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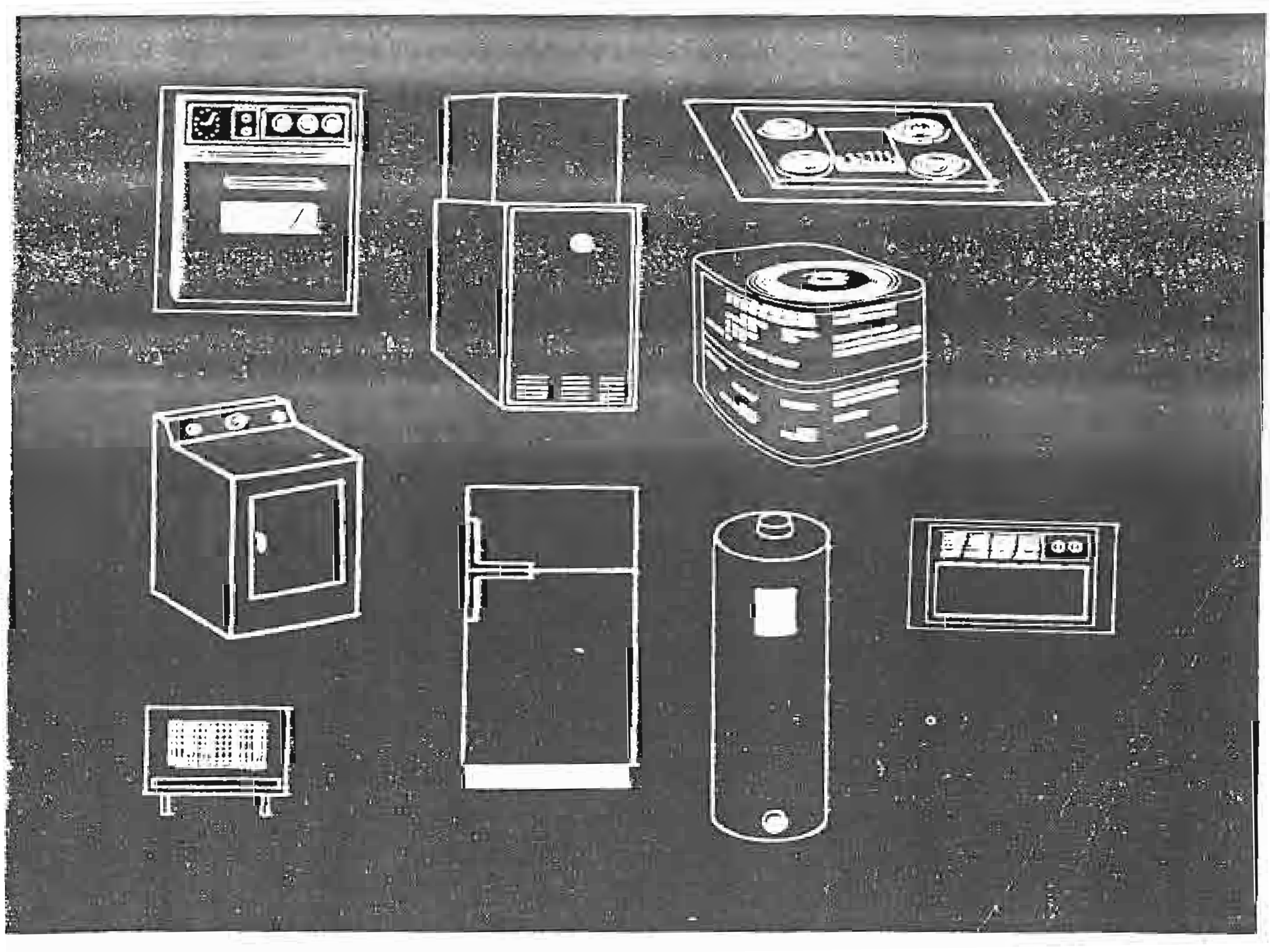

Technical Support Document No. 2

ENVIRONMENTAL ASSESSMENT

Energy Efficiency Standards

for Consumer Products

Covering: Refrigerators and Refrigerator/Freezers, Freezers, Clothes Dryers, Water Heaters, Room Air Conditioners, Home Heating Equipment, Kitchen Ranges and Ovens, Central Air Conditioners and Furnaces

U.S. DEPARTMENT OF ENERGY

Conservation & Solar Energy

Office of Building & Community Systems

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LIST OF ABBREVIATIONS

BEPS = Building Energy Performance Standards
Btu = British thermal unit
B&W = Black and White
CFC = chlorofluorocarbon
CO = Carbon monoxide
CO_2 = Carbon dioxide
CPES = Consumer Products Efficiency Standards
CRT = Cathode Ray Tube
DOE = Department of Energy
EER = Energy Efficiency Rating (room air conditioners)
EPA = Environmental Protection Agency
EPCA = Energy Policy and Conservation Act of 1975
ETA = Energy Tax Act
F = Chlorofluorocarbon
FDA = Food and Drug Administration
FEA = Federal Energy Administration
ft^3 = cubic feet
FTC = Federal Trade Commission
gal = gallons
HC = Hydrocarbons
HP = Horsepower
hr = hour
IID = Intermittent Ignition Device
kWh = kilowatt hour
lbs = pounds
MW = Megawatt
NAS = National Academy of Sciences
NECPA = National Energy Conservation Policy Act of 1978
NO = Nitrogen oxide
NO_2 = Nitrogen dioxide
NO_x = Nitrogen oxide
NOPR = Notice of Proposed Rulemaking
P = Particulates
P.L. = Public Law
Q = cooling capacity (air conditioner)
quad (Q) = quadrillion Btu
RCS = Residential Conservation Program
RUF = rigid polyurethane foam
SEER = Seasonal Energy Efficiency Rating (central air conditioners)
SO_2 = Sulphur dioxide
SO_x = Sulphur oxides
SP = Standing Pilot
TSD = Technical Support Document
V = Volume
w = watt

SUMMARY

The Energy Policy and Conservation Act of 1975 (EPCA) (P.L. 94-163), as amended by the National Energy Conservation Policy Act of 1978 (NECPA) (P.L. 95-619), requires the Department of Energy (DOE) to prescribe energy efficiency standards for thirteen consumer products. The Consumer Products Efficiency Standards (CPES) program covers the following products:

- refrigerators and refrigerator-freezers
- freezers
- clothes dryers
- water heaters
- room air conditioners
- home heating equipment (not including furnaces)
- kitchen ranges and ovens
- central air conditioners (cooling and heat pumps)
- furnaces
- dishwashers
- television sets
- clothes washers
- humidifiers and dehumidifiers

As required by the Act,* DOE has given priority to the development of efficiency standards for refrigerators and refrigerator-freezers, freezers, clothes dryers, water heaters, room air conditioners, home heating equipment, kitchen ranges and ovens, central air conditioners (cooling only) and furnaces. Standards for central air conditioners (heat pumps only), dishwashers, television sets, clothes washers and humidifiers and dehumidifiers are still under development. DOE is proposing two sets of standards for all thirteen consumer products: intermediate standards to become effective in 1981 for the first nine products and in 1982 for the second four products, and final standards to become effective in 1986 and 1987, respectively. The final standards are more restrictive than the intermediate standards and will provide manufacturers with the maximum time permitted under the Act to plan and develop extensive new lines of efficient consumer products. The final standards proposed by DOE require the maximum improvements in efficiency which are technologically feasible and economically justified, as required by Section 325(c) of EPCA.

The thirteen consumer products covered by the CPES account for approximately 90% of all the energy consumed in the nation's residences, or more than 20% of the nation's energy needs. Increases in the energy efficiency of these consumer products can help to narrow the gap between the nation's increasing demand for energy and decreasing supplies of domestic oil and natural gas. Improvements in the efficiency of consumer products can thus help to solve the nation's energy crisis.

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*Hereafter references to the Act or to EPCA refer to EPCA as amended by NECPA.

1. POTENTIAL IMPACT OF THE CPES

This Environmental Assessment evaluates the potential environmental and socioeconomic impacts expected as a result of setting efficiency standards for all of the consumer products covered by the CPES program. DOE has proposed standards for eight of the products covered by the Program in a Notice of Proposed Rulemaking (NOPR). DOE expects to propose standards for home heating equipment, central air conditioners (heat pumps only), dishwashers, television sets, clothes washers and humidifiers and dehumidifiers in 1981.

POTENTIAL IMPACT ON FUTURE ENERGY DEMAND

The standards proposed for refrigerators and refrigerator-freezers, freezers, clothes dryers, water heaters, room air conditioners, kitchen ranges and ovens, central air conditioners (cooling only) and furnaces will reduce energy demand in the residential sector by between 13.6 and 24.9 quads* (quadrillion Btu) for the period 1982-2005. (128) The proposed standards are expected to save from 33% to 50% of the growth in demand for energy created by these eight consumer products between 1981 and 2000, compared to the no-action alternative. (128)

Standards for home heating equipment, central air conditioners (heat pumps only), dishwashers, television sets, clothes washers and humidifiers and dehumidifiers should not reduce energy demand as much as the standards proposed for the first eight products. The products for which standards have already been proposed consumed 71.5% of the demand for energy in the residential sector in 1978. (See Table S-1.) Home heating equipment accounts for a small percentage of the residential sector's energy consumption (12.1% in 1978). Heat pumps and the remaining products also account for a small proportion of the sector's demand for energy (9.5% in 1978). Taken together, these products present fewer opportunities for efficiency improvements than the products for which standards have already been proposed. (134,166)

POTENTIAL ENVIRONMENTAL IMPACTS

The environmental impacts of the proposed action will be primarily positive. For those few instances in which the Program may cause adverse effects, analysis has shown that these effects will not significantly disturb the quality of the nation's environment or the health and safety of consumers.

*The lower estimate represents annual escalation factors of 2.5% for real electricity prices and 3.0% for real natural gas and oil prices. The higher estimate represents annual escalation factors of 1.0% for real electricity prices and 1.5% for real natural gas and oil prices. "Btu" is an abbreviation for British Thermal Unit.

Table S-1. Residential Primary Energy Consumption by Product, 1978

Products Covered by 1980 NOPR	1978 Total Energy Consumption (Quads)	Percent of 1978 Residential Sector Energy Use
Furnaces	5.86	35.2%
Home heating equipment	2.02	12.1%
Refrigerator and refrigerator-freezers	1.54	9.3%
Water heaters	1.52	9.1%
Kitchen ranges and ovens	0.91	5.5%
Central air conditioners (cooling only)	0.63	3.8%
Freezers	0.52	3.1%
Clothes dryers	0.50	3.0%
Room air conditioners	0.41	2.5%
Total	13.91	83.6%

Products Covered by 1981 NOPR	1978 Total Energy Consumption (Quads)	Percent of 1978 Residential Sector Energy Use
Clothes washers	0.81	4.9%
Dishwashers	0.32	1.9%
Television sets	0.19	1.1%
Central air conditioners (heat pumps)	0.15	0.9%
Humidifiers and Dehumidifiers	0.12	0.7%
Total	1.59	9.5%

Products Not Covered by CPES	1978 Total Energy Consumption (Quads)	Percent of 1978 Residential Sector Energy Use
Lighting and small appliances	1.14	6.9%

Sources: 123, 128

The Program's environmental impacts are summarized in Table S-2.

The Program will decrease air pollution as a result of decreasing future energy demand. The greatest decreases in air pollution will occur for sulphur oxides, which may be reduced by as much as 1.1 million tons, compared to the no-action alternative, in the year 2005. This compares with estimated SOx emissions of 25.5 million tons for 1976 and thus represents a 4.3% reduction. Similarly, commitments of land and energy resources will decrease in proportion to the amount of energy saved by the Program. The amount of land disturbed by coal-mining could be reduced by as much as 6,000 acres per year, compared to the no-action alternative, in the year 2000. This compares with annual commitments of land to coal-mining of 111,000 acres in 1978 and thus represents a small reduction. Commitments of land for energy generation sites will also be reduced.

The Program will have other beneficial impacts. The Program will reduce the quantities of water pollutants released in the process of electricity generation, as well as the levels of solid waste produced by coal-fired power plants. The Program is not expected to have any significant effect on noise levels or indoor air quality.

The Program will also cause some adverse effects on air quality, but these are expected to be minor. An increase in the use of chlorofluorocarbons (CFCs) is expected as manufacturers seek to improve the insulating characteristics of refrigerators, refrigerator-freezers, freezers and water heaters. Compared to projected U.S. consumption of CFCs in 1990, however, these increases are expected to be small, representing less than 4% of projected U.S. consumption of CFCs in 1990. Negligible increases in the use of copper, steel, iron, aluminum, plastic and fiberglass are anticipated as a result of improved consumer product designs. In addition, since money saved from lower consumer product operating costs is likely to be spent on goods and services in the general economy, some pollution may be created which would not have occurred without the Program. This amount is estimated to be small and may be offset by the pollution reductions which will occur because the Program will reduce future demand for energy.

POTENTIAL SOCIOECONOMIC IMPACTS

The CPES program will cause both beneficial and adverse socioeconomic effects. While none of the adverse socioeconomic effects of the Program should be significant, the Program's beneficial impact on the future life-cycle costs of consumer products will be substantial. The socioeconomic impacts of the Program are summarized in Table S-3. A detailed analysis of these impacts can be found in the "Economic Analysis," Technical Support Document (TSD) No. 4 for the 1980 NOPR.

While the Program will increase the purchase prices of consumer products, operating costs will be substantially reduced. The total cost to consumers of purchasing and operating consumer products, called the lifecycle cost, will therefore be reduced compared to the no-action alternative. The net present benefit of the Program to the nation should be between $15.3 and $19.3 billion (1978 dollars).

