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Energy Conservation at the NBS Laboratories

John D. Hoffman, Chairman

Energy Conservation Task Force
National Bureau of Standards
Washington, D. C. 20234

July 1974

Interim Report
July 1973–May 1974

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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ENERGY CONSERVATION AT THE NBS LABORATORIES

Executive Summary

An Energy Task Force was established at NBS to effect maximum energy conservation without curtailing programs or services, to develop contingency plans to keep the Laboratories in operation in the event of severely reduced energy supply, to assist employees with transportation problems, and to educate the staff on the importance of energy conservation. The NBS Laboratories use a total of ~115 million kWh of electricity and ~780 billion BTU of heating fuel annually to power equipment and to provide a reliable environment. The Task Force conducted a comprehensive systems analysis of energy use in the light of present energy needs. Approximately 85 percent of the energy used at NBS is used in climate control including ventilation and the remainder is used for lighting and equipment. A mathematical model was developed for the climate control system that affords a comparison between observed and calculated energy use. As part of the analysis of energy use, conservation measures were identified and implemented. These measures include lighting reductions, building and zone shutdowns, thermostat adjustments, and changes in cooling coil control parameters. The conservation actions resulted in a reduction of ~12 percent ($260,000) in electricity and 18 percent ($130,000) for fiscal year 1974 compared to fiscal year 1973 in heating fuel without causing loss of function, significant hazard, or noticeable impairment of either efficiency or morale of employees.

The Task Force carried out transportation surveys to ascertain the needs of employees and participated with local organizations and agencies in planning for mass transit. A carpool locator system based on a grid-map was developed and used to assist employees with formation of carpools. Car counts made at several times during the campaign revealed a significant shift toward carpooling.

The energy conservation campaign included educational activities both within and external to NBS. The NBS Director, Dr. Richard W. Roberts, addressed the Gaithersburg staff. Dr. John D. Hoffman, Director of the Institute for Materials Research and Chairman of the Task Force addressed the Boulder staff and reviewed NBS conservation progress and plans with representatives of the Federal Energy Administration and the Department of Commerce. Energy conservation literature was distributed to employees as well as to local industrial organizations. Conservation suggestions from employees were solicited and evaluated by Task Force members.

The Task Force formulated contingency plans to reduce energy use on short notice in preparation to respond to area-wide energy problems. These plans provide a set of priorities to produce a reduction of 2-5 megawatts in electrical demand. Heating fuel contingency plans effectively double oil storage capacity at the Gaithersburg Laboratories.

The Task Force study includes recommendations that address all phases of energy use at NBS. Adoption and implementation of these recommendations should increase electricity conservation to ~15 percent and heating fuel conservation to ~21 percent in FY 75.

NBS ENERGY TASK FORCE

SUMMARY OF FINDINGS AND RECOMMENDATIONS

NBS ENERGY TASK FORCE

SUMMARY OF FINDINGS

Electrical energy consumption by the National Bureau of Standards in FY 1973 was 103.34 million kWh at the Gaithersburg Laboratories and 11.28 million kWh at the Boulder Laboratories.

The composite distribution of electrical consumption at the two facilities by end use is as follows: equipment, 20 percent; humidity control, 35 percent; air ciculation, 25 percent; and lighting, 20 percent.

The maximum electrical power consumption at the Gaithersburg Laboratories occurs in summertime and coincides with the maximum demand on the power suppliers in the mid-Atlantic region.

In some NBS laboratories, experimental equipment would suffer damage and data would be lost or prolonged down-time would result from brown-out or premature termination of work.

The NBS Gaithersburg Laboratories could reduce operating electrical power by as much as 40-50 percent for a few hours on a contingency basis without terminating long-duration experiments, key experiments, or shutting down critical facilities. Much short-duration work would be lost; inadequate ventilation would necessitate evacuation of some areas.

Electricity conservation in FY 74 at the Gaithersburg Laboratories will exceed 11 percent relative to FY 73 (base year) and should increase to about 13-16 percent during FY 75.

Electricity conservation in FY 74 at the Boulder Laboratories will exceed 12 percent relative to FY 73 (base year) and should increase to more than 15 percent in FY 75.

The cost of electricity at the Gaithersburg Laboratories for FY 74 will be approximately $1.83 million compared with $1.58 million in FY 73. At the FY 73 consumption level, the cost of electricity in FY 74 would have been $2.07 million. Savings attributable to the conservation campaign are therefore $236,000.

The cost of electricity at the Boulder Laboratories for FY 74 will be approximately $139,000 compared with $145,764 in FY 73. At the FY 73 consumption level, the cost of electricity in FY 74 would have been $158,000. Savings attributable to the conservation campaign are therefore $19,000.

Heating fuel consumption by the National Bureau of Standards in FY 73 was 666.17 billion BTU at the Gaithersburg Laboratories and 111.08 billion BTU at the Boulder Laboratories.

The natural gas supply to the NBS Gaithersburg Laboratories is interruptible. Upon interruption, the boilers are converted for burning No. 2 distillate fuel oil. Oil storage capacity at NBS is 150,000 gallons which, prior to FY 74, was a 7-10 day supply.

In the event of a natural gas interruption and insufficient resupply of oil, the Gaithersburg Laboratories could now operate for 12-18 calendar days on a contingency basis. The operating time would depend upon both the oil supply at the time of interruption and the weather during the interruption.

The oil storage capacity at NBS is inadequate because disruptive contingency measures would need to be put in force quickly if oil resupply did not follow within about two days of a natural gas interruption.

The climate control system - heating, air circulation, cooling, and reheating - consumes 85 percent of the energy used at the Gaithersburg Laboratories.

Heating fuel conservation in FY 74 at the Gaithersburg Laboratories will be approximately 18 percent relative to FY 73 (base year) and should increase to about 20-23 percent in FY 75.

Heating fuel conservation in FY 74 at the Boulder Laboratories will be approximately 22 percent relative to FY 73 (base year) and should be maintained near that level in FY 75.

The cost of heating fuel for FY 74 at the Gaithersburg Laboratories will be approximately $538,000 compared with $554,800 in FY 73. At the FY 73 consumption level, the cost of heating fuel in FY 74 would have been $652,000. Savings attributable to the conservation campaign are therefore $114,000.

The cost of heating fuel for FY 74 at the Boulder Laboratories will be approximately $50,500 compared with $55,366 in FY 73. At the FY 73 consumption level, the cost of heating fuel in FY 74 would have been $61,000. Savings attributable to the conservation campaign are therefore $10,500.

The climate control system can be represented by a mathematical model that can be used to evaluate conservation options and to assess the impact of changes in climate control parameters on laboratory environment.

The climate control system for office modules has two settings: summer and winter. Under typical early spring and late fall weather conditions the climate control system may be operated on either the summer or the winter setting. The winter setting consumes less energy but cannot be used when outdoor temperature exceeds 65° F.

Reducing air circulation rates would substantially diminish the use of natural gas and electricity. Circulation rates in individual zones cannot be reduced independently; building air balance must be maintained.

Some fume hoods could be placed on standby provided that alternative exhaust systems are available and overall building air balance is maintained.

Heating fuel use versus outdoor temperature for 1971-1972 may be represented by a straight line relationship. With conservation measures in effect, heating fuel use versus outdoor temperature may be represented by a curve with maximum deviation from the former straight line occurring at temperatures that are typical of spring and fall.

The potential is high for increased energy conservation at NBS. Significant costs of labor and automation will need to be weighed against energy savings to establish the optimum operating conditions consistent with laboratory needs.

NBS Gaithersburg employees drive an average of 34 miles per day in commuting compared with 9 miles for Boulder employees.

In November 1973, an average of 1.29 passengers per car entered the NBS Gaithersburg grounds compared with 1.42 passengers per car in March 1974.

Two-thirds of the NBS Gaithersburg staff expressed an interest in improved bus service and one-quarter in improved train service.

One half of the NBS Gaithersburg staff commute in carpools.

Inadequate shuttle service to Washington increases the use of private vehicles in official travel.

SUMMARY OF RECOMMENDATIONS

The Task Force recommends that:

- Practices initiated during the first year of the conservation campaign be continued. This includes reductions in lighting levels and shutdowns in buildings 101, 202, 236, 301, 304, and 231.
- Wherever feasible, air circulation rates be reduced by 5-15 percent through adjustment of vortex dampers.
- Experiments be carried out in one general purpose building to determine the feasibility of shutting down air systems in perimeter zones at night during the summer. To maintain air balance, hood shutdowns should accompany the perimeter zone shutdowns.
- Office temperatures be set to 73° F for the summer of 1974. Cooling coils for most office zones should be set at 57-58° F and may be set to 60° F for weekends.
- Experiments be carried out to determine the feasibility of placing some fume hoods on standby. Experiments should begin in laboratories that have alternative exhaust systems.
- A meter to measure instantaneous site operating electrical power be made readily accessible to the Chief of the Plant Division.
- Whenever feasible, lighting levels be further reduced by removing four fluorescent tubes from overhead fixtures in interior modules.
- Energy record keeping be established to provide NBS management with up-to-date summaries of energy supply and use. The record keeping should include daily summaries for operating personnel, weekly summaries for Plant Management and monthly summaries for the Associate Director for Administration and for the Policy Committee of the NBS Energy Task Force.
- Operators of major experimental facilities be encouraged to schedule down-time and routine maintenance to occur during the summer.

- Cooling coil temperatures in perimeter zones be varied to take maximum advantage of the cooling capacity of outdoor air. Temperature and humidity criteria supplied by the Task Force should be used to select settings.

- The winter setting of the climate control system be used in spring and fall whenever feasible. Temperature and humidity criteria supplied by the Task Force should be used to select setting.

- The detailed contingency plan provided by the Task Force be used in the event that the electric power supplier requests that NBS reduce demand. As contingency action might entail reduction in ventilation rate in some buildings which have no alternative means of ventilation, early dismissal for some employees might be necessary. It is recommended that dismissal should be at the discretion of supervisors in affected areas with concurrence from the Associate Director for Administration.

- NBS increase on-site storage capacity.

- The Long Range Conservation Committee undertake the following studies:
  1 - reduction of ventilation rate
  2 - optimal year-round inside temperature
  3 - shutdown of additional HVAC units
  4 - optimize chiller operation
  5 - reduction of exhausts (hoods, etc.)
  6 - optimal HVAC control (computer operation)
  7 - evaluate exhaust heat recovery units
  8 - evaluate window load.

- The Policy Committee of the NBS Energy Task Force continue to serve as the focal point for energy conservation activities at NBS and to advise the Director on matters related to energy supply and use at the NBS Laboratories.

- NBS actively encourage employee carpooling and maintain an updated locator system based on x, y grid coordinates. Maintenance of the locator system should be made the responsibility of the Management and Organization Division.

- While encouraging carpooling, no actions be taken such as altering parking zones or roadways that would limit access to NBS parking areas by visitors, participants in conferences or those attending other mission-related activities.

- NBS continue to cooperate with agencies and organizations in the Gaithersburg area to acquire additional bus routes and improved service.
- NBS actively support the State of Maryland with efforts to initiate additional commuter service by the B&O Railroad.
- NBS seek to attain authority to establish shuttle service to and from the railroad station should commuter train service become available.
- NBS continue to support local efforts to modify existing roadways and traffic light timing to facilitate motor vehicle traffic flow and safe passage of bicycles.

