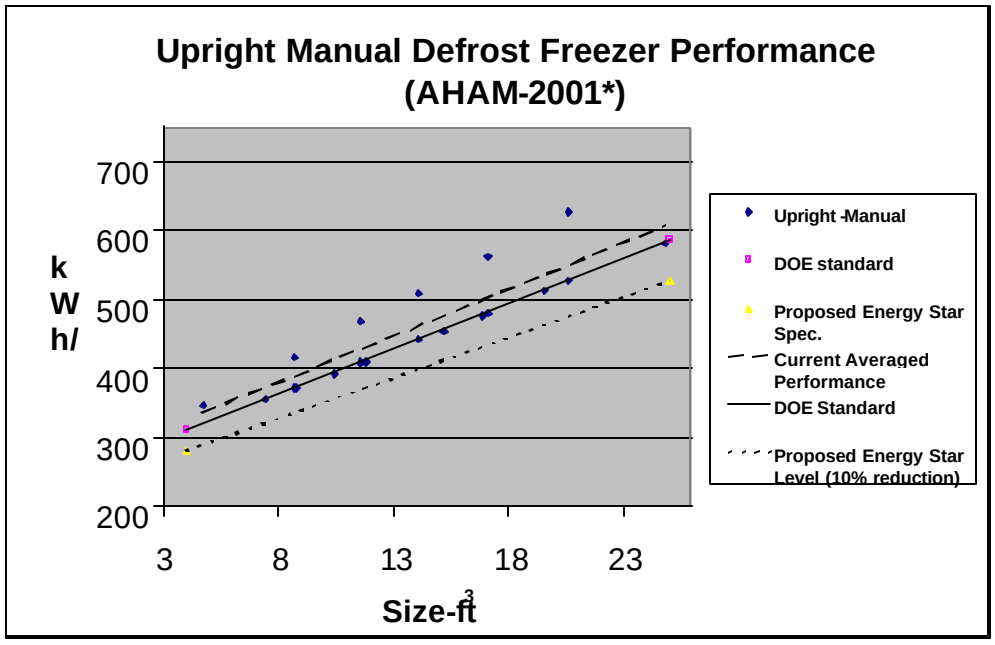
The model created above mathematically combines all sizes of freezers together to simplify the analysis. Freezer sizes vary from 6 to 25 ft^3. As the size of a freezer increases, so does the energy consumption. An ENERGY STAR label will have to address the various sizes and associated performances, as most other ENERGY STAR labeled products do. Typically, capacity ranges will have specific performance levels associated with them. The two major manufacturers currently offer about 20 sizes each. Modeling the potential energy savings using all sizes is difficult because it requires sales data for each model, a proprietary item.

Proposed ENERGY STAR Levels

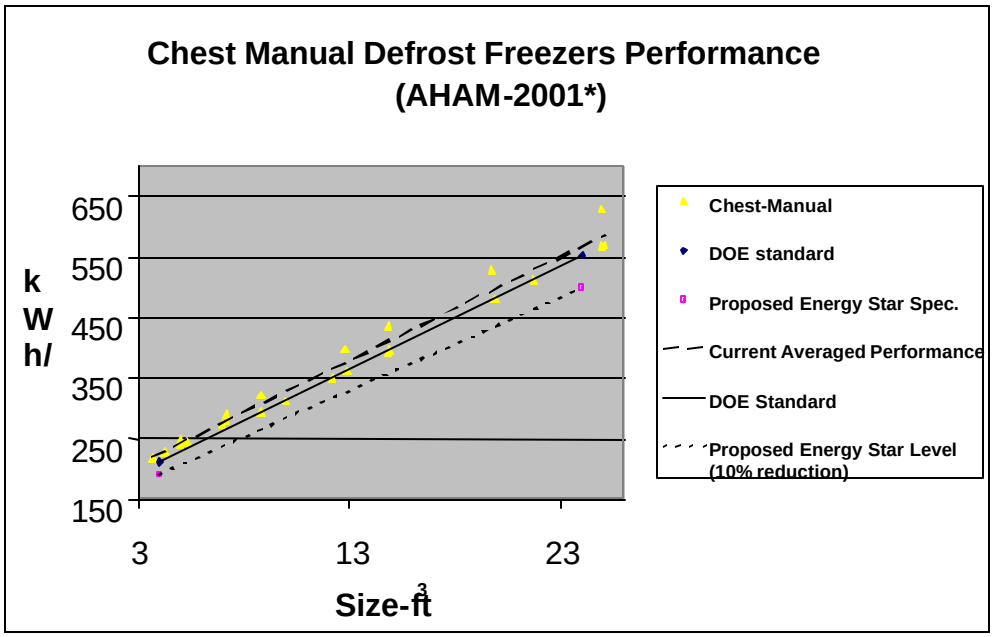
Typically, ENERGY STAR performance levels for appliances have been set a few percent below current federal maximums. We chose 10% as a simple value for the marketplace to target and to coincide with the current specification for refrigerators. Currently, no models would meet even a 10% reduction in energy level as a proposed ENERGY STAR performance might require.