Table S-2. Summary of Potential Environmental Impacts of the CPES

Air Quality					
Sulphur Oxides	Nitrogen Oxides	Particulates	Hydro-carbons	Carbon Monoxide	Chloro-fluorocarbons
Decrease in emissions	Decrease in emissions	Decrease in emissions	Decrease in emissions	Decrease in emissions	Small increase due to use as insulation in refrigerators, freezers and water heaters

Commitments of Natural Resources	Water Quality	Solid Waste	Noise
Decrease in use of land and energy resources Negligible increase in use of raw materials to improve consumer product efficiencies	Small decrease in effluents	Small decrease in solid waste	No significant impact

Table S-3. Summary of Potential Socioeconomic Impacts of the CPES

Consumers			Manufacturers	
Lifecycle Costs	Product Utility	Equity	Profitability	Equity
Decrease in lifecycle cost for most consumer products compared to no-action alternative	Improved or unaffected product utility	No significant impact on distribution of income	Shifts in sales volume, market shares and profitability among manufacturers	Medium-sized and small manufacturers more likely to suffer financial loss

Nation						
Energy Savings (1982-2005)	Net Present Cost of Efficiency Improvements	Net Present Value	Equity Among Regions	Employment	GNP	Inflation
13.6-24.9 quads (net present value of savings: $22.2 to $29.2 billion*)	$7.0 to $9.9 billion* spent to improve efficiency	$15.3 to $19.3 billion*	No significant variation in economic impact on various regions of the country	Small increase in employment	Small increase in GNP	No change or deflationary effect

* discounted 1978 dollars

The Program will cause some adverse socioeconomic impacts, but these should be minor. A small percentage of consumer product manufacturers may be unable to obtain sufficient funds, through profit or short-term debt, to make the necessary capital investment in the period 1981-1986 in order to meet the January 1986 standards. In addition, shifts can be expected in the profit-to-net worth ratios of some manufacturers. Small manufacturers will experience these impacts to a greater degree than medium-sized or large manufacturers.

2. ALTERNATIVES TO THE CPES AS PROPOSED

A number of alternatives to the proposed action were evaluated by DOE. In the "Draft Regulatory Analysis," TSD No. 1, DOE has evaluated the impacts of these alternatives from several perspectives. The ability of each alternative to promote achievement of the nation's energy policy objectives was evaluated. The economic impact of each alternative on consumers, manufacturers and the nation, and the fairness of the distribution of impacts among geographic and demographic groups were also evaluated. Section 2 of this Environmental Assessment briefly summarizes these analyses and in addition evaluates the impacts of each alternative on the quality of the nation's environment. The most important conclusions from the assessment of the environmental impacts of each alternative are depicted in Table S-4.

The alternatives evaluated by DOE include:

- No action
- Alternative efficiency levels
- Alternative time-phasing
- Regional standards
- Financial incentives
  - Tax credits to consumers
  - Tax credits to manufacturers
  - Rebates to consumers
- Prescriptive standards
- Voluntary energy efficiency targets
- Enhanced consumer education

Almost all of the alternatives to the proposed action are estimated to result in lower energy savings in the period 1982-2005 than the energy savings which should result from the CPES as proposed. They are thus likely to have greater adverse impact on air quality and to require greater use of land and energy resources. They may result in less use of chlorofluorocarbons, copper, iron, steel, aluminum and plastic, but this difference is expected to be negligible.* The alternatives estimated to save greater amounts of energy were rejected because of their adverse economic effects on manufacturers and consumers.

*For those alternatives that save more energy than the no-action alternative, it is assumed that some increase in the use of these materials would occur. This increase would be less than that expected from the CPES, as proposed.

Table S-4. Summary of the CPES and Its Alternatives

Alternative	Energy Savings* (1982-2005)	Impact on the Environment: Air Pollution	Commitments of Natural Resources	Water Pollution	Solid Waste	Noise
CPES, as proposed	13.6 to 24.9 quads	Less air pollution than no-action Small increase in use of CFCs compared to no-action	Less use of natural resources for energy production than no-action Small increase in use of natural resources to improve consumer product efficiencies compared to no-action	Less water pollution than no-action	Less solid waste than no-action	No significant impact
No-action	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
Alternative efficiency levels						
More restrictive standards	Greater energy savings than the proposed action	Less air pollution than the proposed action Small increase in the use of CFCs compared to the proposed action	Less use of natural resources for energy production than the proposed action Greater use of natural resources to manufacture consumer products than proposed action	Less water pollution than the proposed action	Less solid waste than the proposed action	No significant impact
Less restrictive standards	Less energy savings than the proposed action	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact
Alternative time-phasing						
1981 standards only - see "less restrictive standards"						
1981-83-86 standards - see "CPES as proposed"						
Post-1986 standards - see "more restrictive standards"						

*The no-action alternative constitutes the baseline for the comparative analysis of energy savings.

Table S-4. Summary of the CPES and Its Alternatives (continued)

Alternative	Energy Savings (1982-2005)	Impact on the Environment: Air Pollution	Commitments of Natural Resources	Water Pollution	Solid Waste	Noise
Regional Standards	13.7-25.1 quads	Less air pollution than the proposed action Small increase in use of CFCs compared to the proposed action	Less use of natural resources for energy production than the proposed action Greater use of natural resources to manufacture consumer products than the proposed action	Less water pollution than the proposed action	Less solid waste than the proposed action	No significant impact
Financial Incentives						
Tax credit to consumers	0.2 to 0.4 quads	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact
Tax credit to manufacturers	0.2 to 0.4 quads	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact
Rebate to consumers	0.4 to 0.6 quads	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact
Prescriptive Standards	9.5 to 17.4 quads*	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact

*In addition, for the period after 1990, the proposed action will save between 1.5 and 1.9 quads more than prescriptive standards.(127)

Table S-4. Summary of the CPES and its Alternatives (continued)

Alternative	Energy Savings (1982–2005)	Impact on the Environment: Air Pollution	Commitments of Natural Resources	Water Pollution	Solid Waste	Noise
Voluntary energy efficiency targets	2.4 to 6.8 quads	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact
Enhanced consumer education	2.2 to 2.7 quads	More air pollution than the proposed action Less use of CFCs than the proposed action	Greater use of natural resources for energy production than the proposed action Less use of natural resources to manufacture consumer products than the proposed action	More water pollution than the proposed action	More solid waste than the proposed action	No significant impact

Source: 127

3. CONCLUSIONS

No significant adverse environmental or socioeconomic impacts have been found to result from instituting the CPES, as proposed. On the contrary, the effects of the Program should be primarily positive. In addition, most alternatives to the Program appear unlikely to achieve equivalent savings of energy and are therefore unlikely to significantly affect the nation's environmental quality or to benefit the environment to the same degree as the proposed action. This analysis of the relevant areas of environmental concern thus shows that the Program does not represent a major federal action significantly affecting the quality of the human environment as defined in Section 102(2)(c) of the National Environmental Policy Act, as amended.

1. PURPOSE AND NEED OF THE PROPOSED ACTION

The Energy Policy and Conservation Act of 1975 (EPCA) (P.L. 94-163), as amended by the National Energy Conservation Policy Act of 1978 (NECPA) (P.L. 95-619) requires the Department of Energy (DOE) to prescribe energy efficiency standards for a wide range of consumer products. The purpose of the Consumer Products Efficiency Standards (CPES) program is to encourage the manufacture and purchase of more efficient consumer products, thereby reducing national energy demand.

1.1. NEED FOR THE PROPOSED ACTION

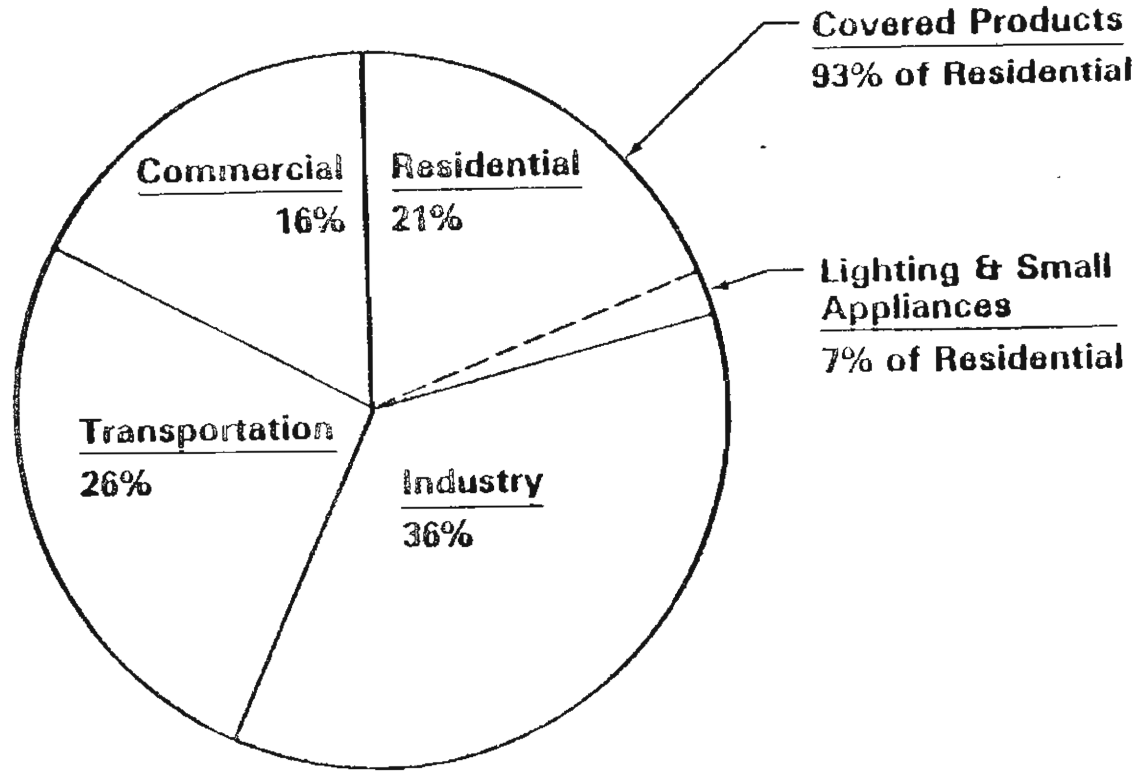
Increasing national energy demand and decreasing domestic oil and gas supplies have combined to create a national energy crisis which renders conservation an indispensable component of the nation's energy policy. The proposed action will lower future energy demand by reducing growth in consumer product energy consumption. The thirteen products covered by the proposed action consumed 93% of the energy required by residences in 1978, more than 20% of the nation's overall energy needs. (Figure 1-1.) The efficiency standards proposed for the first eight products will save between 13.6 and 24.9 quads in the period 1982-2005.

The costs of reducing overall energy demand by means of improvements in consumer product efficiency will be significantly less than the costs of producing new energy supplies. In order to save the equivalent of a barrel of oil, the Program will require expenditure of approximately $1.00 to improve efficiency while a barrel of imported oil costs more than twenty-five times that amount. In addition, the Program will stimulate economic activity by freeing investment capital and consumer expenditures for use in non-energy sectors of the economy. It will also help to lessen the adverse environmental effects of energy supply technologies and to reduce the nation's vulnerability to energy price increases and supply interruptions by foreign governments.

1.2. BACKGROUND

As originally conceived in EPCA, the CPES program employed a dual strategy to achieve improvements in consumer product efficiency. DOE (then the Federal Energy Administration) was charged to develop voluntary 1980 energy efficiency targets for thirteen consumer products. (See Table 1-1.) DOE and the Federal Trade Commission were also charged to develop consumer education programs to encourage comparison shopping and increase consumer demand for energy efficient products. In order to implement these twin approaches, DOE was authorized to prescribe standardized test procedures to determine the energy efficiency of each consumer product type.

Figure 1-1. U.S. Energy Consumption, 1978



Source: 123

Table 1-1. Consumer Products Covered by the CPES

	Product	Covered by Voluntary Target Program	Covered by the FTC Labeling Program[a]	Covered by CPES-1980 NOPR	Standards Proposed in 1980 NOPR	Covered by CPES-1981 NOPR	Standards Proposed in 1981 NOPR
1.	Refrigerators and refrigerator-freezers	x	x	x	x		
2.	Freezers	x	x	x	x		
3.	Clothes dryers	x		x	x		
4.	Water heaters	x	x	x	x		
5.	Room air conditioners	x	x	x	x		
6.	Home heating equipment	x		x	(b)		x
7.	Kitchen ranges and ovens	x		x	x		
8.	Central air conditioners	x		x			
	(cooling only)		x		x		
	(heat pumps only)						x
9.	Furnaces	x	x	x	x		
10.	Dishwashers	x				x	x
11.	Television sets	x				x	x
12.	Clothes washers	x	x			x	x
13.	Humidifiers and dehumidifiers	x				x	x

(a) Five appliances were exempted from the program by the FTC because of economic considerations.

(b) The 1980 NOPR reserves space for efficiency standards for home heating equipment, pending modifications to the DOE test procedure. Standards for this product should be proposed in 1981.

DOE published final rules detailing the 1980 consumer product efficiency targets in 1978. (53,55) The program called for specific percentage improvements in the aggregate energy consumption of each consumer product type compared to a base year of 1972.

The Federal Trade Commission implemented the labeling and advertising program for consumer products in late 1979. (58) Energy efficiency labeling requirements for central air conditioners are being developed. (See Table 1-1.) Five products were exempted from the program because of economic considerations.

The FTC labeling program became effective in May 1980. The labels disclose the estimated annual operating cost of the labeled model as well as the range of estimated annual operating costs for similar products. Energy efficiency ratings, rather than annual operating costs, are displayed on air conditioner and furnace labels. Annual operating costs for these products were found to be too difficult to estimate because of the large variation in consumer usage patterns occasioned by differences in climate. Catalogs and sales information must disclose the same information contained on the labels.

With the assistance of the National Bureau of Standards, DOE adopted test procedures for all the covered products in 1977 and 1978. (44,45,48-52, 54,56) The test procedures identify each product's annual operating costs and at least one other useful measure of energy consumption that is likely to assist consumers to compare product energy costs. Consumer product manufacturers and retailers may not disclose any energy consumption or cost information concerning their products unless they have been tested according to DOE's standardized test procedures. All labeling and advertising must fairly disclose the results of these tests. DOE intends to modify test procedures on a continuing basis to accommodate new product designs for which current test procedures may be inaccurate measures of energy efficiency.