PREFACE

In November 1973, the Director of the National Bureau of Standards, Dr. Richard W. Roberts, established an Energy Task Force. He appointed Dr. John D. Hoffman, Director of the Institute for Materials Research, to head the Bureau-wide Task Force. Dr. Roberts spelled out the basic responsibilities of the Task Force as follows:

- to effect maximum energy conservation without curtailing NBS programs or essential services.
- to develop contingency plans to keep NBS Laboratories in operation in the event of severely reduced energy supply.
- to assist employees with short term transportation needs and to contribute to long term solutions to transportation problems in the area.
- to educate the staff on the importance of energy conservation.

The contingency plan provision was included as part of the energy conservation campaign because the NBS Gaithersburg facility is served by an interruptible natural gas supply backed by only a 7-10 day supply of fuel oil. Moreover, the electrical requirements of the climate control system upon which most laboratory operations critically depend are greatest in summer when electrical power supply to the Washington area is most vulnerable to overload.

The Energy Task Force functioned in Task Groups each with a focus on a specific area: electricity, heating, transportation, staff liaison, and communications. Because conservation necessitates changes in working environment and the campaign would be conducted during a period of great national concern with energy that could lead to changes in codes and regulations, specialists on safety, health, legal, and legislative issues served as members of the Policy Committee of the Task Force. The energy conservation strategy for NBS evolved into a three stage plan:

- to implement quickly conservation measures deemed to be safe and effective and which would have minimum impact on laboratory operations.
- to establish a data and information base to be used in contingency planning and to identify measures for additional conservation. This work involved conducting surveys on temperature and humidity control, critical experiments, major facilities, long-range experiments, and carrying out operations research analysis on past and present system performance.

- to make recommendations for future operating conditions such as temperature and humidity settings, illumination levels, air circulation rates, work schedules, and laboratory equipment modification that would result in reduced energy use.

The Task Groups which carried out this work were staffed by members of technical divisions and the Plant Division. This report represents a summary of the findings, conclusions, and recommendations made in separate reports by the Task Groups and by the Executive Secretary.

NBS ENERGY TASK FORCE

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The Task Force wishes to thank the following Gaithersburg Plant Division personnel for providing valuable services toward achieving the goals of the conservation campaign:

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Mr. C. Swanson
Mr. G. Toms
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Mr. D. Chelton	NBS
Mr. A. Hauler	NBS
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Mr. D. G. McDonald	NBS

The Boulder Task Force wish to thank Mr. George Hahn of NBS for valuable assistance in contingency planning and Mr. C. Smith of NBS for providing liaison and coordinating information for Dr. Hoffman's January 1974 address to the Boulder staff on Energy Conservation.

[a] National Oceanic and Atmospheric Administration
[b] Office of Telecommunication

INTRODUCTION

The National Bureau of Standards serves the United States as the authoritative source of accurate, compatible, and useful physical measurements, standards, and information. Since its creation in 1901, NBS has provided the precision measurement foundation for the Nation's science, technology, and commerce.

The basic enabling legislation of 1901, as amended, establishes the main purposes and functions of NBS as follows:

- the custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards including the comparison of standards;
- the determination of physical constants and properties of materials....of great importance to scientific or manufacturing interests....not to be obtained of sufficient accuracy elsewhere;
- the development of methods for testing materials, mechanisms, and structures and the testing of materials, supplies, and equipment....;
- cooperation with other governmental agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications;
- advisory service to Government agencies on scientific and technical problems;
- invention and development of devices to serve special needs of the Government.

NBS is primarily a measurement and test development laboratory with programs that span a wide range of activities devoted to materials standards, engineering standards, and basic standards. The diversity of NBS is reflected in its present program which includes work in fire research, air and water pollution, computer privacy, toy safety, and research to improve physical measurements. Meeting the changing measurement needs of diverse programs requires a flexible physical plant. The relatively new NBS Gaithersburg Laboratory complex (fig. 1) is, in fact, a flexible facility comprising 21 buildings with more than 2.2 million square feet of floor space including 574,000 square feet of laboratory space and 329,000 square feet of office space. The NBS buildings are distributed over 576 acres to provide a measure of separation for measuring apparatus from sources of noise, vibration, radiation and incompatible activities.

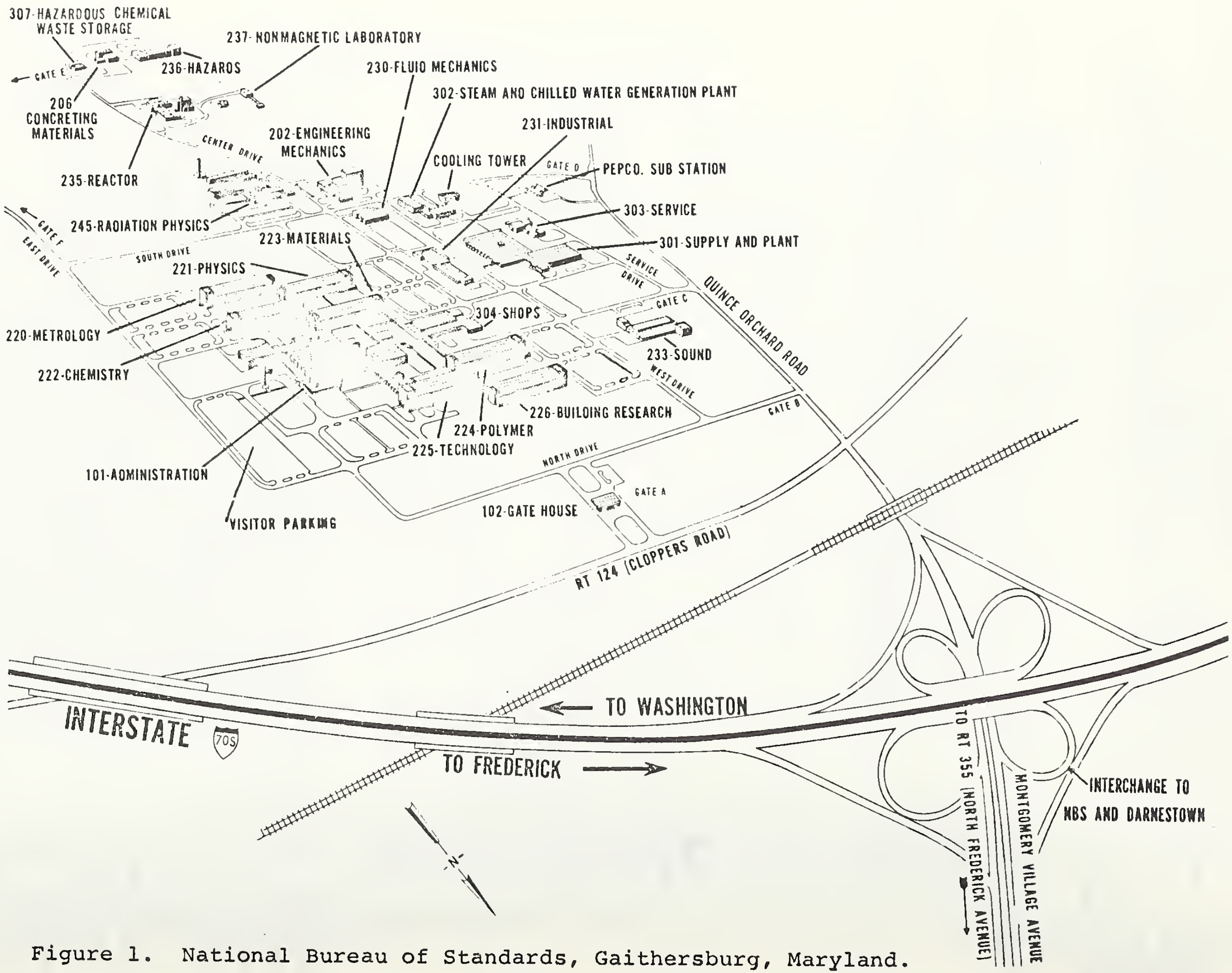

Figure 1. National Bureau of Standards, Gaithersburg, Maryland.

The approximately 2,000 individual laboratories house highly precise and often delicate scientific apparatus, fume exhaust systems, and clean chambers. Specialized laboratory buildings house major facilities such as a nuclear reactor, wind tunnels, linear accelerator, and a 12 million pound mechanical testing apparatus. In addition to specialized equipment, standards and measurement work requires a stable working environment. Providing a stable environment in a geographical area often beset by high temperature and high humidity requires a climate control system capable of maintaining environmental conditions within specified limits. The heating and cooling requirements of the climate control system are provided by steam and chilled water generating plants. Also important to the work at NBS are the supporting service facilities such as instrument and machine shops, glass-blowing shops, special storage areas, and provisions for security and safety.

The NBS laboratories use three sources of energy: electricity, natural gas, and oil. Electricity is used for equipment, lighting, and environmental control. Natural gas and oil are used for heating in winter and for climate control throughout the year. A relatively small amount of natural gas is used in laboratory equipment such as burners and torches. The natural gas supply to NBS is interruptible; this means that during high demand periods, NBS (as well as several other major users) may be cut off on two hours notice. Interruptions for several days at a time during very cold weather are not uncommon. When the natural gas supply to NBS is temporarily discontinued, the boilers in the steam plant are converted for burning No. 2 distillate fuel oil. The oil storage capacity is ~150,000 gallons which represents only a 7-10 day supply. The supply of electricity to NBS, while apparently secure, is subject to brown-out (low voltage) due to excess demand along the network which serves the Washington area. Occasionally, large users of electricity are requested to reduce power to help alleviate the demand problem within the network. During an energy shortage, such requests could become more frequent and necessitate greater power reductions.

The major uses of energy at NBS are for laboratory equipment and environmental control systems. The air circulating system in a laboratory building is divided into zones of 20 to 30 modules (rooms) each; entire buildings are air balanced to make certain that air from laboratories flows directly to laboratory exhaust systems and not into corridors or offices. Much laboratory equipment operates continuously and, for this reason, environmental systems in these buildings also operate continuously.

Relatively minor amounts of energy are used for lighting and for non-laboratory equipment and machinery. These uses of energy are mostly confined to working hours. Of the energy used at NBS, only that used for office and laboratory lighting and for equipment is in direct control of the scientific and administrative staff. The interactive nature of zones within the climate control system precludes independent and arbitrary settings of thermostats and air flow. Therefore, general recommendations to employees regarding energy use, though desirable, would yield only small (2-3 percent) energy savings.

The objective set by the NBS Director to exceed the Government-wide conservation goal of 7 percent, coupled with the above constraints on system operations, was the challenge put to the Task Force. To meet this challenge the Task Force undertook a systems analysis of NBS operations to evaluate energy use in the light of current needs. Task Groups worked to establish accurate energy data and information bases. Surveys were conducted to serve as a basis for both energy conservation and contingency planning. Each Task Group prepared a report of its findings and recommendations for energy conservation. This report is a summary of the Task Group reports. It includes an outline of contingency plans, major recommendations, conservation progress to date, and a prognosis for energy conservation in FY 1975.

THE CLIMATE CONTROL SYSTEM

NBS Gaithersburg

The climate control system - cooling, heating, and air circulation - consumes about 85 percent of the energy used at NBS. Through the settings of the components of the climate control system, the atmosphere within most general purpose laboratories is maintained at 75° F and 45-50 percent relative humidity (RH). Temperature, humidity control, and proper ventilation are maintained by constant flow of fresh and recycled air. Throughout much of the year, the absolute humidity of the outside air exceeds the level that is permissible inside the laboratory. To reduce the moisture content, the fresh air-recycled air mixture is chilled to saturation (100 percent RH) at 55° F and then heated to 75° F.