Refer to the two graphs below for chest and upright manual defrost models. Note that none of the current units' performance points fall beneath the proposed ENERGY STAR performance level. Enacting such a specification however may induce manufacturers to pursue improved energy performance, as many other ENERGY STAR specifications have. One manufacturer expressed interest in supplying a unit in the future with improved performance meeting the proposed ENERGY STAR specification. One manufacturer also suggested that they were awaiting an ENERGY STAR specification before integrating existing energy efficiency technologies into their product line.

With an ENERGY STAR specification in effect, manufacturers may begin pursuing some of the experimental options such as improved insulation, compressors, or smart controls. These innovations may enable manufacturers to meet the ENERGY STAR specification. Application of these innovations placed in the marketplace would get the immediate market assistance of the ENERGY STAR label.



*Note: includes pre-2001 Federal Standard effective date data.



* Note: includes pre-2001 Federal Standard effective date data.

Recommendations

Freezer manufacturers may need to be presented with an ENERGY STAR labeling program as an incentive to explore the feasibility of meeting an energy reduction goal. Frequently, manufacturers simply design for the code or to beat their competition. Competing on energy performance alone is unusual in the residential marketplace. However, consumer attitudes are changing rapidly in the marketplace's newly energy sensitive environment. Freezer manufactures are considering many innovations that could greatly increase energy performance. Enacting an ENERGY STAR label may induce some manufacturers to apply these innovations with the added impetus of the ENERGY STAR label's marketing enhancement.

It is expected that most utility and state partner would take a neutral position on the specification for freezers. However, it is highly unlikely that these partners would sponsor rebates or other incentives for qualified freezers. Their efficiency programs are typically designed to reduce energy demand and to adjust consumer behavior trends towards more efficient choices. Offering a rebate on a stand-alone freezer could encourage a greater number of people to purchase a secondary appliance, resulting in increased energy demand. ENERGY STAR may need to inform interested manufacturers that the impact of a specification for freezers would likely be limited to the existing consumer recognition and market opportunities, but are not expected to include utility incentives.

Both Frigidaire and W.C. Wood, which represent 99 percent of the market, expressed interest in the development of an ENERGY STAR label. Although none of their current products meet the proposed 10% energy level, each said they could quickly produce products meeting the suggested levels.

Regarding ice build-up on manual defrost models, we recommend pursuing an ENERGY STAR label despite the estimated performance degradation. ENERGY STAR labels typically do not address the application of the appliance or product. It is incumbent upon the user to properly apply the product. An option that would consider the ice build-up would be to write the specification including a statement that the ENERGY STAR labeled unit should be regularly defrosted to preserve its superior energy efficiency, and/or to provide consumer and sales associate guidance on the ENERGY STAR web site.

Appendix

Freezers—Energy Consumption Notes:

- ?? 36 million units stock (RECS 97), about 1 in 3 homes has a freezer
- ?? 1,103 average kWh/yr/unit, aggregated, current stock consumption (RECS 97)
- ?? 37.4 billion kWh/year aggregate national consumption (RECS 97)
- ?? 472 kWh/yr/unit for new units, weighted average, 1999 (AHAM)
- ?? 21.0 ft^3/unit, average adjusted volume, weighted average, 1999 (AHAM)

Below is a graph summarizing freezer performance for W.C. Wood & Frigidaire, including automatic and manual defrost for both chest and upright configurations.