In October 1978 Congress amended EPCA's approach to the consumer product conservation program. Title IV, Part 2 of NECPA dispensed with the voluntary targets approach and mandated the development of efficiency standards for the products covered by EPCA. Congress gave priority to the development of standards for nine consumer products because of their large contribution to residential energy demand and required adoption of standards for these products no later than December 1980. These nine products include refrigerators and refrigerator-freezers, freezers, clothes dryers, water heaters, room air conditioners, home heating equipment, kitchen ranges and ovens, central air conditioners (cooling only), and furnaces. DOE was required to develop standards for dishwashers, televisions, clothes washers and humidifiers and dehumidifiers by November 1981. Standards for central air conditioners (heat pumps only) were to be developed by December 1981. In addition, Section 322(a)(2) authorized DOE to prescribe an energy efficiency standard for any other type or class of consumer product if all of the following criteria were met:

(1) the average annual per-household energy use of all such products exceeded 150 kWh/year (or the Btu equivalent);

(2) the aggregate U.S. household energy use by such products exceeded 4.2×10^9 kWh/year;

(3) substantial improvements in energy efficiency would be technologically feasible; and

(4) a labeling requirement alone would not be sufficient to maximize the product's energy efficiency potential.

The Act required DOE to publish a list of products meeting these criteria no later than November 1980 and provided for subsequent revisions. DOE intends to assess the environmental, health and safety effects of any product added to the original list.

1.3. DESCRIPTION OF THE PROPOSED ACTION

The proposed action encompasses the setting of energy efficiency standards for all thirteen consumer products covered by EPCA. DOE has proposed standards for eight of the covered products. DOE expects to propose standards for home heating equipment, central air conditioners (heat pumps only), dishwashers, television sets, clothes washers and humidifiers and dehumidifiers in 1981.

EPCA provided for the phasing-in of efficiency standards over a period of up to five years. DOE proposes to use the full five-year period for establishing final standards in order to provide manufacturers with the greatest possible planning and development time and, hence, to permit the development of more restrictive final standards than would otherwise have been possible had a shorter period been adopted. The proposed action establishes intermediate and final standards to become effective in 1981 and 1986, respectively.

The proposed action requires the maximum improvements in efficiency which are technologically feasible and economically justified, as required by Section 325(c) of EPCA. DOE has defined the maximum technologically feasible level of energy efficiency for the covered products to be the highest level of efficiency achieved by any model that is expected to be commercially available at the time the final standards become effective. The level of efficiency is determined according to DOE test procedures which measure each product's energy factor, energy efficiency ratio, seasonal energy efficiency ratio or annual fuel utilization efficiency. Standards have not been proposed in the 1980 NOPR for those classes of products for which the imposition of a standard would not result in significant conservation of energy, as provided for in Section 325(b) of the Act.

The intermediate and final standards proposed by DOE do not require the maximum improvement in energy efficiency that is technologically feasible. The proposed standards have been set below the maximum level that is technologically feasible because of economic considerations. Section 325(d) of EPCA required DOE to use seven factors in determining whether the proposed standards were economically justified. The seven factors required for making this determination were:

- economic impact of the standard on manufacturers and consumers
- comparison of increases in each product's purchase price and maintenance costs with decreases in expected operating costs for its estimated lifetime

- energy savings likely to result from the standard
- decreases in the utility or performance of covered products likely to result from the standard
- impact of any lessening of competition likely to result from the standard
- need of the nation to conserve energy
- other relevant factors

In order to assess the economic feasibility of requiring the maximum improvements in efficiency which are technologically feasible, DOE solicited comments and testimony concerning the impact of setting final standards at the highest efficiency level achieved by products manufactured in 1978. These comments were solicited in DOE's Advanced Notice of Proposed Rulemaking, dated January 2, 1979. (57) Extensive analyses were also undertaken to document the maximum levels of efficiency which could be expected by 1981 and 1986. (128,164) These analyses provided additional information concerning the economic impact that maximum technologically feasible standards would have on manufacturers, consumers and the nation.

EPCA provided for the development of standards for distinct classes of products within each product type. Criteria used by DOE to select product classes included the type of fuel consumed and performance-related features which affect energy consumption and product utility. DOE may specify different classes of products in the final rule if data received in response to the NOPR justify such changes. Appendix A shows the product types, product classes and proposed standards for the first nine products covered by the Program.

As provided in Section 325(h) of EPCA, DOE will reevaluate the proposed action within five years of its adoption. Technological developments that occur in the next five years, as well as the economic impacts of the standards, will be considered in this reevaluation.

As provided in Section 325(d) of EPCA, the U.S. Attorney General will determine the impact from any lessening of competition likely to result from imposition of the proposed action within sixty days after publication of the Notice of Proposed Rulemaking. Section 325(e) provides that manufacturers having annual gross revenues of less than $8,000,000 may apply to DOE for exemption for up to 24 months from any standards requirement. DOE is authorized to grant the exemption if the Attorney General determines that failure to allow the exemption would likely result in a lessening of competition.

DOE may pre-empt state consumer product efficiency standards for the products covered by EPCA. State standards enacted before January 1, 1980 will not be pre-empted until final rules for federal standards are adopted. State standards enacted after January 1, 1980 are automatically pre-empted until July 1, 1980. This automatic pre-emption is lifted on July 1, 1980 for the first thirteen covered products. However, for other products the pre-emption continues. After July 1, 1980, once a federal standard is prescribed for any product, all state standards for that regulated product are pre-empted. States have the right to petition DOE to be exempted from federal pre-emption and manufacturers have the right to petition DOE to pre-empt a state standard.

An exemption to federal pre-emption may be granted if the Secretary of DOE finds that state regulation would not unduly burden interstate commerce, as long as the state's standard is more stringent than the federal standard and there is a significant state interest to justify state regulation.

2. ALTERNATIVES TO THE PROPOSED ACTION

This section evaluates the reasonable alternatives to the CPES, as proposed. Section 2.1 discusses the potential effects of the no-action alternative. Section 2.2 describes the effects of selected alternatives within the Program. Section 2.3 outlines legislative alternatives that might be used to increase the effectiveness and scope of the Program or to achieve similar goals.

2.1. NO-ACTION ALTERNATIVE

This alternative was analyzed by DOE as the "base case" for the Program. It assumes that no mandatory efficiency standards program is implemented at the federal level and thus provides a baseline for measuring the impacts of the proposed action and its alternatives. The no-action alternative is discussed in more detail in the "Draft Regulatory Analysis," TSD No. 1, and the "Economic Analysis," TSD No. 4. The assumptions of the analytical model used to forecast the base case scenario are also discussed in greater detail in Section 3.2 of this Environmental Assessment.

Even without a federal program to improve consumer product efficiencies, some energy savings will be achieved in consumer product energy consumption for the period 1980-2005 because of other conservation programs. These programs include the deregulation of oil and natural gas prices in 1981 and 1985, state programs to promote improvements in consumer product efficiency, energy labels for consumer products mandated by the FTC, public information and education programs sponsored by DOE, and the federal Building Energy Performance Standards (BEPS) program.

While some improvements in the energy efficiency of consumer products are expected as a result of these programs, the net result of the no-action alternative will be to require production of between 13.6 and 24.9 quads more energy in the period 1982-2005 than would be required if the proposed standards were implemented. (128)

The effect of the no-action alternative on the nation's environmental quality would be adverse, compared to the effect of the proposed action. Without the CPES, greater amounts of sulphur oxides, nitrogen oxides, particulates, carbon monoxide and hydrocarbons would be emitted into the nation's air when fuels are combusted in consumer products or power plants. Greater commitments of land and energy resources for energy production would also be required, and thermal pollution and solid waste from power plants would increase. The no-action alternative could result in less use of chlorofluorocarbons to improve insulation in refrigerators, freezers and water heaters, depending on the nature and extent of efficiency improvements for these products without mandatory federal standards. In addition, the amount of raw materials needed for the manufacture and production of consumer products would probably decrease. These effects, however, would be negligible.

The no-action alternative would have adverse economic impacts, compared to the proposed action. These effects are analyzed in the "Draft Regulatory Analysis," TSD No.1. The most important adverse economic impact of this alternative is the higher lifecycle cost of consumer products compared to the proposed action.

2.2. ALTERNATIVES WITHIN THE PROPOSED ACTION

During the development of the proposed action, DOE considered several options for the formulation of minimum efficiency levels for the covered products. (127,128) This section discusses the major alternatives considered and assesses the effects of each on the environment.

2.2.1. ALTERNATIVE EFFICIENCY LEVELS

DOE considered the effects of establishing both more restrictive and less restrictive standards than those proposed in the NOPR. (127) Several levels of standards were considered for both intermediate and final standards. The "Economic Analysis," TSD No. 4, details the results of these analyses.

DOE found that more restrictive standards would adversely affect consumer product manufacturers. The industry would incur severe economic hardship as a result of stricter standards, and competition in the market for consumer products would likely decrease. In addition, more stringent standards would lead to higher first costs and could adversely affect low income consumers. While more restrictive standards could theoretically lead to greater energy savings than the proposed action and might therefore benefit the nation's environment, DOE rejected this alternative because of its adverse economic impacts.

Less restrictive standards were not selected by DOE because they would lead to less energy savings than the proposed action and would therefore not conform to the Congressional mandate for standards at the maximum levels of efficiency which are technologically feasible and economically justified. In addition, this alternative would adversely affect the nation's environment, compared to the proposed action, because of its greater demand for electricity, natural gas and oil.

2.2.2. ALTERNATIVE TIME-PHASING

Section 325(c) of the Act allows for the phasing-in of standards over a period of up to five years through the establishment of intermediate and final standards. Use of the full five-year period was selected in order to provide manufacturers with the greatest possible planning and development time and, hence, to permit the development of more restrictive standards than would otherwise have been possible. The alternative of adopting final standards that will become effective in 1981 would result in less restrictive standards than the proposed action. Increased future demand for energy and greater adverse environmental and economic impacts would result from this alternative.

DOE also considered extending the mandated phase-in period beyond the 1986 deadline in order to allow the implementation of more restrictive standards than proposed in the NOPR. (127) However, since this alternative would have required action by Congress and would have resulted in additional delay in the promulgation of efficiency standards, DOE determined that this alternative was less attractive than the proposed action. While this alternative might result in greater amounts of energy savings on an annual basis, the delay necessitated by Congressional action could offset these savings by preventing rapid implementation of a federal consumer product efficiency standards program.

DOE also considered the alternative of increasingly stringent standards to become effective in 1981, 1983 and 1986, respectively. This alternative would be unlikely to conserve more energy than the proposed action, since a minimum of five years is necessary for manufacturers to introduce large lines of new and more efficient consumer products. This alternative thus would not differ from the proposed action with respect to its impacts on the environment.

2.2.3. REGIONAL STANDARDS

One alternative considered for the CPES was to vary standards for those regions of the nation where the energy usage of the covered products is higher than in other regions. This approach would require more stringent standards in those areas where particular products are used the most, and less stringent standards where some products are used less frequently. For many of the products covered by the Program, the variation in use by region is insignificant. However, for furnaces, central air conditioners (cooling only), and room air conditioners, the variations are significant. The economic impact of regional standards was therefore evaluated for these three products. The effects of variable standards for these products were analyzed for three climatic regions of the United States. More restrictive standards than those proposed for the nation as a whole were applied to the region where the product was used the most. The same level as proposed for the nation was used for the region where the product was used moderately, and a lower standard was applied to the region in which the product was least used. DOE found that regional standards would result in a modest amount of additional energy savings (0.1 to 0.2 quads for the period 1981-2005) but would increase certain costs to manufacturers and consumers because of higher costs to manufacture and distribute products for different regions. (127,128) These costs outweigh the anticipated benefit of greater energy savings. Since regional standards would result in modest decreases in future energy demand, compared to the proposed action, this alternative would not have significantly different impacts on environmental quality.

2.3. LEGISLATIVE AND POLICY ALTERNATIVES

DOE considered a number of alternatives to the proposed action which would require new policy or legislative initiatives at the federal level. The major alternatives considered are discussed below.

2.3.3. VOLUNTARY ENERGY EFFICIENCY TARGETS

EPCA originally provided for the establishment of voluntary targets for consumer product efficiency. DOE was authorized to determine the amount of improvement that the industry should achieve in the efficiency of products covered by the Program. If it appeared that the targets were not likely to be met and that the labeling program alone would not be likely to induce the production and sale of products to meet the targets, DOE was authorized to prescribe mandatory efficiency standards.

In considering this alternative, DOE assumed that new legislation could specify targets in two different ways. A voluntary program could be developed to provide guidelines to industry, or the program could be modeled after the original target program authorized by EPCA. In the latter case, the voluntary program could become mandatory if the Secretary of DOE determined, after extensive hearings, that the goals of the voluntary program would not be met. DOE assumed that the voluntary program would specify the same improvements in efficiency as the proposed improvements. The fully voluntary program would cause a delay of ten years in achieving these conservation goals, while the partially voluntary program would cause a delay of five years. The effect of these delays is to produce energy savings in the period 1982-2005 of between 4.5 and 6.5 quads for the five-year delay and between 2.4 and 6.8 quads for the ten-year delay. (127) These savings represent between 15% and 50% of the savings expected from the proposed action. The proposed action would therefore have more beneficial effects on environmental quality than this alternative.

2.3.4. ENHANCED CONSUMER EDUCATION

DOE considered the alternative of expanding the current consumer education program and the FTC labeling program through policy initiatives by the respective federal agencies. The labeling program was carefully reviewed for possible improvements. This review failed to identify any significant shortcomings or possibilities for expansion.

A similar review of the DOE consumer education program revealed several possibilities for expansion and improvement. The amount of information provided to consumers could be increased to include product-specific information. A more active approach to reach potential consumers prior to their purchase of products covered by the CPES could also be taken. These efforts would require additional appropriations in order for DOE to pursue them.