Air circulation systems that supply air to office modules have two settings: summer and winter. On the summer setting, a mixture consisting of 25 percent fresh air and 75 percent recycled air is chilled to saturation at 55° F and reheated to 75° F. On the winter setting, the proportion of fresh air varies from a minimum of 25 percent at very low outdoor temperatures to 100 percent at outdoor temperatures of 65° F or above. The mixture of fresh and recycled air is heated in attics to 65° F and blown down ducts to individual offices where the air is heated by hot water units located beneath windows to the room temperature set point. Schematic representations of control systems for perimeter modules and interior modules are given in figure 2 and 3, respectively.

During the winter, heating fuel use depends upon the difference between inside and outside temperature. Consequently, lowering thermostat settings in offices from 75° F to 68° F reduces heating fuel use. The lowering of laboratory temperatures to 68° F would also conserve heating fuel but would result in an unacceptable increase in relative humidity. Energy conservation options for winter are therefore limited to adjustments in office temperature, relatively small adjustments in laboratory temperatures, zone shutdowns, and reductions in rates of air circulation.

During spring and fall, energy conservation strategies are inherently more complex because outdoor temperatures cross the 65° F point frequently. The minimization of energy use under such weather conditions depends upon several important variables: thermostat set points, cooling coil set points, outdoor dew point, outdoor temperature, and control (summer or winter) setting.

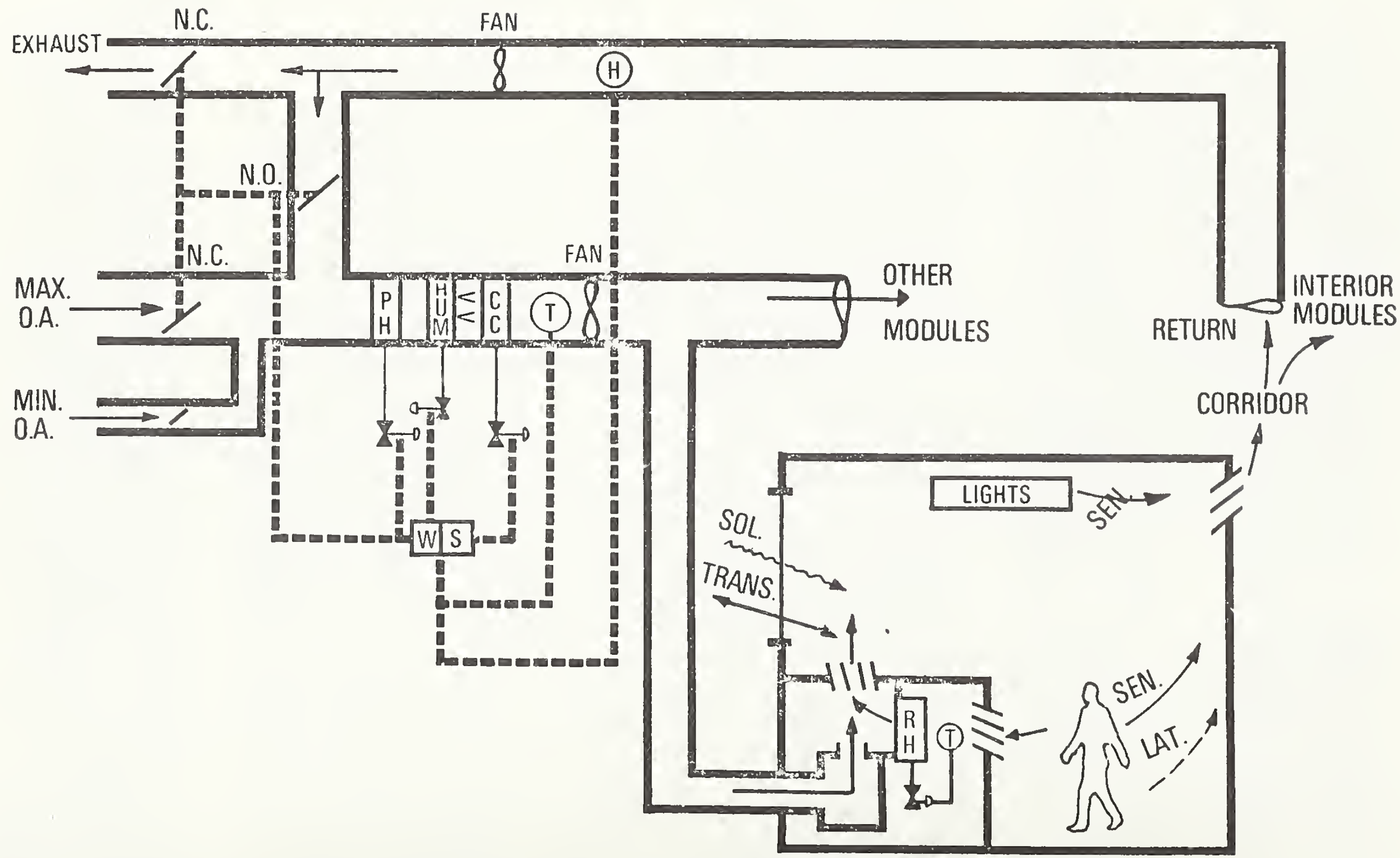

Figure 2. Schematic shows climate control system in a typical perimeter module in the general purpose buildings. (NBS, Gaithersburg)

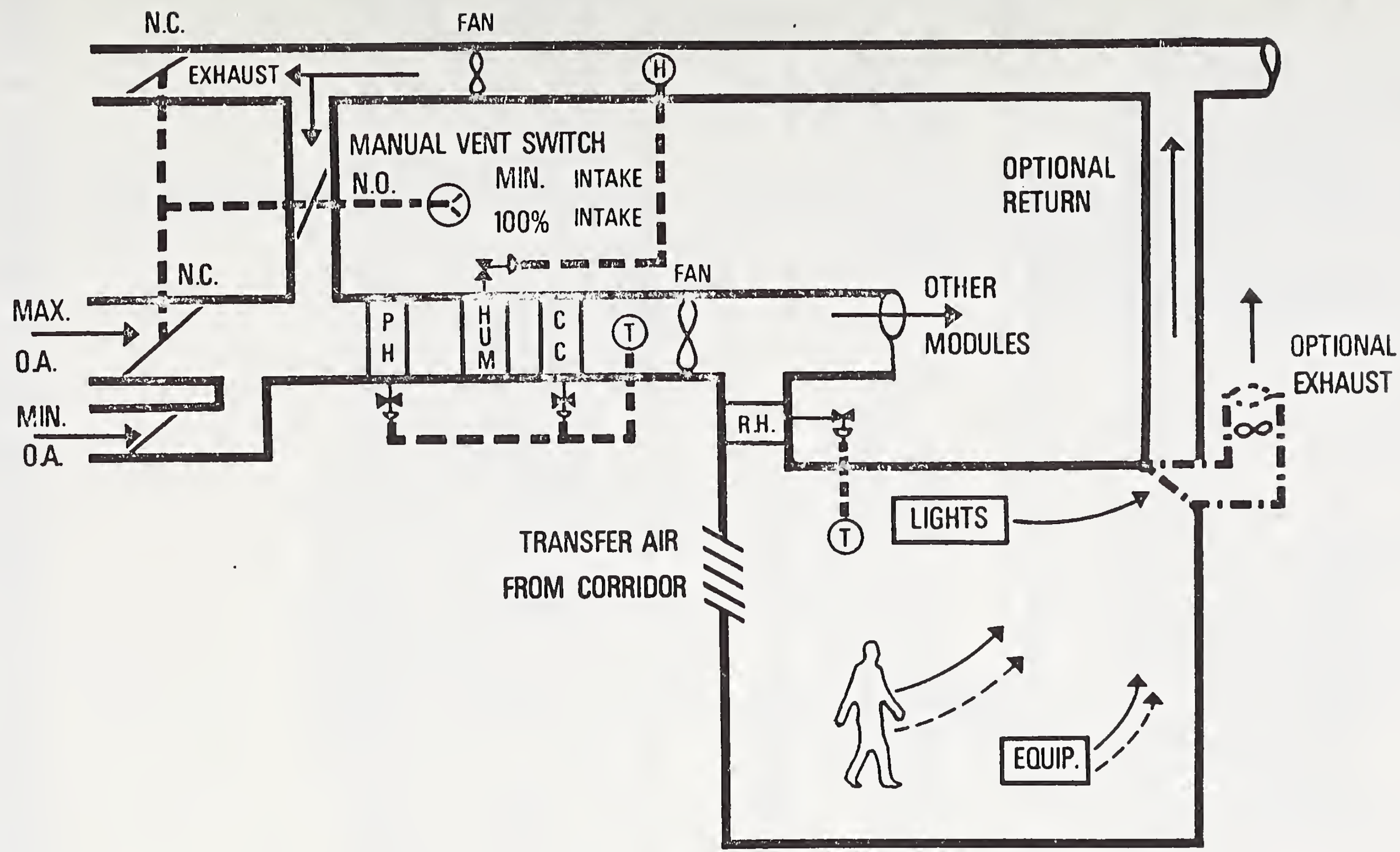

Figure 3. Schematic shows climate control system in a typical laboratory module in general purpose building. (NBS, Gaithersburg)

During the summer, outdoor temperature exceeds 65° F most of the time and the climate control system is always kept on the summer setting. Both temperature and humidity control are important and both heating fuel and electricity are used in this control. Electrical energy (up to 12 megawatts) is used to produce chilled water that is used to cool fresh and recycled air; heating fuel (up to 1.5 billion BTU/day) is used in summer to reheat chilled air. From the standpoint of energy use, the most important factor in the large cooling load is the humidity of the atmospheric air. The heat released when moisture condenses is taken up by chilled water. The flow of chilled water must be sufficiently rapid to maintain the temperature set point of the cooling coil.

Energy use during summer may be visualized with the aid of figure 4. The three levels that determine how much energy is used are as follows:

(1) <u>The cooling coil set point</u>. This point fixes the absolute humidity of the interior air. Cooling coil set points are controlled in attics zone-by-zone. Each zone consists of 20-30 laboratories.

(2) <u>The laboratory set point</u>. The laboratory temperature set point, together with the cooling coil set point for that zone, determines the relative humidity.

(3) <u>The wet bulb* temperature of the atmospheric air</u>.

The fresh air cooling load is proportional to the separation between levels 1 and 3; the recycled air cooling load and reheat load depend upon the separation between levels 1 and 2. The diagram shows that reduction in energy use could be brought about by raising levels 1 and 2, narrowing the gap between levels 1 and 2, or by both actions. As both of these levels are involved in temperature and humidity control, changes in them can neither be made arbitrarily nor can they be made at all in some zones.

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*Wet bulb temperature is defined as that temperature at which water, by evaporating into air, can bring the air to saturation adiabatically at that same temperature.

