Manufacturers stated the cost estimated by LBL for electronically commutated motors is about 40 to 60 percent less than estimates provided to it by suppliers. (AHAM, No. 17, Attachment 17 at 2).

Sub-Zero stated that it expects efficiencies of evaporator and condenser fan motors to improve. (Sub-Zero, Transcript at 427). U-Line stated that some improvement in the fan motor still may exist. (U-Line, No. 11 at 5). General Electric Appliances said it is pursuing various options with both evaporator and condenser fan motors and that reliability and testing of these components are fairly well understood. (GEA, No. 39 at 8).

The Department obtained cost and efficiency data from three manufacturers of evaporator and condenser fan motors. Averages of these data were used in the analyses performed by the Department. The cost estimates obtained by the Department are for quantities equal to the present volumes of fan motors being purchased by refrigerator-freezer manufacturers. The Technical Support Document (Chapter 3) provides details on these data for the various product classes.

Improved Fan Efficiency. Whirlpool stated that potential savings through this option are very limited. Fan motor size is governed not only by the operating load on the fan, but also by the need to ensure starting under all anticipated voltage and temperature conditions. Whirlpool said that most of the potential for fan energy savings lies in the fan motors themselves. (Whirlpool, No. 36 at 7). U-Line stated that where fan motors and blades are employed, optimization does provide opportunity for energy improvement. (U-Line, No. 11 at 5). General Electric Appliances stated it found energy savings benefits for condenser fans are marginal and that an energy savings of approximately 4 kWh/yr are available from evaporator fan redesign. (GEA, No. 39 at 8).

The energy savings from improved condenser and evaporator fans and the associated costs have been provided to the Department by AHAM and its members. These figures have been used in the analysis for the full-sized refrigerator products. Because most of the compacts employ natural convection and do not use fans, this option is not included in the analysis for compacts.

Variable-Speed Fans. Whirlpool stated that with a single-speed compressor, the rate of heat transfer for either the evaporator or condenser does not vary appreciably with changes in either ambient temperature or control setting because the compressor operates at only one speed. The compressor has a longer duty-cycle as either the ambient temperature goes up or the control setting is lowered. In order for the variable-speed fan feature to reduce energy consumption, it must allow the refrigerator to attain a more optimal air flow condition for a particular set of circumstances. The optimal air-flow condition is a trade off—reduced heat transfer versus reduced fan use. Because the heat transfer rate with single-speed compressors does not vary appreciably, Whirlpool stated there is little potential for energy reduction due to variable fan speed with a single-speed compressor. In addition, it stated there are concerns about excessive costs for the motors and required electronic controls, and the reliability of both the mechanical (bearing) and electrical (windings and controls) systems. Whirlpool argued that variable-speed fans should not be counted on to save energy. (Whirlpool, No. 36 at 7). U-Line stated this option is considered infeasible by the compact/undercounter AHAM subcommittee. (U-Line, No. 11 at 5).

General Electric Appliances said fan energy consumption reductions achieve false savings to the extent that a change in fan speed and airflow adversely affects energy performance elsewhere within the refrigerator system. General Electric Appliances found from a recent internal study that a 25 percent reduction in evaporator fan power input for its 24 cubic foot side-by-side product (with an ECM fan motor) lowered the evaporator saturation temperature, lowered system capacity, increased compressor run-time, and increased overall energy consumption. General Electric Appliances also said that while increasing fan speed enhances heat exchanger performance, it also increases gasket heat leakage which, in turn, requires more fan motor input power. Additionally, GEA said noise from higher fan speeds is becoming such a significant issue with consumers that noise attenuation costs must be factored into this cost-performance assessment. (GEA, No. 39 at 8–9).

Based on the comments provided, the Department has decided this option should not be included in the analysis.

Hybrid Evaporator. Whirlpool commented that it has no experience with ''hybrid evaporators.'' (Whirlpool, No. 36 at 8). U-Line stated the evaporator may offer potential for energy improvement by enhancing air to refrigerant heat exchange. (U-Line, No. 11 at 5). General Electric Appliances understands this option to be a two-stage dual evaporator system. (GEA, No. 39 at 9).

A hybrid evaporator employs two evaporators, one for the freezer and the other for the fresh-food section.The Department did not include this option in the analysis because the data available showed little energy savings using this technology.

Other Refrigeration Cycles. Whirlpool commented that it worked cooperatively with a major university in a development program for the Lorenz cycle for more than 2 years. During that period, a number of prototype systems were built and tested in its labs. While some energy savings were measured, it was unable to consistently demonstrate substantial savings using this technology. For products tested, the maximum savings achieved was about 8 percent. Because the second evaporator required for such systems reduces the storage volume by approximately ½ cubic foot, the net savings were something less than 8 percent. Because of the difficulty in obtaining reproducible results and the relatively small savings achieved, Whirlpool found this not to be a viable technology. (Whirlpool, No. 36 at 8). U-Line stated that other refrigeration cycles do not offer a feasible alternate technology. (U-Line, No. 11 at 6). Maytag stated thermo-acoustic refrigeration system prototypes are not available. (Maytag, No. 20 at 6). General Electric Appliances stated it has undertaken studies of various refrigeration cycles (Brayton, gas absorption, thermoelectric, magneto-caloric, and thermoacoustic) to compare their energy savings potentials against enhanced Rankine cycle designs. Of the alternative cycles studied, only the Stirling presented a credible opportunity for competitive efficiencies. (GEA, No. 39 at 9–11). The company undertook development of Stirling cycles in concert with Sunpower, Inc. General Electric Appliances confirmed that the Stirling cycle could perform on a par with the Rankine cycle currently being used, but it did not present any material improvement. In addition, GEA said the problems and costs associated with developing a completely new cycle design, versus upgrading existing cycle technology, argued against pursuing the Stirling cycle. (GEA, No. 39 at 9).

Except for the Lorenz cycle, the Department is not aware of any prototypes using alternative refrigeration cycles. In the case of the Lorenz cycle, the reports of energy savings vary considerably. Although this option has a significant potential for future energy savings, this technology is not developed well enough at this time to be considered an option for 1998 refrigerator-freezers.