DOE's analysis of the potential of this alternative to save energy reveals that improving the consumer education program will save 10.8% to 16.2% of the energy that could be saved by the proposed Program. (127) The assumptions used to make these estimates are discussed in the "Draft Regulatory Analysis," TSD No. 1. This alternative is thus unlikely to have as positive an effect on the environment as the proposed action.

APPENDIX A: PROPOSED MINIMUM ENERGY EFFICIENCY LEVELS

PRODUCT TYPE/CLASS	JULY 1981	JANUARY 1, 1986
REFRIGERATORS AND REFRIGERATOR-FREEZERS[1]		
Electric refrigerator; manual defrost	1.2 + 0.524V	11.04 + 0.474V
Electric refrigerator-freezer; manual defrost freezer	0.06 + 0.400V	6.29 + 0.432V
Electric refrigerator-freezer; automatic defrost with top freezer	1.69 + 0.178V	4.91 + 0.183V
Electric refrigerator-freezer; automatic defrost with side freezer	3.19 + 0.02V	5.20 + 0.082V
Electric refrigerator-freezer; automatic defrost with bottom freezer	4.5	8.1
Electric refrigerator-freezer; automatic defrost with top freezer and through-the-door ice or liquid service	5.4	7.4
Electric refrigerator-freezer; automatic defrost with side freezer and through-the-door ice or liquid service	4.7	6.3

[1] Energy Factor, ft^3/kWh/24 hours; V = total uncorrected volume, expressed in ft^3

Source: 128

PRODUCT TYPE/CLASS	JULY 1981	JANUARY 1, 1986
FREEZERS[1]		
Chest freezer, manual defrost	6.18 + 0.337V	13.72 + 0.332V
Upright freezer, manual defrost	3.00 + 0.393V	10.85 + 0.342V
Upright freezer, automatic defrost	3.30 + 0.197V	8.07 + 0.093V
CLOTHES DRYERS[2]		
Electric, standard size	2.96 - 0.048V	3.31 - 0.048V
Electric, compact size, 120 Volt	2.63	2.85
Electric, compact size, 240 Volt	2.35	2.54
Gas	2.71 - 0.048V	2.91 - 0.048V
WATER HEATERS[3]		
Electric	0.86 - 0.0013V	0.996 - 0.0013V
Gas	0.546 - 0.0018V	0.653 - 0.000625V
Oil	No Standard	No Standard

[1]Energy Factor, ft^3/kWh/24 hours; V = total uncorrected volume, expressed in ft^3

[2]Energy factor, lbs of clothes/kWh; V = drum volume, expressed in ft^3

[3]Energy factor = total heat content in an average daily hot water usage of 64.3 gal divided by the daily consumption of the water heater; V = storage volume, expressed in gallons

Source: 128

PRODUCT TYPE/CLASS	JULY 1981	JANUARY 1, 1986
ROOM AIR CONDITIONERS[4]		
With outdoor side louvers; capacity of 6000 Btu/hr or less	6.5	8.4
With outdoor side louvers; capacity greater than 6000 Btu/hr but less than 20,000 Btu/hr	7.5	9.5
With outdoor side louvers; capacity of 20,000 Btu/hr or greater	6.7	8.4
Without outdoor side louvers or reverse cycle	6.7	9.0
HOME HEATING EQUIPMENT	Space reserved[5]	Space reserved[5]
KITCHEN RANGES AND OVENS[6]		
Microwave oven	No standard	No standard
Electric cooking top	No standard	No standard
Electric oven	17.6 - 1.57V	20.2 - 1.57V
Electric oven, self-cleaning	17.6 - 1.57V	18.3 - 1.57V
Gas cooking top	31	45
Gas oven	6.4 - 0.73V	9.2 - 0.73V
Gas oven, self-cleaning	6.4 - 0.73V	8.6 - 0.73V

[4]Energy Efficiency Ratio, Btu/watt-hr

[5]Space reserved until test procedure modifications can more adequately measure efficiency.

[6]Energy factor = annual useful cooking output divided by the annual energy consumption at the point of use.

Source: 128

PRODUCT TYPE/CLASS	JULY 1981	JANUARY 1, 1986
CENTRAL AIR CONDITIONERS[7]		
Split system -- cooling only	7.8	11.0
Single package -- cooling only	7.5	10.5
FURNACES[8]		
Electric	No standard	No standard
Gas gravity	No standard	No standard
Gas, forced air, indoor	65	81
Gas, forced air, outdoor nonweatherproof horizontal	56	74
Gas, forced air, outdoor other than nonweatherproof	68	76
Gas boiler, indoor	65	79
Gas boiler, outdoor	No standard	No standard
Oil, forced air, indoor	75	80
Oil, forced air, outdoor	71	78
Oil boiler, indoor	76	82
Oil boiler, outdoor	No standard	No standard

[7] Seasonal Energy Efficiency Ratio, Btu/Watt-hr

[8] Annual Fuel Utilization Efficiency = heat output of the furnace divided by the energy content of the energy input

Source: 128

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APPENDIX C

APPENDIX C: ANALYSIS OF CONSUMER PRODUCTS AND DESIGN OPTIONS

Section 3 of the text gives an overview of the current market penetration and aggregate energy consumption of all consumer products considered in this assessment. Based on the energy-consumption figures, energy-saving design options can have a substantial impact on the energy consumed by each consumer product as well as on the nation's total energy consumption. This Appendix describes each covered product, gives its annual production statistics, identifies possible energy-saving design options, and discusses the potential effects of these design options on environmental quality and product utility. Detailed tables, summarized from DOE analyses, list design options, product utility and environmental impact for each product.(138)

I. REFRIGERATORS AND REFRIGERATOR-FREEZERS

The refrigerator is a household consumer product designed to maintain a refrigerated volume for the storage and cooling of foods. After furnaces, refrigerators and refrigerator-freezers are second only to water heaters in the amount of energy they yearly consume in the U.S. Most units available today have two storage spaces: one for storing frozen food at 0° to 5°F and another for fresh-food storage at 35° to 40°F. A typical new model is a 16 cubic-foot, top-mount combination refrigerator-freezer, with the freezer on top of the fresh-food compartment with automatic defrost in both compartments.

In order to maintain the compartment temperatures, the unit runs 60% of the time, during which about 75% of the energy flows through the compressor used to produce cooling; additional energy is used to drive the fans, which are needed within to help chill the food, and on the outside (for certain models) to cool and condense the refrigerant after it has been compressed. Additional energy is consumed by electric resistance heaters around the door-flange area, where one finds the lowest skin temperatures and where condensation normally occurs on humid days.

The five major components of the refrigeration unit are the compressor, the evaporator, the condenser, the heat exchanger, and the filter dryer. In a typical combination automatic defrost, refrigerator-freezer, common to all major manufacturers, a single evaporator unit carrying the cold refrigerant is used to cool the circulating air drawn by a fan from both the freezer and refrigerator compartments. The cooled air returning to the cabinet is distributed back to the freezer and the fresh-food compartment. The proportion of air provided to the two compartments is a determinant of overall performance. In general, about a five-to-ten times greater airflow is provided to the freezer to maintain the lower temperature. In most designs, a single thermostatic sensor in the fresh-food compartment controls the operation of the refrigerant unit, while the airflow to the freezer compartment is adjusted by a manual damper.(155)

Table C-1. Refrigerator Shipments (5,6,147)

	Units Shipped (Millions)	Retail Value (Millions $)	Saturation Level (percent)
1975	4.582	$1,425.0	99.8%
1976	4.817	1,686.0	99.9
1977	5.707	2,425.5	99.9
1978	5.890	3,227.7	99.7
1979	6.199	3,811.7	

DESIGN OPTIONS

Extensive tests have been conducted on refrigerator and refrigerator-freezer designs and models in order to improve their energy efficiency, although two basic models have been most thoroughly tested, for they represent the majority of product designs now in operation in the United States. These models have basically the same storage volume (16 cubic-feet) and differ only in type of insulation, wall thickness, compressor design (reciprocating versus rotary), and condensor operation (forced convection versus free convection). DOE initially examined thirty energy-saving design options for these models.(155) These options for improving the energy efficiency of refrigerators are associated with the following components: 1) insulation system, 2) compressor, 3) evaporator, and 4) defrost and moisture control. From these initial choices of design options, the following are cost-effective and technically feasible.(138)

1) Foam insulation substitution -- Fiberglass insulation is replaced with polyurethane foam insulation. Since polyurethane foam has a thermal conductivity about one-half that of fiberglass, this option greatly reduces cabinet heat leak.

2) Improved compressor motor efficiency -- A run capacitor is added to the compressor motor to decrease electric power consumption.

3) Improved door seal -- An improved door seal gasket reduces heat leak and air infiltration in the door area.

4) Anti-sweat heater switch -- A switch is installed to permit, in a dry environment, shutting off the cabinet heaters which prevent condensation on the cabinet exterior in high humidity. Energy savings are realized by eliminating both the heater power consumption and the heat which flows into the cold space from these heaters which must be removed by the refrigeration system.

5) Improved fan/motor efficiency -- Improved fan and motor provide equivalent airflow with less electric power input.

6) Increased evaporator or condenser surface area -- Increased heat exchanger surface area in the evaporator and/or condenser provides for more efficient operation of the refrigeration system.

7) Place evaporator fan motor outside of cold space -- Conventional refrigerator and refrigerator-freezer designs place the evaporator fan motor within the cold space of the unit; there, waste heat from the motor is a heat load. This option places the fan motor outside of the refrigerated space, and the motor heat is rejected to the ambient environment.

8) Replace forced air condenser with static back-mounted condenser -- This option replaces the forced air convection condenser and fan mounted beneath the unit with a back-mounted natural convection condenser. Because no condenser fan is required, energy is saved. Since natural convection condensers have less overall heat rejection capacity, this option is usually incorporated with the insulation substitution of foam for fiberglass (#1) which decreases cabinet heat load.

9) Reduce compressor size -- When foam insulation is replaced by polyurethane foam (#1), reduced cabinet heat load permits the use of a smaller compressor with less cooling capacity; therefore, compressor power consumption decreases.

10) Reduce heat load of through-the-door feature -- Better design and improved insulation can be used to decrease the heat leak and additional power consumption attributable to the through-the-door service feature (ice, water, etc.).

SUMMARY

Table C-2 presents a summary and analysis of refrigeration design options, their impact on the environment, and their impact on product utility.

II. FREEZERS

A freezer is an insulated and enclosed cabinet designed to store foods at temperatures of about 0°F in order to prevent their deterioration. The energy source is electricity, and the system used to achieve the desired temperatures is explained in detail in the section on refrigerators and refrigerator-freezers above. Freezers are of two basic types, the chest or horizontal model with door pivoted on a horizontal axis and the upright model whose door is pivoted on a vertical axis. Freezers like refrigerators use manual or automatic defrost systems. Saturation levels for freezers have not exceeded 50%, with the 1978 saturation figure reaching the 44.9% level. (See Table C-3.)

TABLE C-2. REFRIGERATORS AND REFRIGERATOR-FREEZERS

Design Option	Product Utility	Environmental Impact
Foam Insulation Substitution	No change	Small increase in CFC emission
Improved Compressor Motor Efficiency	No change	Not significant
Improved Door Seal	No change	Not significant
Anti-Sweat Heater Switch	No change	Not significant
Improved Fan/Motor Efficiency	No change	Not significant
Increased Evaporator or Condenser Surface Area	Possible size increase	Not significant
Place Evaporator Fan Motor Outside of Refrigerated Space	Possible size change	Not significant
Replace Forced Air Condenser with Static Back Mounted Condenser	No change	Not significant
Reduced Compressor Size	Possible decrease in high load performance	Not significant
Reduce Heat Load of Through-the-Door Feature	Possible loss of some convenience options	Not significant

Source: 169

Table C-3. Freezer Shipments (5,6,147)

	Units Shipped (Millions)	Saturation Level (percent)
1975	2.457	43.5%
1976	1.542	44.4
1977	1.598	44.8
1978	1.522	44.9
1979	1.310	

DESIGN OPTIONS

The design options for freezers are identical to design options 1-9 for refrigerators and refrigerator-freezers.

III. WATER HEATERS

Water heaters consume 8.6% of the residential sector energy. The water heater controls the supply water temperature to other major consumer products in the home and to the tap.

The water heater is a large insulated container with a heat source. The three major types of water heaters sold in the U.S. are electric, gas, and oil-fired. For each type, an insulated tank of water is continually maintained at some desired delivery temperature usually between 140°F to 150°F. Typical gas models have a burner under the tank and an exhaust stack that runs up through the tank and vents outside. The stack has a two-fold function. It transfers some heat to the water and simultaneously vents the burner. Most electric water heaters have two resistance immersion coils, one at the top of the tank and another at the bottom.

Table C-4 presents a summary of water heater shipments for the period 1975 through 1979. In 1975, about 45% of the units shipped were electric and 55% were gas. Saturation levels for the last five years (1975-1979) were almost 100%.

Table C-4. Water Heater Shipments (5,6,147)

	Units Shipped (Millions)	Saturation Level (percent)
1975	4.828	99.2%
1976	5.000	
1977	5.000	
1978	5.605	
1979	5.549	

DESIGN OPTIONS

A significant amount of energy is lost in the heating and storing of water; the possible reduction of this waste is sensitive to several factors. The measures for reducing energy consumption of water heaters can be classified according to four forms of energy loss: (1) energy loss through the jacket, (2) energy loss through the flue during standby operation (gas and oil water heaters only), (3) energy loss through the flue during main burner operation (gas and oil water heaters only), and (4) energy loss through the water pipe connections.

The design options for hot water heaters are as follows:

1) Improved insulation -- Improved insulation involves using thicker fiberglass insulation, denser fiberglass insulation, or substituting polyurethane foam insulation for fiberglass. This option may require changing jacket sizes. (See Table C-5.)

2) Increase flue heat transfer and reduce main burner rate -- These two design options are coupled since increasing the flue heat transfer requires reducing the main burner firing rate in order to maintain acceptable pressure drops through the system. Increased heat transfer is generally accomplished by modifying an existing flue baffle by adding surface area or flow resistance.