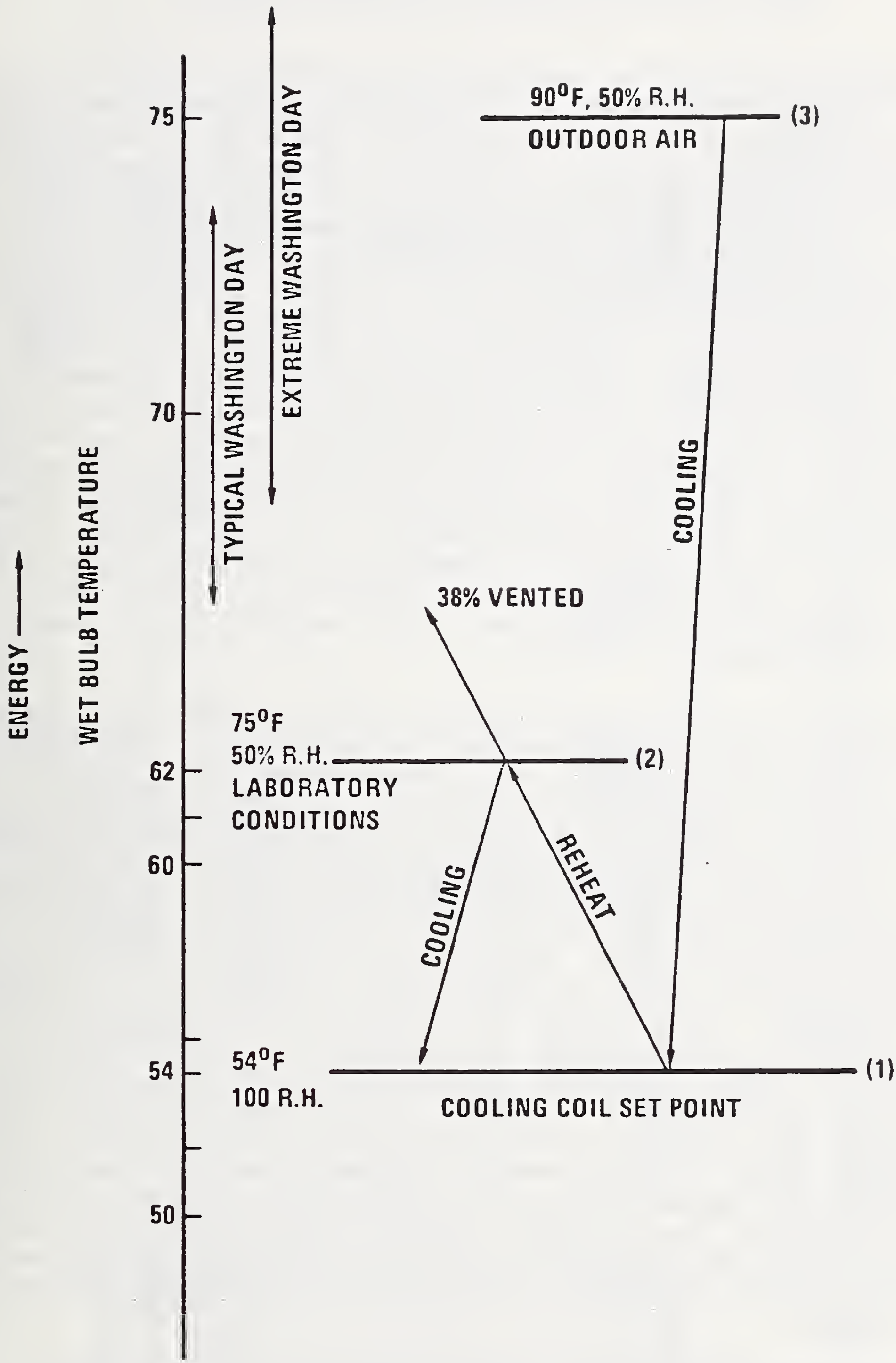

Figure 4. Schematic representation of energy use in humidity control in laboratories. (NBS, Gaithersburg)

MODEL OF THE CLIMATE CONTROL SYSTEM

In order to evaluate conservation plans in terms of the impact of changed environment on operations as well as energy savings, a model has been developed to serve as a basis for energy calculations (fig. 5). The only input parameters in this "box" model are air circulation rates and temperature settings. Electrical and heating requirements and time variation of electrical demand are derived as a function of weather conditions and building heat loads. The cooling load computed from the model is shown in figure 6. The load is divided into two parts - a recycled air cooling load and a fresh air cooling load. Several conclusions may be drawn from the calculated cooling loads. When the outdoor wet bulb temperature is 55° F, as is often the case in May, the cooling load should be ~3000 tons. When the wet bulb temperature in the Washington area reaches ~80° F, as it does several times each summer, the cooling load should be ~10,000 tons. Cooling loads of 4-7000 tons should be observed on typical summer days when wet bulb temperature ranges from about 65° F to 73° F. All these features are consistent with cooling loads observed from May to October.

According to the "box" model of NBS, the heating requirement should be constant throughout the summer at $\sim 10^6$ BTU/min. The observed loads, however, are found to be less than 10^6 BTU/min, they vary throughout the day, and differ from weekday to weekend day as shown in figure 7. These variations appear because heat is provided by sources other than the heating system - equipment, lights, personnel, sunlight, and conduction. Calculations were carried out using estimates of typical loads that are known to occur at various times during the weekly cycle. The results (fig. 8) show that the sum of all loads was $\sim 10^6$ BTU/min. Therefore, the reheat system operates by "subsidizing" the other loads to maintain a total load of $\sim 10^6$ BTU/min. This "subsidy" explains why the cooling load depends only upon weather and not on the internal building load whereas the heating load depends upon both weather and the building load. The agreement between observed and calculated energy use shows that the "box" model closely simulates the functioning of the climate control system and that factors not incorporated in the model such as air infiltration are not sufficiently large to negate conclusions that might be derived from the model.

Several possible conservation measures that involve changes in operation or response of the climate control system were evaluated using the model. Actions considered include changes in temperature settings, humidity levels, air-flow rates, and insulation. The principal observation based on the study of the climate control system are as follows:

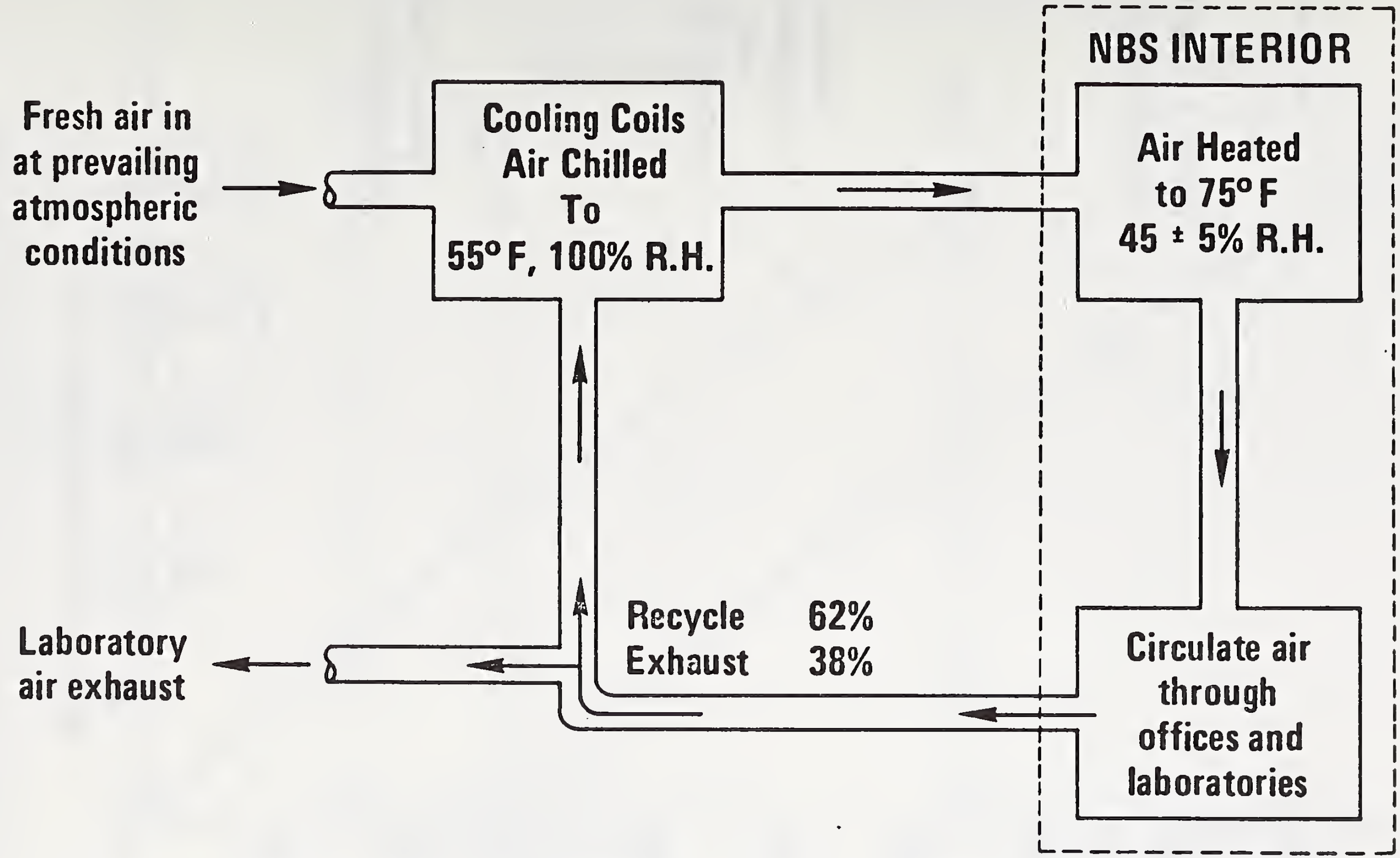

Figure 5. Schematic model of climate control system: Summer operation. (NBS, Gaithersburg)

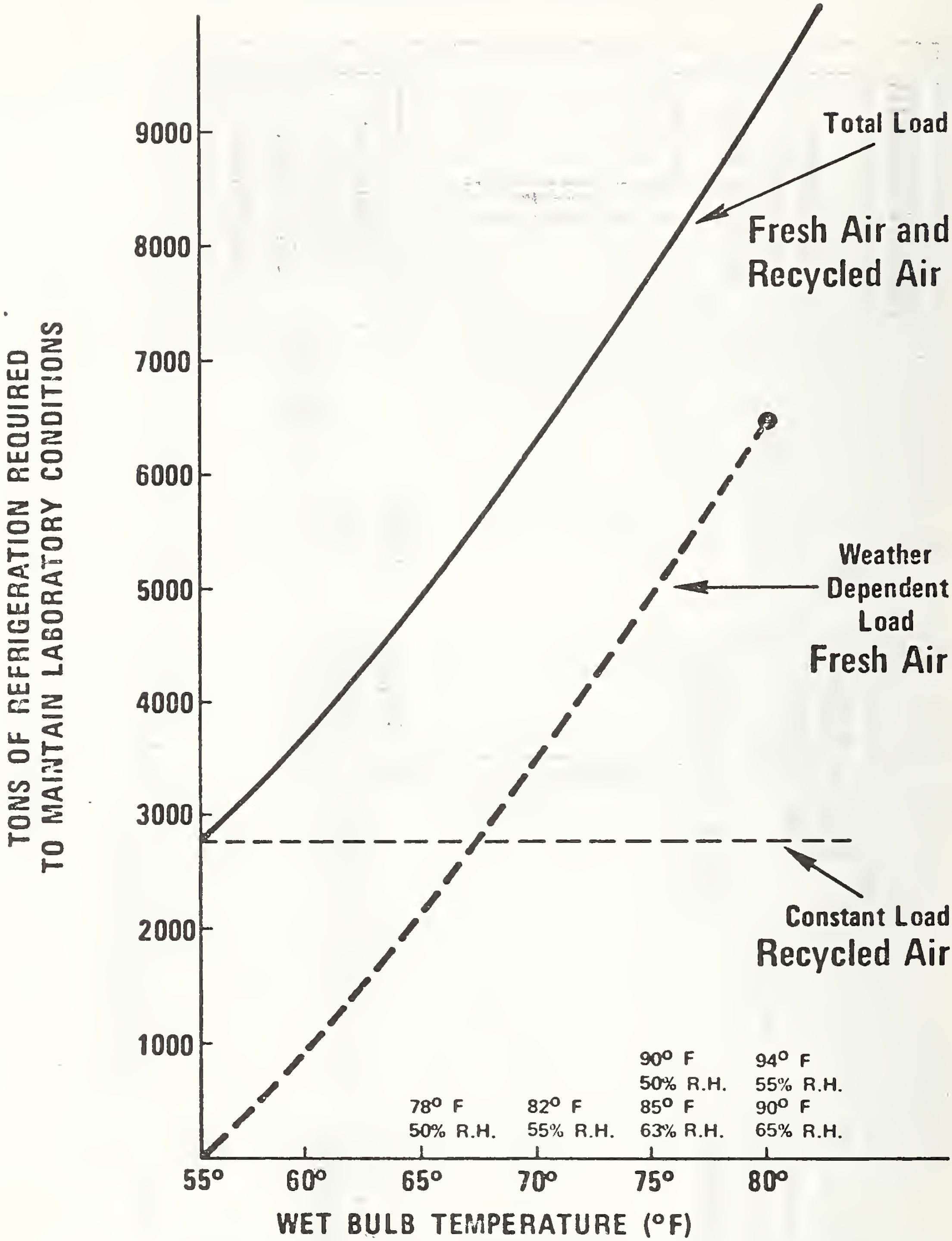

Figure 6. Cooling load (tons of refrigeration) vs wet bulb temperature. (NBS, Gaithersburg)

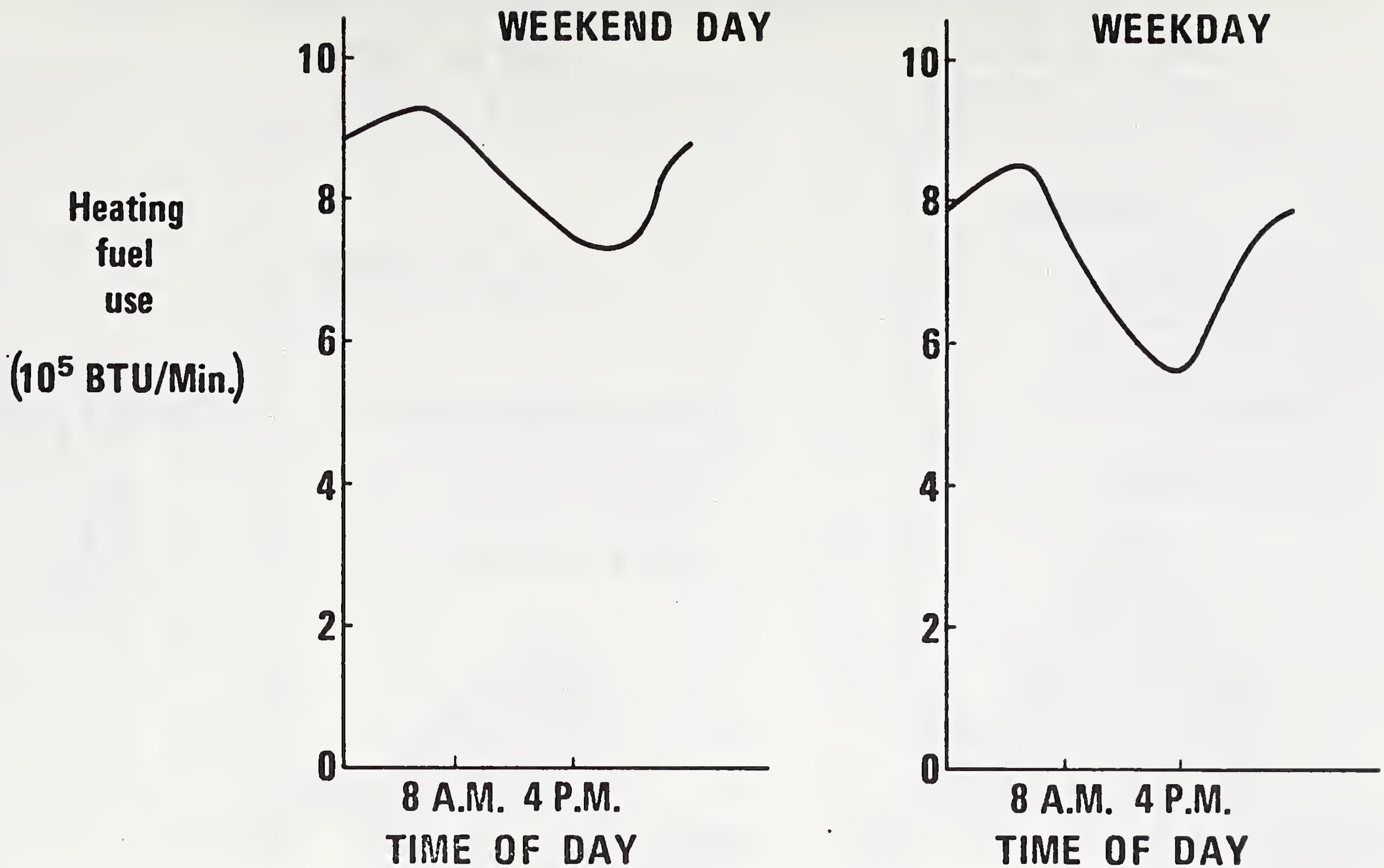

Figure 7. Summer heating fuel use profiles in terminal reheat climate control system: Weekend Jay vs weekday. (NBS, Gaithersburg)

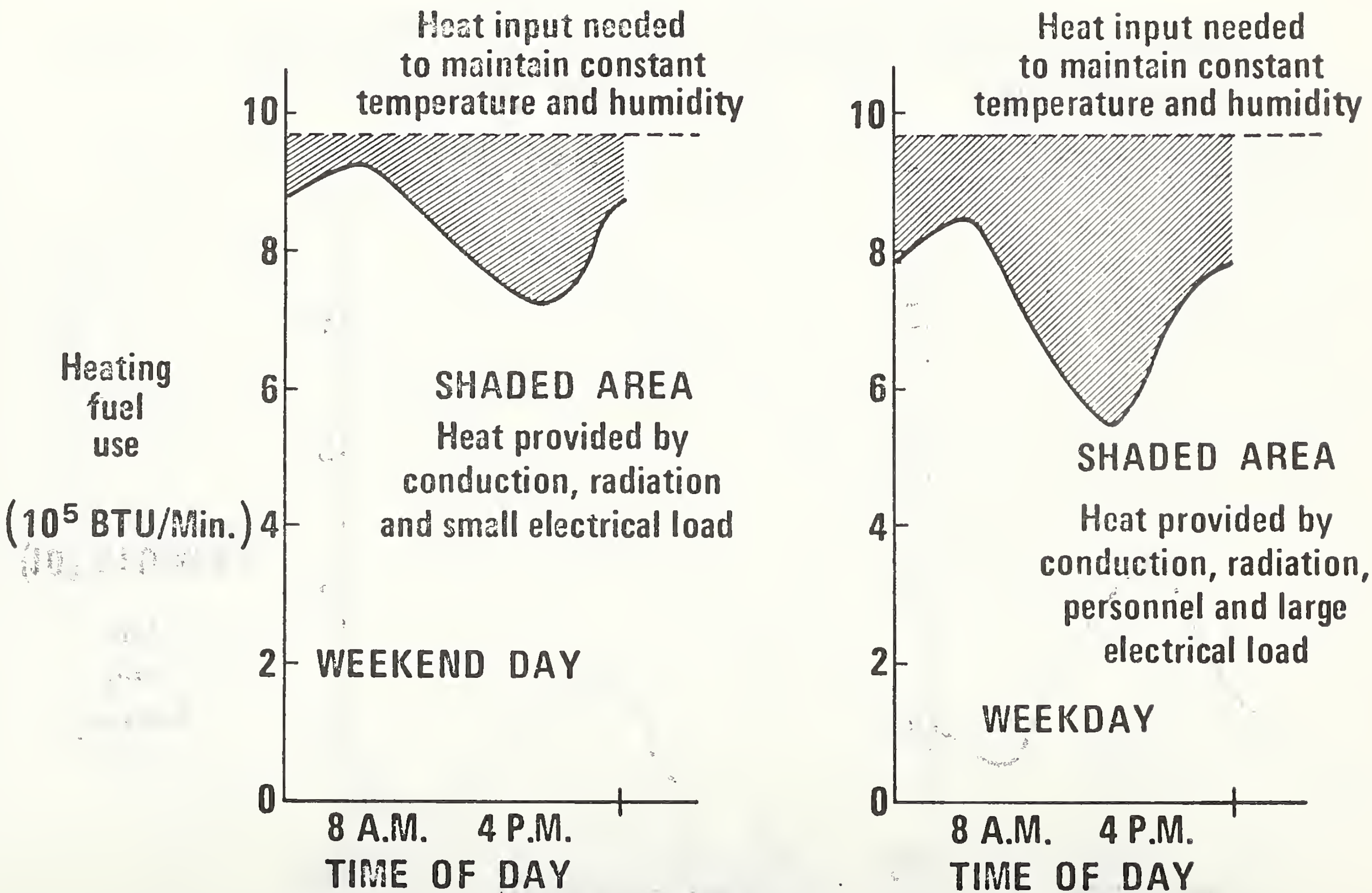

Figure 8. Interpretation of summer heating fuel use profiles in terminal reheat climate control system. (NBS, Gaithersburg)

1. Reduction in air circulation rate is the most efficient energy conservation measure. Figure 9 shows the reductions in heating and cooling loads that would result from a 25 percent reduction in air flow. Fume hoods exhaust an average of 750 ft^3 per minute and necessitate generally larger air flow rates in laboratory buildings. Removal of hoods from active use would result in considerable savings as shown in figure 9. Zone shutdowns have been effective in energy conservation during the first year of the campaign: zone air flow rate reductions of 5-15 percent have been tested and are feasible in some zones. Reduced air flow in many laboratories is now possible because most of the newer laboratory equipment has solid state components instead of electron tubes which were common when the Laboratory was designed. Design air-flow levels are undoubtedly too high in many laboratories. However, zone control precludes adjustments of air flow in individual laboratories.

2. Frequent switching between summer and winter setting positions of the climate control system would conserve considerable electricity (see fig. 12) and heating fuel (see fig. 15) in spring and fall. The summer setting should be used when the outdoor temperature exceeds 65° F. If the dew point is ~57° F or greater, cooling coils should be set at 57° F; if the dew point is less than 57° F, cooling coils should be set at 65° F. As it is not always possible to make the recommended cooling coil adjustments, it is particularly important to have office thermostats set as low as practicable during spring and fall.

3. For a given level of absolute humidity in the interior of NBS, lower thermostat settings in office modules save electricity and heating fuel relative to higher thermostat settings.

4. For a constant year-round temperature mode of operation in office modules, ~71° F is the optimum choice. A temperature as low as 71° F, however, would be uncomfortable during the summer for many employees. The heating and cooling requirements associated with two possible choices of temperature settings compared with past operations are shown in figure 10.