3) Intermittent ignition device (IID) -- A spark device is utilized to light the main burner, for gas water heaters, and may be electrically powered or use a piezoelectric/mechanical spark system. The analysis assumes that electricity can be supplied to the unit.

4) Flue damper -- A flue damper is utilized on gas fired units to reduce standby losses during the off-cycle. Dampers are available; however, they are not approved for installation upstream of the draft relief (in the flue).

5) Reduced pilot rate -- The pilot rate on baseline units is approximately 700 Btu/hr. This can be reduced to a value of approximately 400 Btu/hr, without reducing the reliability of the unit. This reduction is accomplished by using a smaller orifice.

6) Heat traps -- Heat traps are used on the water inlet and outlet pipes to reduce natural convection losses. The analysis assumed that heat traps were installed on both pipes and used the standard DOE test procedure credits.

SUMMARY

The potential impacts of the design options for hot water heaters as they may affect the environment and product utility are summarized in Table C-6.

TABLE C-5. DETAILS OF WATER HEATER DESIGN OPTIONS

Natural Gas

Baseline: 40 gallon nominal capacity (actual 38 gallons) with 400 Btu/hr pilot and 3" flue.

	LEVEL				
	Baseline	1	2	3	4
Input Btu/hr	40,000	30,000	30,000	30,000	30,000
Recovery Efficiency	74	76	76	76	76
Insulation	1" ½-lb. fiberglass	1" foam	1.5" foam	1.5" foam	2" ½-lb. fiberglass
Other Options	-	-	-	Heat traps	IID & Damper
Energy Factor (%)	47.5	58.7	61.2	63	65.5

Electric

Baseline: 52 gallon nominal capacity

	LEVEL				
	Baseline	1	2	3	4
Insulation	2" ½-lb. fiberglass	1.25" foam	1.8" foam	2.4" foam	1.8" foam
Other Options	-	-	-	-	Heat traps
Energy Factor (%)	77	85	89	91.5	93

Source: 138

TABLE C-6. WATER HEATERS

Design Option	Product Utility	Environmental Impact
Improved Insulation	Possible increase in outer dimension	Small increase in CFC emission
Increase Flue Heat Transfer	No change	Not significant
IID-Intermittent Ignition Device	Slight increase in complexity Increased utility: no regulating of pilots	Not significant
Flue Damper	Slight increased complexity and maintenance	Not significant
Reduced Pilot Rate	Increased pilot outage	Not significant
Reduced Main Burner Rate	No change	Not significant
Heat Traps	No change	Not significant

Source: 169

IV. ROOM AND CENTRAL AIR CONDITIONERS

Air conditioners perform four major functions: (1) cool room air by transporting room heat to the ambient (outside) air, (2) dehumidify room air to enhance comfort, (3) circulate room air to provide uniform cooling, and (4) filter room air to remove solid impurities, such as pollen and dust. Additional features may include: (1) ventilation, i.e., exchanging inside for outside air, (2) multiple indoor fan speeds, (3) continuous fan operation for room air circulation and purification during non-cooling periods, and (4) thermostatic temperature control.

Air conditioners are presently rated according to their cooling capacities (Q) and their energy-efficiency rating (EER-room, SEER-central). Cooling capacity is the maximum rate (Btu/hr) at which a unit can remove room heat under standard conditions of 95°F ambient temperature, 80°F room temperature, and 51% room relative humidity.(1) Capacity increases with decreasing ambient temperature. The actual efficiency of air conditioners is determined by the design of the components and the humidity of the outdoor and indoor air. Table C-7 lists shipments for room and central air conditioners.

Table C-7. Summary of Room and Central Air Conditioners Shipments (5,6,147)

Year	Room Air Conditioner Units Shipped (Millions)	Room Air Conditioner Saturation (percent)	Central Air Conditioner Units Shipped (Millions)
1975	2.670	52.8	
1976	2.962	54.5	
1977	3.270	55.3	1.982
1978	4.037	55.9	2.155
1979	3.749		2.060

DESIGN OPTIONS

1) Improved controls -- This option includes a compound switch which permits auto fan or continuous fan settings. It also includes anticipation/sensor features resulting in separate fan motor and compressor motor operation (room air conditioners only).

2) Improved cycle efficiency -- This option includes reducing the energy consumed by the compressor by enlarging the surface areas of the heat exchangers to reduce the temperature differential between the condenser and evaporator.

3) Increase motor efficiency -- This option involves the substitution of split capacitor motors for shaded pole motors for all units below ½ horsepower (hp). Above ½ hp, high efficiency ball bearing motors are used.

4) Improved compressor efficiency -- This option involves the use of split capacitor motors in the compressor and improvements in the vapor compression process and flow.

5) Improved heat exchanger efficiency -- This option includes improving the heat transfer characteristics and increasing the surface area of the evaporator and condenser coils by approximately 55 and 75 percent respectively.

6) Improved thermal insulation -- Thermal insulation is applied to the cold section of the unit to decrease heat transfer from the environment.

SUMMARY

See Table C-8 for a summary of the design options and impacts for room and central air conditioners.

V. KITCHEN RANGES/OVENS

Conventional ranges and ovens have reached fairly high levels of saturation. The major types in use are, of course, gas and electric. Table C-9 gives a summary of shipments and saturation data for these products.

Table C-9. Summary of Ranges/Ovens Shipments (5,6,147)

Year	Electric Ranges/Ovens		Gas Ranges/Ovens	
	Units Shipped (Millions)	Saturation Level (Percent)	Units Shipped (Millions)	Saturation Level (Percent)
1975	2.083	68.5	1.618	99.9
1976	2.463	70.1	1.823	99.9
1977	3.009	71.9	1.753	99.9
1978	3.218	70.6	1.797	99.7
1979	3.253			

DESIGN OPTIONS

1) Increased insulation -- Denser or thicker fiberglass insulation is used to reduce losses. This may involve a change in oven cavity dimensions in order to maintain standard outside dimensions.

TABLE C-8. ROOM AND CENTRAL AIR CONDITIONERS

Design Option	Product Utility	Environmental Impact
Improved Controls	Increased complexity	Not significant
Improved Cycle Efficiency	No change	Not significant
Increased Motor Efficiency	Possible lower capacity under extreme conditions	Not significant
Improved Compressor Efficiency	Possible size change	Not significant
Improved Heat Exchanger Efficiency	Possible size change	Not significant
Improved Thermal Insulation	No change	Not significant

Source: 169

2) Improved gasket or reduced excess air -- The vent air is reduced by utilizing an improved gasket to seal the door or by reducing the excess air flow to the gas burners either in the oven or on the cooktop.

3) Intermittent ignition device (IID) -- This design option applies to both range cooktops and ovens. It involves utilizing a spark ignition device or a glow bar type ignition device coupled with a thermal valve to replace standing pilots. In both cases electrical hook-up is required.

4) Reduced cavity size or rack mass -- This option applies to ovens. Reducing the cavity size, thereby reducing the mass of metal in the oven, improves efficiency. This can also be accomplished by reducing the mass of the racks that are used in the oven because the energy that is put into heating up the cavity and racks is not recovered during the oven cool down.

5) Reduced contact resistance -- This applies to sheath type electrical resistance heaters for cooktops. Their efficiency is improved by designing them to maintain better thermal contact with cooking utensils. In the costing of this design option we assumed a higher reject rate and higher inspection costs. This should make it possible to select the better burners.

6) Reflective pans under burners -- The baseline units used porcelainized drip pans under the burners. The design improvement involves using chrome-plated higher reflective pans to reduce radiation losses.

SUMMARY

The major design options and their expected impacts are summarized in Table C-10.

VI. FURNACES (INCLUDING HOME HEATING EQUIPMENT)

Home heating equipment ranges from portable space heaters to central furnaces. Table C-11 provides shipment data for selected product classes. Gas furnaces are the largest single product with 1.6 million units produced per year.

Table C-11. Shipments of Selected Home Heating Equipment Including Furnaces (5,6,147)

	Furnaces, Warm Air Units Shipped (Millions)	Wall Furnaces Units Shipped (Millions)
1975	1.380	0.401
1976	1.791	0.499

(Table C-11 continued on page C-15)

TABLE C-10. KITCHEN RANGES/OVENS

Design Options	Product Utility	Environmental Impact
Increased Insulation	Possible size change	Not significant
Improved Gasket	No change	Not significant
Intermittent Ignition Device (IID)	Slight increase in complexity Increased utility: no relighting of pilots	Not significant
Reduced Cavity Size	Limit on cooking large items	Not significant
Reduced Contact Resistance	No change	Not significant
Reflective Cavity under Burners	No change	Not significant

Source: 169

Table C-11. Shipments of Selected Home Heating Equipment Including Furnaces (5,6,147) (continued)

	Furnaces, Warm Air Units Shipped (Millions)	Wall Furnaces Units Shipped (Millions)
1977	1.819	0.457
1978	1.987	0.200
1979	2.149	0.206

DESIGN OPTIONS

1) Increased heat exchanger surface area -- This design option involves increasing the size of the heat exchanger to improve heat recovery. It can be utilized in both gas-fired and oil-fired furnaces and boilers.

2) Intermittent ignition device (IID) -- Intermittent ignition devices are used in gas-fired furnaces in place of pilots. The IID's costed require electrical hook-up.

3) Stack damper -- Stack dampers are used to reduce losses during the standby period. The stack damper is electrically powered and wired into the control system so that it opens prior to the firing of the furnace or boiler and closes after the firing period is terminated.

4) Power burner or power vent -- This design option applies to gas-fired units. It involves using a power blower on the inlet or exit side of the unit to promote flow of the combustion products through the heat exchanger. This option permits higher combustion efficiency and reduced standby losses.

5) Retention head burner -- The retention head burner is a type of oil-fired burner which is designed to minimize standby losses due to the shape of the burner head. In a properly designed unit it also improves the firing efficiency.

6) Direct vent with interchange -- In this design option the combustion products are vented to the outside through a pipe which passes inside a second duct through which the combustion air is drawn. This configuration permits an exchange of heat between the existing flue gas and the incoming combustion air.

SUMMARY

Table C-12 presents a summary of design options for furnaces including home heating equipment.

TABLE C-12. FURNACES INCLUDING HOME HEATING EQUIPMENT

Design Option	Product Utility	Environmental Impact
Increased Heat Exchanger Surface Area	No change	Not significant
IID-Intermittent Ignition Device	Increased complexity Increased utility: No pilot relighting	Not significant
Flue Damper	Potential hazards from improper installation or maintenance	Possible indoor air pollution malfunction
Power Burner or Power Vent	Increased complexity	Not significant
Retention Head Burner	Increased complexity	Not significant
Improved Blower Motor Efficiency	No change	Not significant
Direct Vent with Interchange	No change	Not significant

Source: 169

VII. CLOTHES DRYERS

Clothes dryers in widespread use in the U.S. today are powered either by electricity or by gas. The basic design configuration of clothes dryers is consistent throughout the industry, varying only in size and heat source. Electric dryers account for about 75 percent of productions, and gas for the remaining 25 percent.

The general definition of a clothes dryer is a "cabinet-like appliance designed to dry fabrics in a tumble type drum with forced air circulation." (14) The typical dryer has an opening in the front, with a door that gives access to the drum. The drum is mounted on a horizontal axis and is rotated by an electric motor which also drives the fan that provides the air flow. The principal function of a clothes dryer is to provide a flow of heated air through the drum facilitating evaporation of the water in the load. To provide better evaporation, the load is tumbled by the combination of the rotating drum and vanes that protrude into the drum. Air flow through the dryer is effected by a negative pressure system. The heated air enters through the back of the drum and exits, or is vented, through the front or back of the drum.

For the gas dryer there are two types of fuel ignition devices: The Intermittent Ignition Device (IID) and the Standing Pilot (SP) system. About 95 percent of the energy used by an electric dryer goes to the heater; 5 percent is used to operate the motor. For a gas dryer with IIDs, only 0.1 percent of the energy goes to the ignition device, and 95.3 percent to the heater. (133) However, gas dryers now manufactured by members of the Association of Home Appliance Manufacturers do not have standing pilot lights.

Both gas and electric dryers have push-to-start buttons and an automatic shutdown switch which activates when the door is opened. The drying cycles usually consist of a choice of a timed cycle and one or two automatic cycles. Two types of automatic sensing devices are used: moisture and temperature sensing. Other options are also provided, such as heat control and fluff or air dry.

Clothes dryers, like clothes washers, fall somewhere between a convenience and a necessity, although more clothes washers are produced per year than dryers. Between 1975 and 1978 the saturation level for clothes dryers increased from 57.7 percent to 60.3 percent. (147) (See Table C-13.)

There are a number of design options possible for improvement of the efficiency of clothes dryers. The feasibility of these improvements has been studied both from the standpoint of energy savings and cost-effectiveness. Because of the difference in construction and operation of electric and gas dryers, a greater number of design options are feasible for improving the efficiency of electric dryers than for gas dryers.

Table C-13. Summary of Clothes Dryer Shipments (5,6,147)

	Units Shipped (Millions)	Saturation Level (percent)
1975 - Electric	2.198	
- Gas	0.672	
	2.870	57.7%
1976 - Electric	2.466	
- Gas	0.708	
	3.174	58.6%
1977 - Electric	2.817	
- Gas	0.736	
	3.553	59.3%
1978 - Electric	2.864	
- Gas	0.757	
	3.621	60.3%
1979	3.551	

DESIGN OPTIONS

1) Insulation -- When a clothes dryer is operating, its cabinet surface temperatures increase above the ambient temperature and heat is lost to the surrounding environment. By adding thermal insulation to the cabinet surfaces, less heat is lost, resulting in higher efficiency.

2) Heating element -- This improvement applies only to electric dryers and consists of substituting an expanded-strip heating element in place of a helical coil or similar heat unit. Because of a larger surface to volume ratio, more heat is transferred to the air by convection and results in a lower element temperature which, in turn, results in less heat conduction to parts adjacent to the element, and less heat loss by radiation.

3) Improved dryness sensor -- Clothes dryers have controls of two types, time controlled and automatic. Time controlled devices depend upon user judgment, which may result in overdrying and hence a loss of energy.

Automatic dryness sensing controls react to the moisture content of the clothes in the dryer and shut off the heat automatically when the clothes have attained a preset dryness.

4) Door seals -- Air tight seals on the dryer would eliminate hot air leakage from the dryer to the outside or from the outside into the dryer, depending on which side has the higher pressure. For the forced air dryer, the pressure inside the drum is higher; and for the induced air dryer, the pressure outside the drum is higher. Making the seals air-tight would increase energy efficiency by reducing energy loss to the outside.

5) Electric motor -- The potential for efficiency improvement in the dryer's electric motor is from 15-20 percent; however, these motors use only a small fraction of the total energy, typically 5 to 10 percent.

6) Lint filter -- A restricted lint filter increases the pressure against which a fan has to work and cuts down on the air flow rate, resulting in higher air temperatures that affect the energy efficiency of the dryer. As the drying cycle progresses, lint accumulates on the filter and restricts the air passage. How much this accumulation of lint affects the air flow rate depends on the blower characteristics. The effect on the overall performance of the dryer is difficult to evaluate without further study; however, DOE estimates that approximately 0.5 percent improvement is possible.(125)

7) Reduce thermal mass -- A standard dryer weighs from 120 to 180 pounds. At the start of the drying cycle, the ambient temperature is 75°F. At the end of the cycle, the temperature in different parts of the dryer varies, with the highest near the heater and the lowest on the outside dryer surfaces. An improvement of 0.5 percent energy efficiency using this design option requires only about a 5 percent decrease in dryer weight.(125)

8) Reduce drying air temperature -- Reducing the drying air temperature in dryers results in less energy consumption and a longer drying time. Reducing the heating rate to about one-fourth (reduction of dryer voltage from 240 volts to 120 volts) would result in a 15-20 percent improvement in energy efficiency; however, the drying time would increase from about 25 minutes to 65 minutes. It would be easy to incorporate this design option in electric and gas dryers, but what the consumer reaction will be to longer drying times is not known and needs further study. An acceptable drying time should be determined and the heating rate adjusted accordingly. Manufacturers can also provide controls to allow the user to vary continuously or in steps the rate of heat put into the dryer. This is a feasible design option.

SUMMARY

Table C-14 presents a summary of the energy saving design options available for clothes dryers.

VIII. CLOTHES WASHERS

Most home clothes washers in use today fall into two general categories, top-loading or front-loading. Within each of these classifications there are size categories; the two most frequently used categories are regular and compact. Regular-sized top-loading models account for the largest share of the market.

Clothes washers fall somewhere between a convenience and a necessity. Between 1969 and 1975 the saturation level for washing machines increased from 61.9% to 69.9%. The number of units shipped has increased somewhat slowly through 1978. (See Table C-15.)

TABLE C-14. CLOTHES DRYERS

Design Options	Product Utility	Environmental Impact
Improved Insulation	Possible size change	Not significant
Improved Heating Element	Possible increased heater element failure	Not significant
Improved Dryness Sensor	Improved utility	Not significant
Improved Door Seals	No change	Not significant
Improved Motor	No change	Not significant
Lint Filter	No change	Not significant
Reduced Thermal Mass	No change	Not significant
Reduced Drying Air Temperature	Increased drying time	Not significant

Source: 169

Table C-15. Clothes Washer Shipments (5,6,147)

	Units Shipped (Millions)	Saturation Level (percent)
1975	4.228	69.9
1976	4.492	72.5
1977	4.933	73.3
1978	5.039	75.2
1979	4.965	

Design options for the improvement of clothes-washer efficiency have been the subject of extensive theoretical and experimental investigations. (133,141,166) Research has shown that the energy consumption and the performance of clothes washers are sensitive to a number of factors such as:

- water hardness
- water temperature
- detergent amount and type
- bleach and other additives
- machine cycles and pre-wash options
- water level
- clothes fiber and kinds of soil

There is reasonable agreement on the effectiveness of the design options that present feasible means of increasing the energy efficiency of clothes washers. Ninety-five percent of the energy used by a clothes washer is in the form of hot water; hence the most useful design options are aimed at decreasing hot-water usage.

DESIGN OPTIONS

1) Elimination of warm-rinse option -- Washing-machine manufacturers, contractors to the consumer product efficiency program, and government laboratories all agree that elimination of the warm-rinse option will not affect the performance of washers.(14,26,165) The elimination of the warm-water rinse would reduce hot-water consumption by approximately four gallons per cycle. The design change consists of modifying or eliminating the selector switch controlling the rinse-water temperature. Actually, many washing machines now have the option of cold-water rinse, and the use of this option is up to the discretion of the consumer.

2) Reduced hot water usage -- Currently the flow setting used for warm-water washing is produced by mixing a fixed fraction of hot and cold water. Typically this fraction is 50-50 or 60% hot and 40% cold and the mixed-water temperature is in the range of 100°F. Approximately 9% of the hot water supplied to the clothes washer can be saved if the mixing ratio of washing machine water inlet values were changed to 40% hot and 60% cold.

One means of controlling the hot-water flow consists of replacing the currently used fixed valve with one which controls the mix of hot and cold water thermostatically. This valve will automatically control hot-water flow to give the optimal warm water setting. However, the thermostatic valve is expensive, has no clearcut advantage over the fixed valve, and has questionable dependability.

3) Suds-saver option -- Modern detergents all have cleaning ability sufficient to use the same water for two to three washes. Some clothes washers currently being marketed take advantage of this under the label of "suds-saver." The water from the first wash is used to wash clothes for up to two additional washes. It is estimated that about 50 percent of the hot wash water can be saved if three washes are performed sequentially using this feature. This option has been available in some machines for some time.

4) Improved fill control -- This design option would reduce water usage by utilizing an improved filling mechanism to adjust the water level to a minimum for each cycle.

5) Improved insulation and reduced thermal mass of drum -- Increased insulation would cut down heat loss and reduction of thermal mass would decrease the amount of thermal energy lost in warming up the drum. Both these options would provide minimal improvements in efficiency.

6) Conversion to front-loading design -- Front-loading tumbler-type washers use considerably less water and detergent than the top-loading machines that now dominate the market. Although front-loading machines have the capability of reducing water consumption by as much as 25 percent, they have not been widely accepted by consumers. This seems to be a long-range option; some time would be required for education of the consumer and for manufacturers to retool.

7) Improved motor efficiency -- Clothes washers currently use split-phase motors. Capacitor-type electric motors are more reliable and perform better under high-torque conditions. While the efficiency of each type of motor varies, split-phase motors are about 45 percent efficient while the efficiency of the capacitor motor (which is roughly twice as expensive) is 55 percent. The electric motor consumes only about 5 percent of the energy used in a typical clothes washer; switching to the more efficient motor would save only about 15 kWh per year.

8) Reduced water volume between inner and outer tub -- This redesign option can be accomplished on large usage machines at a substantial cost. Increasing energy costs may eventually make this design option feasible.

SUMMARY

Table C-16 provides a concise summary of the energy-efficient options for clothes washers. These options vary in cost, energy savings, and present feasibility. (Some will become more attractive as the price of gas

TABLE C-16. CLOTHES WASHERS

Design Option	Product Utility	Environmental Impact
Eliminate Warmrinse Option	No change	Not significant
Reduce Hot Water Usage	Performance decreases	Not significant
Suds-saver Option	No change	Not significant
Improve Fill Control	Complexity may increase maintenance requirement	Not significant
Improve Thermal Mass & Insulation	No change	Not significant Negligible CFC-bearing insulation required
Conversion to Front-loading	No change	Not significant Negligible difference in material requirement
Improve Motor Efficiency	No change	Not significant
Reduce Water Volume between Inner and Outer Tubs	No change	Not significant

Source: 14, 20

and electricity increases.) Conservation of hot water is the key to washer energy savings, and most of the hot water saving options require the active participation of the consumer.

IX. DISHWASHERS

Dishwashers are a convenience item that is becoming increasingly prevalent in American households. Their use accelerated rapidly from 1963 to 1973, but leveled off in the late 1970's.(5) Built-in dishwashers are now commonly incorporated into new homes and an increasing number of portable models are being installed in homes not originally equipped with a dishwasher. Shipment and saturation level data for dishwashers are shown in Table C-17.

Table C-17. Summary of Dishwasher Shipments (5,6,147)

Year	Units Shipped (Millions)	Saturation Level (percent)
1975	2.702	38.3
1976	3.140	39.6
1977	3.356	40.9
1978	2.557	41.9
1979	3.488	

Dishwashers provide considerable timesaving and convenience over manual dishwashing. More importantly, it has been clearly shown that dishwashers provide a considerable advantage to sanitation and washing performance.(68,103,147) Hence the dishwasher can be viewed as making a positive contribution to the health of the consumer.

Dishwashers can be classified into four basic categories, under-counter (built-in), portable, free-standing and convertible. Undercounter models account for the largest share of the market. The dimensions and operation of all four types are similar.

Dishwasher fractional energy consumptions are shown in Table C-18. Since most of the energy is utilized in the heating of wash and rinse water, the most effective energy-saving strategies involve improving this aspect of the cycle.

X. HEAT PUMPS

Heat pumps are similar to central air conditioners, but by the addition of reversing valves and defrost equipment they supply useful heat to the conditioned space during winter months, and extract unwanted heat from the conditioned space during summer months. In the winter months, the outdoor coil is used to extract heat from the outdoor air, and the indoor coil is used to provide heat to the indoor air. Conversion from one mode to the other is achieved by redirecting the flow of the refrigerant. The energy-efficient design options for heat pumps are quite similar to those discussed for room and central air conditioners.

Heat pump shipments have increased steadily since 1970, when the industry shipped less than 100,000 units. Growth slowed somewhat in the late 70's as shown in Table C-20; however, the industry predicts approximately 600,000 shipments in 1980 and a million units per year by 1985.(59) Heat pumps are inherently more efficient than some conventional methods of heating and cooling and will play an increasing role in space-conditioning technology during the coming decade.

Table C-20. Summary of Heat Pump Shipments (5,6,147)

Year	Units shipped (millions)
1977	.482
1978	.560
1979	.548

DESIGN OPTIONS

1) Improved cycle efficiency -- This option includes reducing the energy consumed by the compressor by enlarging the surface areas of the heat exchangers to reduce the temperature differential between the condenser and evaporator.

2) Improve fan motor -- This option involves the substitution of split capacitor motors for shaded pole motors for all units below 1/4 horsepower. Above 1/4 hp, high efficiency ball bearing motors are used.

3) Improved compressor efficiency -- This option involves the use of split capacitor motors in the compressor and improvements in the vapor compression process and flow.

4) Improved heat exchanger efficiency -- This option includes improving the heat transfer characteristics and increasing the surface area of the

evaporator and condenser coils by approximately 55 and 75 percent respectively.

SUMMARY

Detailed consideration of design characteristics is limited at this writing by a lack of quantitative data. The design options are presented in Table C-21 for qualitative comparison with other similar consumer products. There are some relatively efficient heat pumps presently on the market, and economic feasibility will be the deciding factor in applying design options to raise efficiency further.

XI. TELEVISIONS

Television sets enjoy a unique position in the consumer product marketplace. Virtually every American household has at least one television set, and many households have more than one; the saturation level of monochrome (black and white: B&W) television sets has been over 99% since 1971. Color television sets were found in 74.4% of the American homes in 1975; they are now moving towards the same level of saturation that monochrome holds. Table C-22 documents the size and growth of the television-set market.

Table C-22. Summary of Television Shipments (5,6,147)

	Units Shipped (Millions)	Saturation Level (percent)
1975 (B&W)	4.968	99.9
(color)	6.485	74.4
1976 (B&W)	5.196	99.9
(color)	7.700	77.7
1977 (B&W)	5.664	99.9
(color)	9.107	81.3
1978 (B&W)	6.064	99.9
(color)	10.236	85.2
1979 (B&W)	6.255	
(color)	9.846	

The television industry has been characterized by rapid technological change and intense competition. As a result of these factors, the television sets available to the American public have increased in reliability, performance and efficiency in a relatively short time.

TABLE C-21. HEAT PUMPS

Design Options	Product Utility	Environmental Impact
Improved Cycle Efficiency	No change	Not significant
Improved Fan Motor	Possible increase in size	Not significant
Improved Compressor Efficiency	No change	Not significant
Improved Heat Exchanger Efficiency	Possible increase in size	Not significant

Source: 59, 121, 167

The unit power consumption of television sets is rather modest, approximately 50-150 watts. However, there are 150 million sets in use in this country, and the approximate viewing time for the average receiver has been determined to be 2,200 hours per year. If it were possible to decrease significantly the power consumption of television sets, an appreciable energy saving would result.

DESIGN OPTIONS

1) Solid-state circuitry -- One of the technological improvements proposed in 1976 by the FEA for increasing television set efficiency was a shift to solid-state circuitry.(35) The 100-percent solid-state receiver not only uses much less energy than the earlier vacuum-tube counterpart, but also performs better, longer, and more reliably. Since this design option was recommended, the industry has proceeded to maximize the use of solid-state circuitry in television sets, resulting in the realization of the expected energy savings.

In the present day solid-state sets, the high-voltage vacuum cathode-ray picture tube (CRT) remains the most energy-expensive component. Techniques for reduction of CRT energy consumption have been proposed. For example, a beam index color CRT was proposed at a recent public meeting sponsored by DOE.(148) This system has been under study by several manufacturers* as well as by the National Bureau of Standards.(79)

Replacement of the picture tube with a solid-state device (perhaps a flat-panel plasma-optics video display) would bring about the most significant increase in television-set efficiency now considered feasible. There are a number of approaches to replacing the CRT that are under study, not all of them energy efficient. It is estimated that a technical "breakthrough" in the replacement of the CRT is more than ten years away.(65)

The present utilization of solid-state circuitry in television is nearly maximal, and further efficiency improvements are not expected from this approach.(37)

2) Elimination of instant-on -- Another recommendation of the FEA in the early Targets program was the elimination of the instant-on feature of television sets. This option used energy to keep vacuum-tube and/or picture-tube filaments warm while the set was off so that the picture would appear instantaneously upon activating the "on" switch. Since the instant-on feature was introduced, two things have happened. First, the trend to solid state and the elimination of vacuum tubes resulted in a decrease in the power consumption of the instant-on feature by about a factor of ten. Then, more recently, manufacturers have moved to eliminate the instant-on feature altogether, and it has essentially disappeared from the market. The energy savings from this design option are now being realized.