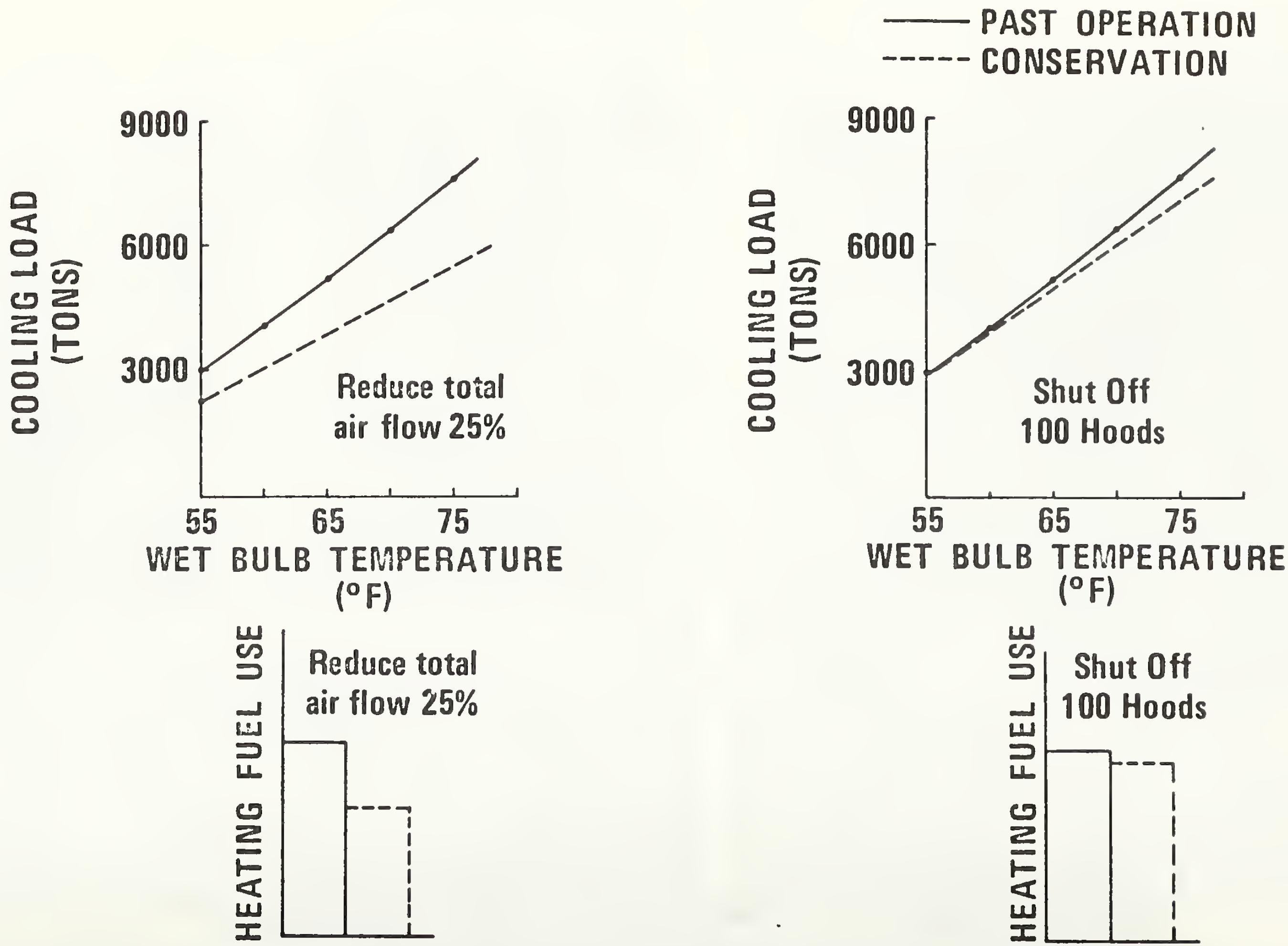

Figure 9. Long range heating fuel and electricity conservation: Reduction of air flow and deactivation of fume hoods. (NBS, Gaithersburg)

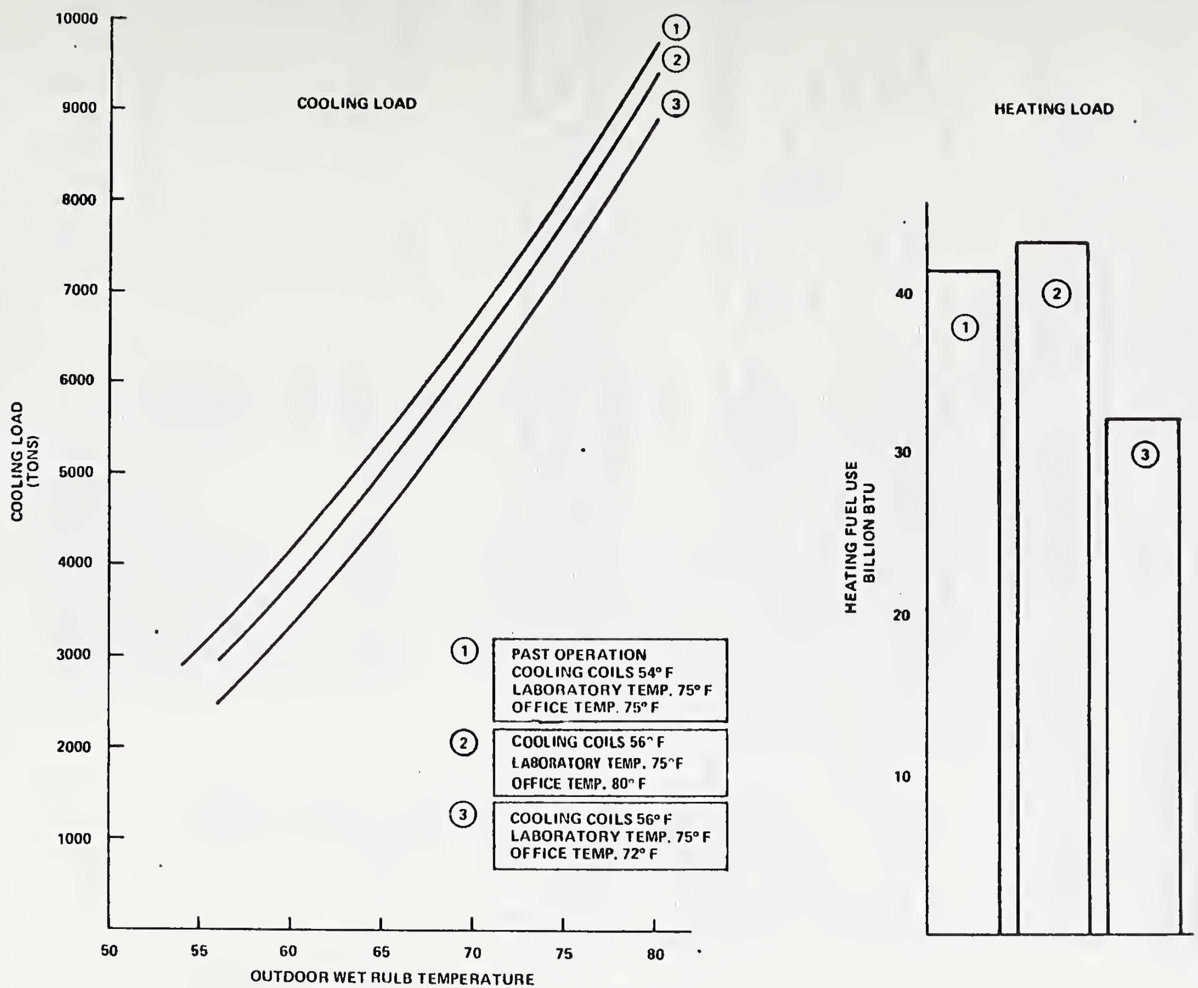

Figure 10. Electricity and heating fuel use vs cooling coil and thermostat set points. (NBS, Gaithersburg)

5. For a two temperature mode of operation in office modules, a high temperature of $\sim 74°$ F and a low temperature of 68° F should be selected. The period of operation at high temperature should be from early June to early October.

6. Window heat leaks during hot weather do not increase cooling loads, they decrease heating loads. Thermally insulating glass would therefore increase energy use in summer.

7. The solar load through most windows is beneficial all year except insofar as it necessitates greater air flow rates all year instead of for the relatively short periods when all interior loads are near maximum levels. Peak reduction in solar loads through use of blinds rather than solar pane or solar shades should be considered on the south side of general purpose buildings.

8. The potential for continued improvement in energy conservation at NBS is great but increased use of labor or automation of some controls will be necessary to realize most of the energy savings.

ELECTRICITY

NBS Gaithersburg

Electrical energy consumption by month from July, 1971 through May, 1974 is given in table 1.

TABLE 1

ELECTRICAL ENERGY CONSUMPTION

NBS, Gaithersburg

(July 1971 - May 1974)

	kWh		kWh		kWh
July (1971)	10,300,000	July (1972)	11,560,000	July (1973)	10,430,000
Aug.	10,500,000	Aug.	9,940,000	Aug.	9,900,000
Sept.	9,830,000	Sept.	10,180,000	Sept.	10,370,000
Oct.	8,820,000	Oct.	9,750,000	Oct.	8,850,000
Nov.	9,110,000	Nov.	7,690,000	Nov.	6,860,000
Dec.	7,000,000	Dec.	7,060,000	Dec.	5,750,000
Jan. (1972)	7,380,000	Jan. (1973)	6,690,000	Jan. (1974)	5,610,000
Feb.	6,880,000	Feb.	7,260,000	Feb.	6,150,000
Mar.	7,240,000	Mar.	7,160,000	Mar.	5,750,000
Apr.	7,960,000	Apr.	7,960,000	Apr.	6,040,000
May	8,000,000	May	7,870,000	May	6,590,000
June	9,430,000	June	10,420,000		
	102,450,000		103,340,000	TOTALS	

The functional breakdown of electricity use is given in table 2.

TABLE 2

ELECTRICAL ENERGY CONSUMPTION

By Function[a]

(NBS, Gaithersburg)

Function	Percent of Total Consumption (Yearly Average)
Main Power Plant (Primarily chilled water production)	37.2 ± 0.1
Motors (Air circulation, hoods, exhausts and pumps)	25.3 ± 2.5
Lighting	18.4 ± 3
Major Experimental Facilities	6.3 ± 0.5
General Purpose Equipment	12.9 ± 3

[a]Electrical consumption by function was determined from records kept at major experimental facilities and by analyzing day, night and seasonal variations in electrical demand and total consumption. Plant records on motors used in air and water circulation and chilled water production were also used.

NBS electricity use is monitored by only two electric meters. Therefore, indirect methods were used to determine the functional breakdown; they are summarized in table 2.

A general interpretation of the seasonal consumption pattern and functional breakdown can be given in relation to the equipment used in NBS laboratories. The ~2000 laboratories house electrical equipment ranging from fractional wattage to hundreds of kilowatts. In order to provide a stable environment for laboratory measurement systems, temperature and humidity must be controlled. Control is maintained by air which moves through the laboratory at a rate sufficient to remove heat and moisture emitted from equipment and occupants. The recirculation air must be cooled to prevent buildup of moisture and heat. As the circulating air must also provide ventilation, fresh air is mixed with the recirculation air before passing through laboratories. The temperature and humidity of fresh air depend upon prevailing atmospheric conditions. In general, fresh air is unsuitable for direct intorduction into laboratories. In the summer, the fresh air contains considerably more moisture than permitted in laboratories and it must be dehumidified. The air is dehumidified by passing it over cooling coils fed by chilled water produced by electrically powered refrigeration units. The electrical load of the refrigeration units is very large in summer (fig. 6) which accounts for the largest electricity use which occurs during that season. Laboratory fume hoods and much laboratory equipment operate continuously for valid reasons and circulation of air is required at all times.

CONSERVATION OF ELECTRICITY

The principal conservation measures taken since July 1973 and the savings resulting from them are listed in table 3. Recommendations made by the Electricity Task Group for conservation in FY 1975 and FY 1976 are also summarized in table 3. These measures could be implemented in whole or in part depending upon factors such as the availability of manpower to carry out labor intensive measures (i.e., reduction in laboratory lighting), the maintenance of building air balance, and the availability of funds to modify ducts to provide the necessary changes in air flow.

Conservation progress to date (May 1974) is given in table 4 and figure 11.