*Sally Browne, Electronic Industries Association, letter, February 6, 1980.

3) Miscellaneous options -- Several additional design options have been proposed that do not warrant extensive discussion. It has been suggested that an upper limit be placed on television screen brightness. However it is not clear that this would produce a substantial saving of energy; furthermore, it would be difficult to determine what "normal viewing conditions" are and what screen brightnesses would be appropriate for these conditions.

It has been suggested that improved thermal design of television sets may increase efficiency.(159) Internal design improvements such as spacing of circuit boards, utilization of heat sinks and optimization of component configurations have been indicated as possible means of lowering operating temperatures and thereby decreasing energy consumption.

SUMMARY

The options discussed above and their impacts are summarized in Table C-23. Most practical energy-saving design options have already been implemented by the manufacturers with no negative impacts on the environment or the consumer. There appear to be no substantial efficiency improvements that can be expected in the next few years.

XII. DEHUMIDIFIERS

Dehumidifiers are self-contained, electrically powered appliances designed to decrease the moisture content of air in an enclosed space. The heart of the dehumidifier is a refrigerated surface onto which moisture from the air condenses. This surface is cooled by a refrigerating system which includes a compressor, an electric motor, an air circulating fan, and a drainage system for collecting and disposing of the condensate. The compressor uses 85 to 90% of the total energy consumed by this appliance and the fan uses the remainder. Hence, the compressor is the component that requires most attention in efforts to reduce energy consumption. In this respect, dehumidifiers are similar to heat pumps and refrigerators, freezers, and air conditioners, considered above.

Dehumidifier sales have held steady at around 440,000 units per year since 1975 and presently there are an estimated 4.8×10^6 units in use.(147) Dehumidifier shipments are not increasing rapidly, and the aggregate energy consumption of dehumidifiers is significantly less than the aggregate consumption of any other appliance considered in this report. However, design options (which are similar to those proposed for refrigerators and air conditioners) have been proposed for improving their efficiency.

TABLE C-23. TELEVISIONS

Design Option	Product Utility	Environmental Impact
Changeover to 100% solid-state circuitry	Improved performance	Not significant
Elimination of instant-on feature	With solid state sets, no appreciable loss in performance	Not significant

Source: 35, 37

Table C-24. Summary of Dehumidifier Shipments (5,6,147)

	Units (Millions)	Retail Value (Millions $)
1975	0.392	$37.2
1976	0.440	52.4
1977	0.314	46.8
1978	0.441	61.7
1979	0.684	95.7

DESIGN OPTIONS

1) Improve fan motor efficiency -- Propeller-type fan blades and shaded pole-motors are used in dehumidifiers. An improvement in efficiency could be achieved if permanent split-capacitor motors were employed. Evidently, permanent split-capacitor motors are not currently manufactured in the very small sizes (5-9 watts) required for dehumidifier fans.(134) Also, as stated above, the fan is responsible for only 10 percent of the total energy consumed in this consumer product.

2) Compressor efficiency improvement -- Some improvement in dehumidifier efficiency can be achieved by using smaller compressors, increasing coil surface area, and improving airflow characteristics.

3) Cycle efficiency improvement -- The major design option for increasing cycle efficiency is to increase condenser coil area. This provides a lower discharge pressure and a more favorable compression ratio for the compressor. Also, the compressor is able to operate at a somewhat higher volumetric efficiency.

4) Insulation of interchanger -- The interchanger is the heat-transfer connection between the capillary and the return line from the evaporator. Improved insulation of the interchanger would diminish energy loss.

SUMMARY

In the period 1972-78, the energy efficiency of dehumidifiers was significantly increased by the manufacturers, primarily through improvement of component selection. The level of potential energy savings that could be obtained by improvement of the efficiency of dehumidifiers has been estimated to be very small (166), small enough to make implementation of design options and enforcement of minimum energy efficiency standards of questionable value.

Table C-25 provides a summary of the energy-efficient design options proposed for dehumidifiers. The marginal potential total energy savings, and the fact that the efficiency of this product has gradually improved over the past few years makes the implementation of the design options questionable. In any case, there seems to be no impact on the environment or on product utility as a result of the influence of the standards program on the dehumidifier industry.

XIII. HUMIDIFIERS

Humidifiers are appliances designed to add moisture to the air. They fall into two general categories, "room humidifiers" which are designed to operate independently in an enclosed space and "central system humidifers" which are designed to add moisture to the airstream of a heating system. The room and central system humidifiers utilize common physical and mechanical principles of operation, employing a variety of devices to vaporize water and circulate moist air. It has been suggested that the use of humidifiers may have secondary effects on home heating requirements; however, these are small and unsubstantiated.

Humidifier shipments have steadily declined since 1976, dropping below a million units in 1978. (See Table C-26.) In the coming decade, they will probably not represent a substantial portion of the appliance industry market.

Table C-26. Summary of Humidifier Shipments (5,6,147)

Year	Units (Millions)
1975	1.031
1976	1.246
1977	1.200
1978	0.94
1979	0.850

Humidifiers are technologically straightforward in their operation, relying on heat and airflow to evaporate water. Some units contain humidistats to optimize the "on time" of the appliance. The amount of humidification and the efficiency of the humidifier are both rather independent of the technological features of the appliance itself. As a result, all humidifiers cost about the same to operate. In fact, the FTC has decided that it is not economically feasible to require that humidifiers be included in the labeling program. Furthermore, Science Applications Incorporated, in the background notice for proposed rule-making which included humidifiers stated that "minimum energy standards for humidifiers will not result in significant energy savings because the humidifiers being sold today are about as efficient as economically

TABLE C-25. DEHUMIDIFIERS

Design Option	Product Utility	Environmental Impact
Improve Fan Motor Efficiency	No change	Not significant
Compressor Efficiency Improvement	No change	Not significant
Cycle Efficiency Improvement	No change	Not significant
Insulate Interchanger	No change	Not significant

Source: 169

feasible. (Those units that can accommodate humidistats already have them.)" (166)

Given this situation, it seems unlikely the implementation of design improvements for humidifiers would result in any appreciable energy savings, and with reference to present-day "baseline" consumption of energy, the future manufacture, sale and use of humidifiers is unlikely to have any significant impact on the environment or on the consumer.

APPENDIX D

APPENDIX D: METHODOLOGY USED TO ASSESS THE IMPACT OF THE CPES ON AIR QUALITY

The data used to estimate the effects of the CPES on future levels of sulphur oxides, nitrogen oxides, particulates, carbon monoxide and hydrocarbons are displayed in Table D-1. The pollution factors for electricity generation were determined by dividing the quantity of electricity produced in the U.S. in 1976 by the amount of pollution attributed to electricity generation in 1976. (See Table D-2.) The pollution factors for natural gas and oil represent the pollution associated with combustion of these fuels in home appliances.

The assessment of the effects of the Program on these five pollutants probably overstates the extent of decreases in pollution that will occur as less energy is required to operate appliances. Increasing attention to control of air pollution in the energy sector should result in lower pollution factors in future years than those presented in Table D-1.

Table D-1. Emissions Data for Electricity Generation and the Combustion of Oil and Natural Gas in Home Appliances, 1976

Pollutant	Electricity Generation[(a)] (10^6 tons/kWh)	Natural Gas Combustion[(b)] (10^6 tons/therm)	Oil Combustion[(b)] (10^6 tons/gallon)
SO_x	10.47	0.03	16.08
NO_x	3.94	2.42	5.97
P	1.89	0.92	4.98
CO	0.16	0.97	2.48
HC	0.05	0.38	1.48

[(a)] Source: Table D-2

[(b)] Source: 107

Table D-2. Method of Analysis to Determine Emission Data for Electricity Generation

1. 1976 Gross Product for Electricity Generation[a]	1.852×10^{12} kWh

	SO_x	NO_x	P	CO	HC
2. 1976 Levels of Pollution for Electricity Generation[b] (10^6 tons)	19.4	7.3	3.5	0.3	0.1
3. Rate of Pollution[c] (10^6 ton/kWh)	10.47	3.94	1.89	0.16	0.05

[a] Source: 20

(b) Source: 177

[c] line (2) divided by line (1)

APPENDIX E

APPENDIX E: CHLOROFLUOROCARBONS: REGULATION AND ALTERNATIVES

I. Regulatory considerations

In March, 1978, after evaluating public comments, scientific studies and economic reports, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) issued rules prohibiting the manufacture and processing of CFCs for nonessential aerosol propellant uses. These rules comprised phase I of a two-part approach to the problem. Phase II, an investigation of non-aerosol and miscellaneous uses, is currently underway. The investigation is directed to the use and control of CFCs, including refrigerants for refrigeration and air conditioning units and foam blowing agents used in the manufacture of foam insulation. (Tables E-1 and E-2 summarize the major sources of CFC emission and the potential for emission reduction.) The EPA is considering a number of regulatory strategies to reduce CFC emissions, including direct regulation, economic incentives, and a conservation program relying on industry cooperation. (71,176)

The action taken as a result of the Phase - II investigation will be influenced by a report (presently in "working note form") prepared by the Rand Corporation for the EPA. This report, which deals with the use of CFCs and the feasibility of their regulation and control, will be published later this year. The National Academy of Sciences (NAS) has just released its own report in two parts: (1) Stratospheric Ozone by Halocarbons: Chemistry and Transport;(2) Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons. The document indicates that CFCs may be destroying the atmospheric ozone twice as fast as previously estimated, greatly heightening the concern about the problems the CFCs pose for the environment. This new evidence may focus more attention on the possible increase of CFCs in the atmosphere as a result of implementing the design options required to meet appliance energy efficiency standards.

Of course, questions have been raised about the validity of theoretical studies on CFC atmospheric chemistry from the standpoint of: the appropriateness of the models used as predictive tools; the extent to which the pertinent chemistry is understood; the question of CFC "sinks" that are not as yet defined; and the sufficiency of the experimental data. (21-23, 176, 177)

II. Alternatives

CFC-blown rigid polyurethane foam (RUF) is the most efficient insulating material now used in home appliances. This substance can be manufactured with a non-CFC blowing agent such as CO_2; however, the CO_2-blown foam is less than half as effective as an insulator. Similarly, non-urethane, non-CFC insulating materials, such as fiberglass, are also comparatively poor insulators. Clearly, as Table 3-5 in the text shows, the present options to RUF are not attractive; it appears that CFCs are the most practical substances for appliance insulation. Should extreme regulatory actions be enacted, several possible "trade off" strategies might be considered; CFC use in home appliances could be counterbalanced by more stringent control in one or more other areas. (See Table E-3.)

The primary refrigerant used in home refrigerators and freezers is CFC-12, approximately 10 oz. per unit. This refrigerant leaks into the atmosphere from the appliances at three operational phases: 1) in the manufacturing process during charging and testing; 2) in normal product use, due to leakage and servicing; and 3) during the disposal of the product at the end of its lifetime. The last phase is the stage of largest emission.

The design options for the improvement of the efficiency of refrigerators or freezers do not call for a change in the quantity of the refrigerant; therefore, as a first approximation, there should be no change in the "baseline" estimation of CFC emissions from this source. However, a second-order evaluation should consider the possible impact of imposition of strict controls by the EPA. These controls might require: 1) consideration of possible substitutes for CFC-12; 2) decreasing the use of CFC-12; and/or 3) controlling the release of CFC-12, the refrigerant, upon disposal of the appliance.

Practical methods for reducing CFC refrigerant emissions from home refrigerators and freezers have not yet been determined (Table E-4), however, CFC emission from domestic sources is only about 2% of total emissions. (71)

Table E-1. Major Domestic Nonaerosol Applications and Emissions of Fully Halogenated Chlorofluorocarbons[a]

Applications	Primary CFCs Used	Estimated Annual Domestic Emissions in Millions of Pounds[b] 1976-1977[c]	1990
Refrigerants	F-12	83	129
Mobile air conditioning Chillers[d]	F-11, F-12, F-114, F-500[e,f]	15	20
Retail-food-store refrigeration	F-12, F-502[g,h]	13	16
Household refrigerators and freezers[i]	F-12	6	8
Blowing Agents			
Flexible urethane foams: cushioning in furniture, bedding, automobile seats, carpet underlay	F-11	38	59-97
Rigid urethane foams: thermal insulation in buildings, refrigerators and freezers, and transportation; packaging; marine flotation	F-11, F-12	21	83
Reaction injection molding; high-density-foam molded parts for automobiles, furniture, building construction	F-11	<1	<1
Nonurethane foams: polystyrene for thermal insulation and packaging (egg cartons, meat trays, disposable food containers); polyolefins for electric cable insulation, packaging, gaskets and seals, marine products	F-12, F-114	24	71
Solvents			
Industrial cleaning, drying, and degreasing; solder flux removal; cleaning electronic assemblies; dry cleaning of garments	F-113	66	160-202
Other Uses			
Sterilization: hospital and institutional sterilization; industrial sterilization of disposal medical and surgical supplies	F-12	12-14	37-43
Liquid fast freezing: frozen fruit, vegetables, seafood	F-12	7	15-30
Fire extinghishing: total flooding systems for computer, electronic, and communications facilities	Halon 1301[j]	<1	1-2
Whipped topping stabilizers	F-115	<1	<1
Presurgical skin cleaning	F-113	<1	<1

[a]This does not include the hydrogen-containing CFCs, of which the most widely used is F-22.
[b]Based on preliminary estimates, provided by EPA, drawn from a study being conducted by the Rand Corporation except the estimates for reaction injection molding, whipped topping stabilizers, and presurgical skin cleaning, which are based on data gathered by the CARCE Panel on Industrial Technology.
[c]Refrigerant data for 1976; all other data for 1977.

[d]Chillers are central air-conditioning systems employing both primary (often CFC) and secondary (non-CFC) refrigerants, usually used in large buildings of three or more stories.
[e]F-500 is an azeotrope consisting of 73.8% F-12 and 26.2% F-152a. F-152a is not a fully halogenated CFC, and the F-152a portion is not included in these figures.

[f]F-22 is also used, primarily in the smallest chillers but also in some of the largest; it is not a fully halogenated CFC and is not included in these figures.

[g]F-502 is an azeotrope composed of 48.8% F-22 and 51.2% F-115. F-22 is not a fully halogenated CFC, and the F-22 portion is not included in these figures.

[h]F-22 is also used but is not included in these figures.

[i]Household (central and room) air conditioners, which use F-22, are not included.

[j]Halon 1301 is a bromofluorocarbon. It contains no chlorine.

Source: 71

Table E-2. Selected Major Sources of CFC Emissions and Potential for Emission Reduction (for Each Application the Primary CFCs Used are Indicated)

	Air Conditioning			Refrigeration		Plastic Foams			
	Commerical F-11, F-12, F-114, F-500	Residential F-22	Mobile F-12	Commercial F-12, F-502	Residential F-12	Flexible Urethane F-11	Rigid Urethane F-11, F-12	Reaction Injection Molding F-11	Non-urethane F-12, F-114
Current Level of Emissions									
United States	M	L	H	M	L	M	M	L	M
Rest of world	M	L	H	M	L	M	M	L	M
Expected Growth in Emissions									
United States	L	L	L	L	L	H	H	H	H
Rest of world	M	M	M	M	L	H	H	H	H
Source of Emissions									
Manufacture	L	L	L	L	L	H	L	L	b
Normal use	L	L	M	L	L	L	M	L	b
Service and repair	M	M	H	M	L	L	L	L	b
Disposal	L	L	M	L	M	L	H	H	b
Alternatives for Reduction									
Substitute material or technology									
Near term	M	c	M	M	M	Y	M	Y	b
Long term	Y	c	Y	Y	Y	Y	Y	Y	Y
Penalty for substitution									
Cost	H	c	H	H	H	O	H	O	b
Performance	L	c	L	L	L	L	H	L	b
Added hazard	U	c	U	U	U	O	O	O	b
Containment, recovery, recycle, or reclamation	Y	M	Y	Y	M	M	Y[d]	M	b
Overall Potential for Reduction									
Near Term	L	L	M	L	L	H	L	L	b
Long Term	M	L	H	M	M	H	H	L	b

L, Low; M, Medium, H, High; Y, Yes; N, No; O, Zero; U, Unknown; b, Four different foam products involved. The categorization differs for product areas.

TABLE E-3. Fifteen Control Options Selected for Examination

Option	Objective	Primary CFCs Affected	Industries Affected	Possible Modes of Implementation	Potential Exemptions or Special Treatment[a]
Bans					
(1) Ban all CFCs	Eliminate all U.S. contributions to global CFC emissions	All CFCs	All CFC-producing and-using industries	Ban on production, sale, or use within the United States of all CFCs	Small-quantity uses essential to health and safety, e.g., sterilizing medical and surgical supplies, fire extinguishing
(2) Ban all fully halogenated CFCs	Eliminate all U.S. contributions to global emissions of these CFCs that pose the greatest threat to the ozone layer	F-11, F-12, F-113, F-114	All CFC-producing and-using industries except household air conditioning	Ban on production, sale, or use within the United States of fully halogenated CFCs	Same as (1)
(3) Ban use of CFCs to insulating foam	Eliminate a major U.S. source of virtually unrecoverable CFC emissions	F-11, F-12	CFC producers, foam suppliers and fabricators, construction and building materials, refrigerators and freezers	Ban on production, sale, or use within the United States of rigid insulating foam blown with CFC	Insulating panels for thin-wall refrigerators
(4) Ban all CFC uses other than refrigerants	Eliminate all U.S. contributions to global CFC emissions except those perceived as most essential to material standard of living	F-11, F-12, F-113, F-114	All CFC-producing and using industries other than air conditioning and refrigeration	Ban on CFC sale or use within the United States for nonrefrigeration purposes	Same as (1)
(5) Ban all CFC uses other than refrigeration of food and essential medical supplies and stationary air conditioning	Eliminate all U.S. contributions to global CFC emissions except those most essential to health and industry	F-11, F-12, F-113, F-114	All CFC-producing and-using industries other than commercial and household refrigeration	Ban on CFC sale or use within the United States for purposes other than refrigeration of food and medical supplies and stationary air conditioning	Same as (1)
Taxes and Quotas					
(6) Tax on all fully halogenated CFCs	Reduce U.S. contribution to global emissions of those CFCs that pose the greatest threat to the ozone layers	F-11, F-12 F-113, F-114	All CFC-producing and -using industries except household air conditioning	Tax on production or sales of fully halogenated CFCs and of equipment of material made with or containing fully halogenated CFCs (taxes may be "tuned" by gradually increasing rates until the desired restriction in CFC use is achieved)	None
(7) Quotas for all fully halogenated CFCs	Same as (6)	Same as (6)	Same as (6)	Ceilings on production or sale of fully halogenated CFCs, or on purchases by individual firms, implemented by marketable permits (quotas may be set to freeze use at current levels or to reduce use to any desired level)	None
(8) Tax on CFC uses other than as refrigerants	Reduce U.S. contributions to global CFC emissions except those perceived as most essential to material standard of living	F-11, F-12, F-113, F-114	All CFC-producing and-using industries other than air conditioning and refrigeration	Tax on sales of CFCs for nonrefrigeration use or on production or sale of nonrefrigeration equipment of material made with or containing CFCs; taxes may be tuned as in (6)	None
(9) Quotas for CFC uses other than as refrigerants	Same as (8)	Same as (8)	Same as (8)	Ceilings on purchases of CFCs for nonrefrigeration use or on purchase of nonrefrigeration equipment or material made with or containing CFC; quotas may be set and may be implemented by permits as in (7)	None

Sources: 71

(10) Tax on CFC uses other than refrigeration of food and essential medical supplies and stationary air conditioning	Reduce U.S. contributions to global CFC emissions except those most essential to health and industry	F-11, F-12, F-113, F-114	All CFC-producing and-using industries other than commerical and household refrigeration	Tax on sales of CFCs or on production, sale, or purchase of equipment or material made with or containing CFCs for use other than refrigeration of food and medical supplies and stationary air conditioning; taxes may be tuned as in (6)	None
(11) Quotas for CFC uses other than refrigeration of food and essential medical supplies and stationary air conditioning	Same as (10)	Same as (10)	Same as(10)	Ceiling on purchases of CFCs or on production, sale, or purchase of equipment or material made with or containing CFCs, for use other than refrigeration of food and medical supplies and stationary air conditioning; quotas may be set and may be implemented by permits as in (7)	None
Control Technology and Recycling					
(12) Mandatory emission control technology in all manufacturing operations	Reduce U.S. contributions to global CFC emissions from manufacturing	All CFCs	All CFC-producing and-using industries	Identify as appropriate "best available control technology" (BACT) for each major CFC-emitting manufacturing process; these may include emission capture, containing, recycling, or destruction and may include "best management practice" (BMP) such as hermetically sealed equipment; require BACT, BMP, or SOP, or combinations, to be installed in all manufacturing facilities; induce use by tax incentives of subsidies. NOTE THAT THIS APPROACH WILL REQUIRE PERIODIC UPDATING (IF STANDARDS ARE NOT TO STIFLE DEVELOPMENT OF NEW TECHNOLOGY) AND INSPECTING	Very small manufacturing operations and those for which no economically or technologically feasible control technology exists
(13) Mandatory emission control technology in refrigeration and air conditioning	Reduce U.S. contributions to global CFC emissions from servicing of refrigeration equipment	F-11, F-12, F-22	Refrigeration and air-conditioning manufacturers and service and repair industries; refrigerant manufacturers	Identify and require BACT, BMP, or BOP, or combinations, as in (12); induce use by tax incentives or subsidies. NOTE THAT THIS APPROACH WILL TEND TO INDUCE USE OF FULLY SEALED REFRIGERATION EQUIPMENT	None
(14) Mandatory recycling of CFCs used in refrigeration and air conditioning	Reduce U.S. contribution to global CFC emissions from disposal of refrigeration equipment	F-11, F-12, F-22	Refrigeration and air-conditioning manufacturers and service and repair industries; refrigerant manufacturers; possibly dealers and other sales outlets	Require all used refrigeration equipment to be sent on disposal to authorized recycling center for reclamation of CFCs; require all spent refrigerant from rechargeable equipment to be sent to authorized recycling center. Responsibility for pickup, sorting, and maintenance of recycling centers could be divided among owners, dealers, and government bodies	Large central air-conditioning systems and built-in refrigeration systems that cannot readily be removed from the structure and transported may require special provisions for draining refrigerant to return to recycling center or to dealer
(15) Refundable deposit on CFCs in refrigeration and air-conditioning equipment	Reduce U.S. contribution to global CFC emissions from servicing and disposal of refrigeration equipment	F-11, F-12, F-22	Refrigeration and air-conditioning manufacturers and service and repair industries; refrigerant manufacturers; possibly dealers and other sales outlets	Require deposit on purchase of equipment or refrigerant. For nonrechargeable equipment, deposit is refunded on disposal of equipment at authorized recycling center. For rechargeable equipment, deposit is refunded on return of spent refrigerant to authorized recycling center.	Large central air-conditioning systems and built-in refrigeration systems that cannot readily be removed from the structure and transported may require special provisions for draining refrigerant to return to recycling center or to dealer

[a] Potential exemptions or special treatment is indicated for essential purposes in the case of bans, where CFC use for these purposes would otherwise be forbidden, but not in the case of options that reduce but do not forbid use; under such options the essential uses would be permitted but would be more costly.

Table E-4. Summary of Alternatives for Household Refrigerators and Freezers

Alternative	Time to Implement (Years)	Time to Full Effectiveness (Years)	Potential Reduction in Annual Ozone-Depleting CFC Emissions, Based on 1976 Data (in Millions of Pounds per (Year)[a]	Penalty for Reduction: Performance	Penalty for Reduction: Cost	Penalty for Reduction: Added Hazard
I. PROMISING ALTERNATIVES						
None						
II. POTENTIAL ALTERNATIVES REQUIRING FURTHER RESEARCH						
F-22	4-8	20-30	5[b]	Small	Large	Possible health hazard
F-134a	>10	>20	6	Small	Medium	Unknown
Stirling cycle	>20	>20	6	Unknown	Large	Unknown
III. ALTERNATIVES CONSIDERED BUT DEEMED TO BE UNSUITABLE FOR ONE OR MORE REASONS						
Other refrigerants[c]		The available materials have at least one of the following defects: toxicity, flammability, corrosivity, explosivity				
Recovery on retirement		Very expensive, owing to small quantities, widely dispersed				

[a]Based on preliminary emission data and reduction estimates, provided by EPA, drawn from a study being conducted by the Rand Corporation.

[b]Based on the assumption that F-22 is 25% as effective in depleting ozone, per pound, as F-12.

[c]Ammonia, sulfur dioxide, propane, methyl chloride, etc.

Source: 71

APPENDIX F

APPENDIX F: LIST OF AGENCIES AND INDIVIDUALS CONSULTED AND ORGANIZATIONS IDENTIFIED FOR DISTRIBUTION OF THIS DOCUMENT IN ACCORDANCE WITH 40 CFR PART 1506.6(b)(2)

Organization	Location	Individuals
Air Conditioning and Refrigeration Institute (ARI)	Washington, DC	Ben Sienkowitcz John Reardon Dave Hunt
Arthur D. Little, Inc. (ADL)	Cambridge, MA	David Lee Thomas Lawrence
American Gas Association Research	Los Angeles, CA	Vince Carnez
California Department of Health Services	Sacramento, CA	Dick Rush Jack Sheneman
California Energy Commission, Conservation Division (CECCD)	Sacramento, CA	Greg Newhouse Teri Gaston Scott Mathews John Leber Mike Martin Prabhunam Kalsa
Chase Econometrics	Washington, DC	Henry Beal Harold Rivkin
Citizens Energy Project	Washington, DC	Ken Busson
Electronics Industries Association	Washington, DC	Sally Browne J. Edward Day
Energy Applications	Columbia, MD	James Coggins
Environmental Defense Fund	Berkeley, CA	Zack Wiley
Environmental Protection Agency (EPA)	Washington, DC	Ferial Bishop Steven Weil
Gas Appliance Manufacturers Association, Inc. (GAMA)	Arlington, VA	Jack Langmead Jerry Iacuzzi
General Electric Company	Louisville, KY	Russell Sasnett
Lawrence Berkeley Laboratory (LBL)	Berkeley, CA	Mark Levine Bob Clear Jim McMahon

Organization	Location	Individuals
National Bureau of Standards (NBS)	Gaithersburg, MD	Andrew Fowell Charles Howard Jack Snell
Oakridge National Laboratory	Oakridge, TN	Dennis O'Neal
Pacific Gas & Electric Co.	Los Angeles, CA	Gregory Booth
Policy Planning and Evaluation, Inc. (PP&E)	McLean, VA	Bruce Edleston Tom O'Brien Bill Flynn Judson Parker
Proctor and Gamble Company	Cincinnati, OH	Robert Ahern
Rand Corporation	Santa Monica, CA	Adele Palmer Timothy Quin
Science Applications, Inc. (SAI)	McLean, VA	Elliot Ratner David Ross Robert Fink
Science Applications, Inc.	LaJolla, CA	Bob Ericson Mort Blatt
Southern California Gas Company	Los Angeles, CA	O. C. Davis
The Conservation Foundation	Washington, DC	Grant P. Thompson
Virginia Polytechnic Institute	Blacksburg, VA	Rebecca Lovingood

The document will also be made available to all state clearinghouses, per Circular A-95 of the Office of Management and Budget.

APPENDIX G

APPENDIX G: LIST OF PREPARERS

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