TABLE 4

CONSERVATION PROGRESS

(FY 74 vs FY 73)

Electricity Use
(Million kWh)

Quarter	FY 73	FY 74	Conservation
1	31.48	30.70	2.5%[a]
2	24.50	21.46	13.3%[a]
3	21.11	17.51	13.4%[a]
April	7.96	6.40	
May	7.87	6.59	
Cumulative	92.92	82.66	11.0%

[a]Corrected for number of days in billing period

Beginning in November 1973, consumption every month has been lower than the corresponding month in the previous two years. Conservation progress to date is in good agreement with the level predicted from an analysis of the conservation measures. The higher percentage levels reached from October 1973 - May 1974 are due in part to lower levels of electrical consumption which is a normal seasonal pattern. An analysis of yearly weather data and past energy use shows that, relative to past operation, the greatest level of conservation should occur in the fall (fig. 12).

TABLE 3

EVALUATION OF ELECTRICAL ENERGY SAVING MEASURES FY 1974

	ITEM	PER CENT SAVINGS[a] Individual	Cumulative	REMARKS
1.	Lighting reduction - Corridors, etc.	1	1	Done
2.	Lighting reduction - outside offices	1.5	2.5	Done
3.	Lighting reduction - attics and mechanical equipment rooms	2.4	4.9	Done
4.	Night and weekend building shut-down (Bldgs. 101, 202, 231, 233, 236, 301, 304)	5.5	10.4	Done
5.	Voluntary use of daylight for outside offices	1.2	11.6	Already 50% effective. Requires educational campaign.
6.	Lighting reduction - laboratories	1.3	12.9	No apparent problem
7.	Conversion of synchrotron to storage ring	0.27		Scheduled for Spring 1974
8.	Place 158 hoods on standby[b]	3.6	16.4	Retrofit, requires extra man-power for rapid progress.
9.	Night and weekend shut-down of office space in GP Lab Buildings[b]	>1.8		Air-flow balance problem
10.	Convert 286 hoods to intermittent operation[b]	(>5)[a]		Retrofit, safety problem
11.	Installation of intermediate size chiller[b]	-2		Capital item, requires study.
12.	Use of desk lamps	(3)		Very risky. Not recommended

[a]Using FY 1973 as base year

[b]Long Range Conservation Committee will develop implementation strategy

Figure 11. Electricity use from July 1972 to May 1974. (NBS, Gaithersburg)

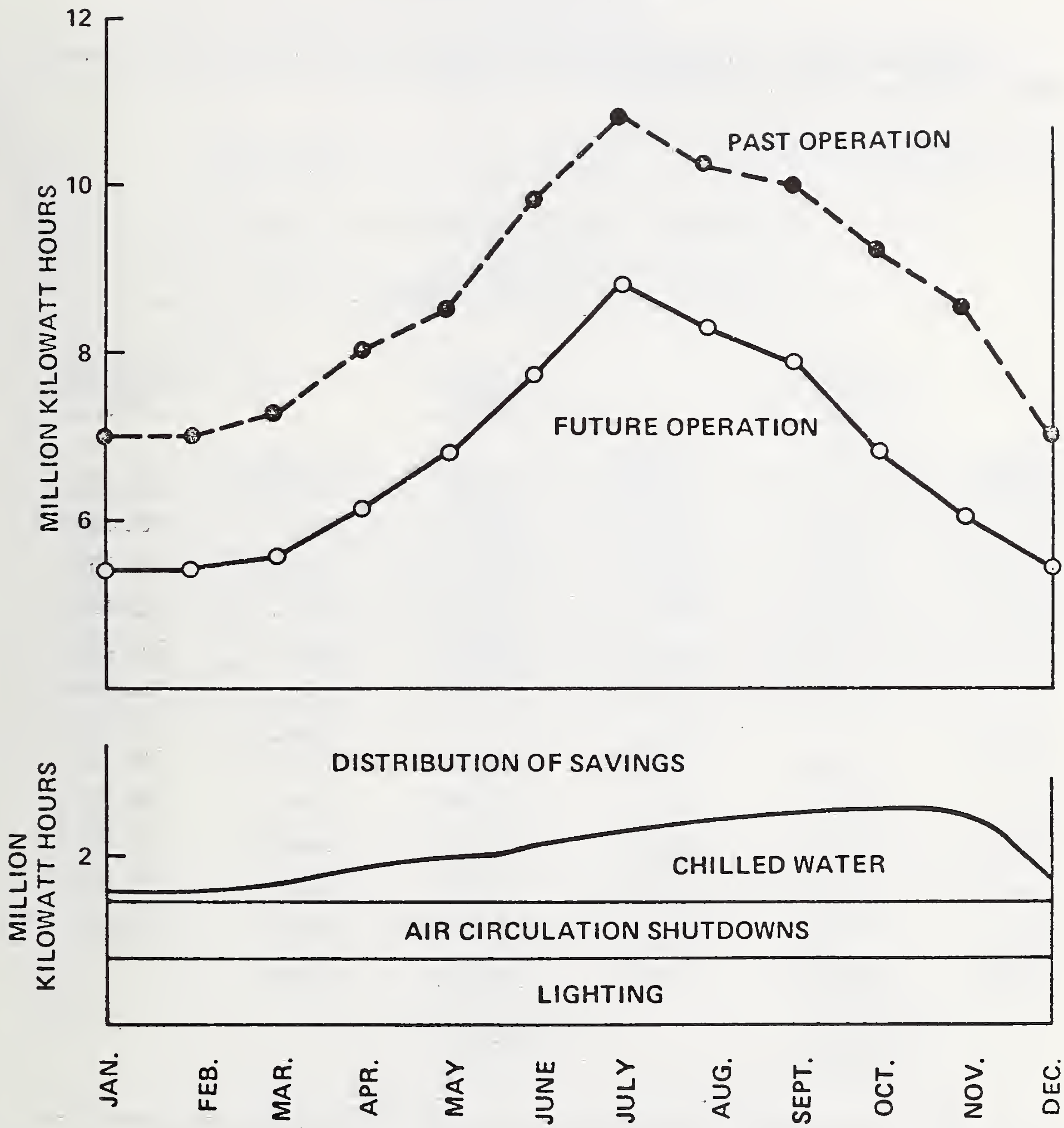

Figure 12. Electricity use: Schematic comparison of past and future operation. (NBS, Gaithersburg)

HEATING FUELS

NBS Gaithersburg

Heating fuel consumption by month from July, 1971 through May, 1974 is given in table 5.

TABLE 5

HEATING FUEL CONSUMPTION

NBS, Gaithersburg
(July, 1971 - May, 1974)

	Billion BTU		Billion BTU		Billion BTU
July (1971)	39.68	July (1972)	42.94	July (1973)	39.58
Aug.	40.60	Aug.	42.84	Aug.	40.80
Sept.	42.33	Sept.	44.37	Sept.	43.35
Oct.	48.76	Oct.	59.98	Oct.	52.43
Nov.	62.22	Nov.	63.34	Nov.	51.41
Dec.	64.26	Dec.	68.31	Dec.	54.67
Jan. (1972)	70.88	Jan. (1973)	71.41	Jan. (1974)	58.45
Feb.	68.97	Feb.	64.89	Feb.	55.17
March	56.30	March	61.01	March	49.90
April	55.69	April	57.02	April	40.27
May	51.61	May	49.67	May	37.62
June	45.39	June	40.39	June	
	646.69		666.17		

The functional breakdown of heating fuel use is given in table 6.

TABLE 6

HEATING FUEL CONSUMPTION
BY FUNCTION
(NBS, Gaithersburg)

Function	Percent of Total Consumption (Yearly Averages)
Steam Production	>99
"Winter" Heating	40 ± 5
Climate Control (Reheat)	40 ± 5
Fume Hoods	20 ± 3
Laboratory Gas	<1

For each of the first three categories listed in table 6, heating fuel is used in steam production. Steam is fed to NBS buildings to produce hot water which in turn is used to warm the air that circulates through all NBS buildings. "Winter" heating designates heat needed to maintain building temperature above prevailing atmospheric temperature regardless of season. Heating fuel used in climate control is needed to reheat air that has been chilled to remove excess moisture Some of the heated air supplies the ~700 laboratory fume hoods which operate full time.

CONSERVATION OF HEATING FUELS

The conservation measures taken since July, 1973 and the savings resulting from them are listed in table 7. Recommendations made by the Heating Fuels Task Group for conservation in FY 1975 and FY 1976 are also listed.

Conservation progress to date (May 1974) is given in table 8 and figure 13.

TABLE 8

CONSERVATION PROGRESS

FY 1974 vs FY 1973

Heating Fuel Use
(Billion BTU)

Quarter	FY 73	FY 74	Conservation (%)
1	130.15	123.73	4.9
2	191.63	158.51	17.3
3	197.31	163.52	17.2
Apr.	57.02	40.27	29.4
May	49.67	37.62	24.3
Cumulative	625.78	523.65	16.3

Heating fuel consumption depends upon weather. Air temperature is the primary factor in fuel consumption but sunshine and wind also are of some importance. Figure 14 shows monthly heating fuel consumption vs monthly average mean daily temperature from July, 1971 to the present time. Observed monthly consumption levels from July 1971 to October 1973 lie along a straight line. Early in the conservation campaigning, (July 1973-October 1973), measures were taken primarily to conserve electricity. Beginning in November, however, consumption every month has been significantly below previous levels. An analysis of the climate control system parameters, weather data, and distribution of zones shows that the heating fuel use vs temperature curve should bend downward during the spring and fall. The expected response is shown schematically in figure 15. According to the curve labeled future operation, energy savings should be greatest in spring and fall. Operating criteria have been developed to bring the climate control system response more in accord with the future operation curve.

TABLE 7

EVALUATION OF HEATING FUEL SAVING MEASURES

FY 74

ITEM	PERCENT SAVINGS INDIVIDUAL	PERCENT SAVINGS CUMULATIVE	REMARKS	TASK FORCE RECOMMENDATIONS
1. Turn down office temperature from 75°F to 68°F, October - May	7%	7%	Done	Long-Range Study Group will recommend temperature settings for summer and winter
2. Night, weekend, holiday shutdown of some zones in buildings 101, 202, 231, 233, 236, 301, 304	6%	13%	Done	Continuation of this practice
3. Increase temperature of perimeter cooling coils from 55°F to 58°F	3%	16%	Done	Continuation of this practice
4. Reduce air circulation rates 5-15% in zones where feasible	3-5%		Excellent conservation measure	Implement this measure where feasible
5. Increase frequency of summer-winter control setting changes	4-5%		Labor intensive measure. Joint Task Force Long-Range Study	Adopt this practice where feasible
6. Shut down some zones in General Purpose Buildings	2-3%		Labor intensive measure	Carry out experiments in one building. Implement with caution

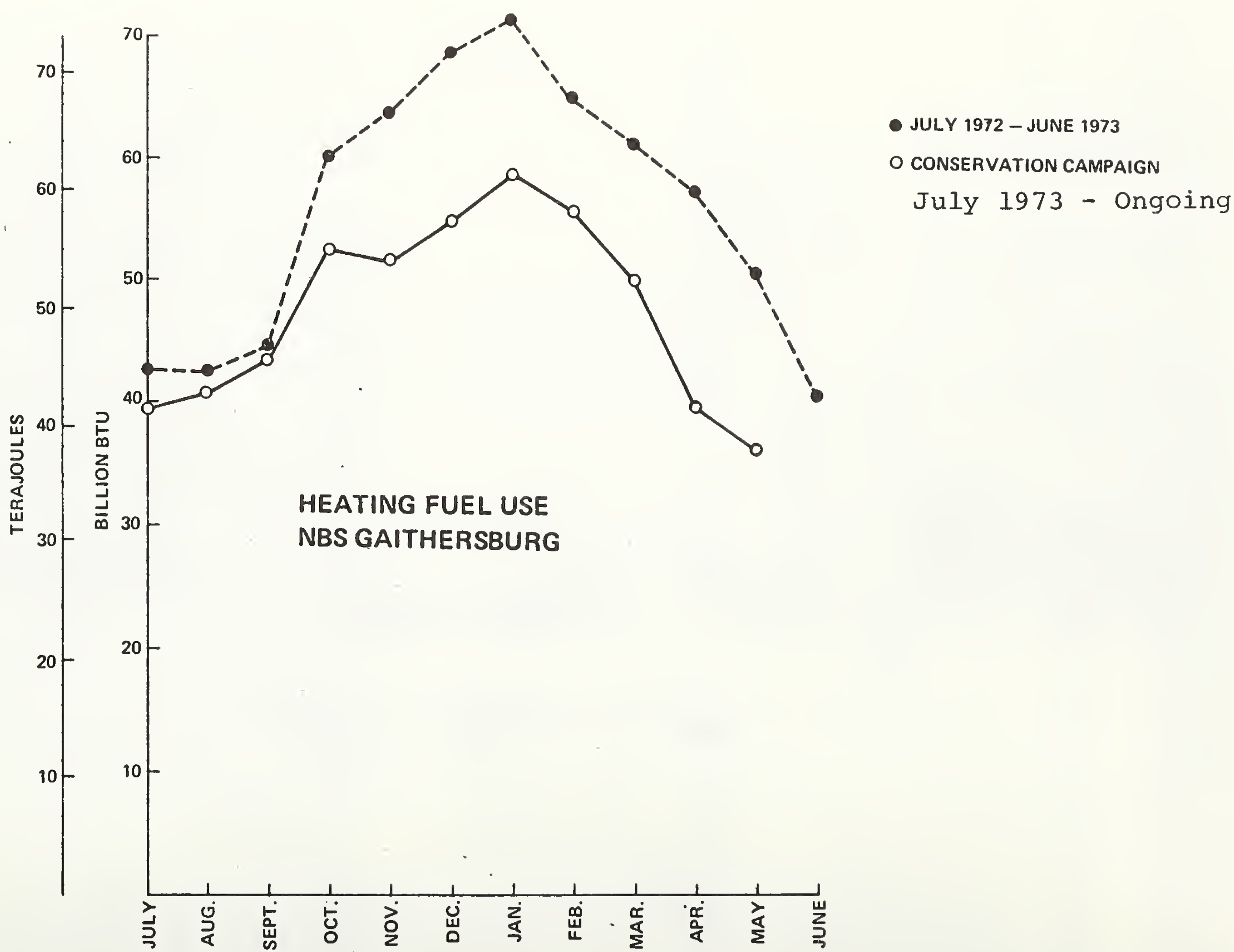

Figure 13. Heating fuel use from July 1972 to May 1974. (NBS, Gaithersburg)

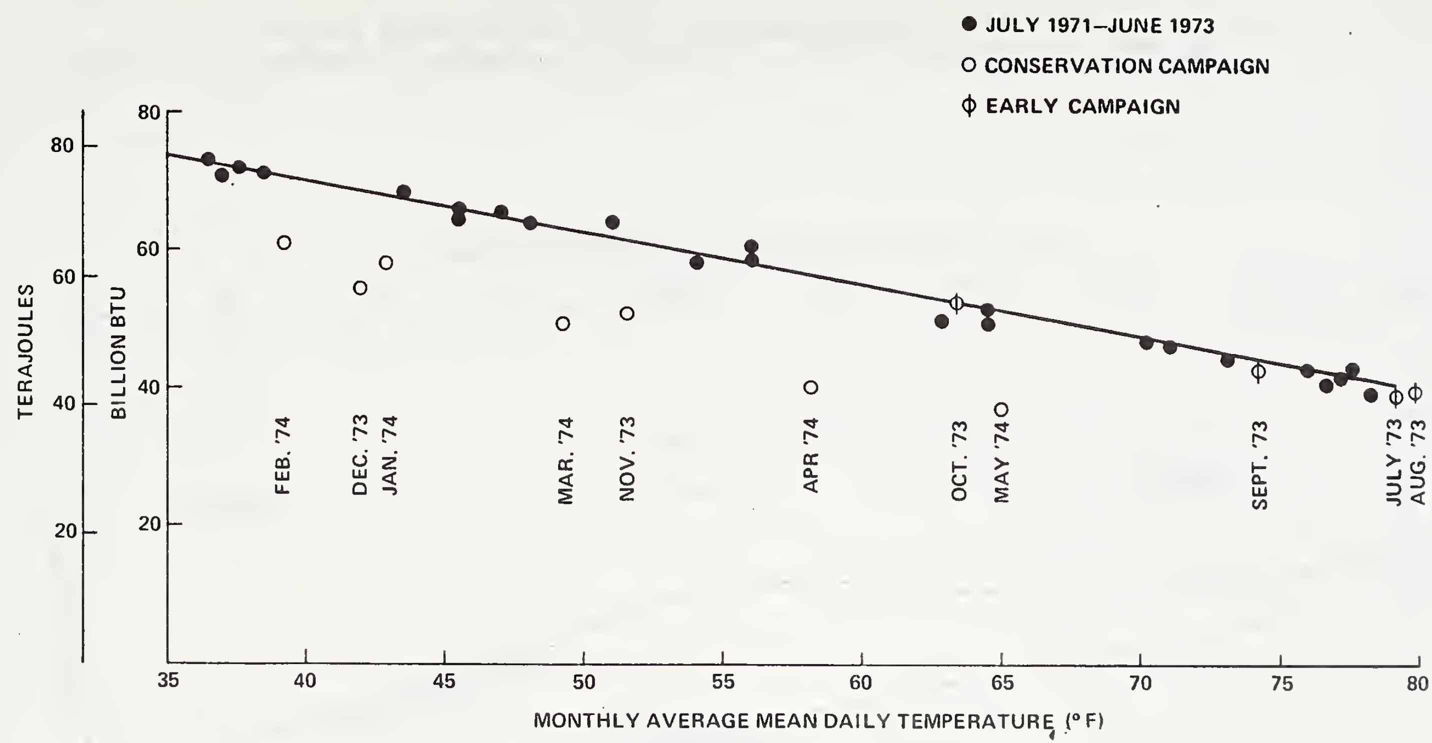

Figure 14. Heating fuel use vs outdoor temperature from July 1971 to May 1974. (NBS, Gaithersburg)

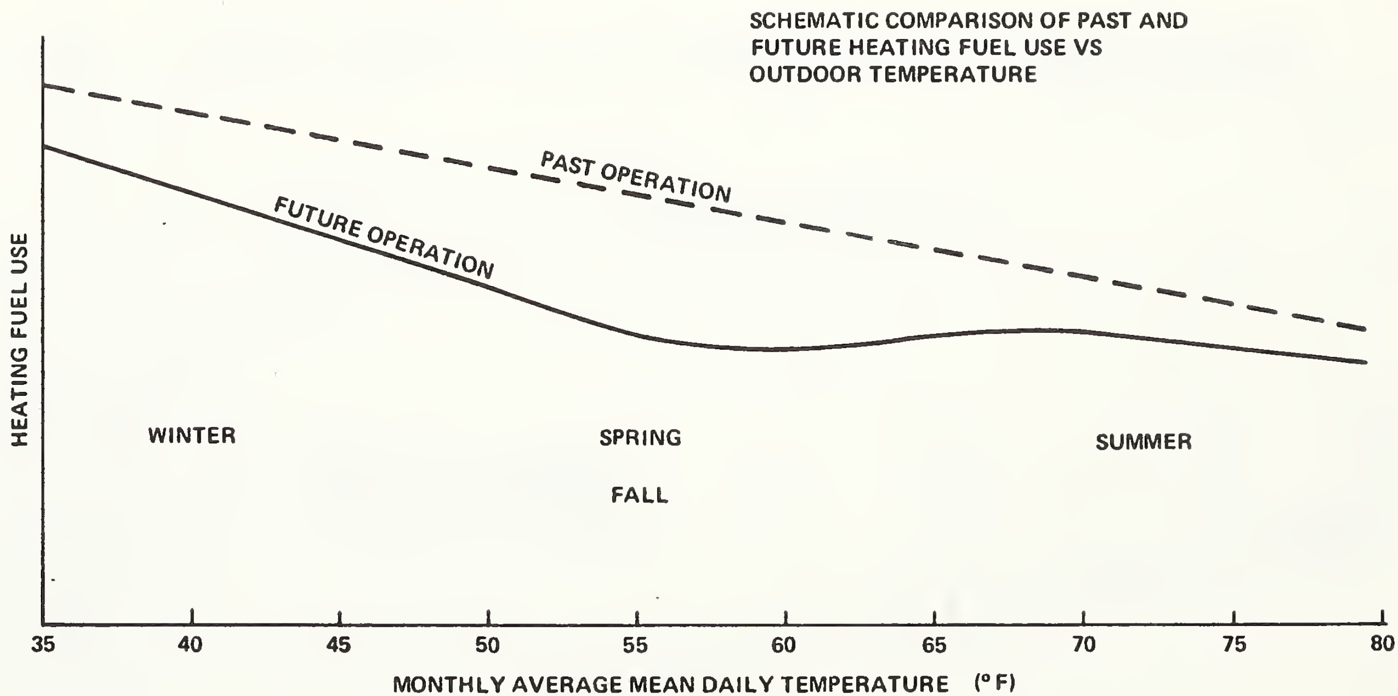

Figure 15. Schematic comparison of past and future heating fuel use vs outdoor temperature. (NBS, Gaithersburg)

An interesting feature of the crossover region between summer and winter portions of the curve is that the weather correction to fuel use virtually vanishes. This is quite unlike home fuel use, which, in April and November, is very sensitive to 5-10° F differences in average temperature.

CONTINGENCY PLANS

NBS Gaithersburg

Many experiments and tests conducted at NBS are of a nature or duration that serious damage or loss could result if either the environment or controls normally maintained are altered for even a short time. For example, disruption of electrical service would terminate some experiments and, depending upon the nature or extent of the distruption, damage some experimental equipment. Selected examples of vulnerable experiments are given in table 9. A reduction in heating fuel supply might necessitate changes in temperature and humidity set points with resulting deleterious effects on work and equipment. As indicated above, the NBS Gaithersburg Laboratories are served by an interruptible natural gas supply. Interruptions usually occur during very cold weather and often last for several days. The oil supply maintained for such eventualities represents about one week's supply. Prior to 1974, consumption was equivalent to about 3 truckloads of oil per day. Therefore, either an oil shortage or delay in deliveries because of weather could create a situation requiring prudent contingency action to extend available supply. Similarly, there are periods when electrical demand in the area approaches the generating capacity of the system serving the Washington area. When this occurs, the power supplier may request that large users reduce demand. Near peak operation might result in a brown-out (low voltage) which itself is troublesome in some work. Based upon the best evidence available at the start of the conservation campaign, actual energy outage was considered quite remote but a heating fuel shortage and electrical demand problems were considered sufficiently likely to warrant careful analysis and planning. Thus, contingency planning was carried out to properly prepare the NBS Laboratories for possible interruptions or shortages in essential energy supplies that might occur during the anticipated energy deficiency of the 1970's.

The first step in the contingency planning involved determining what information and data would be needed to formulate a plan to simultaneously serve the needs of management, plant operators, and laboratory scientists. As the energy problem and the actions required would need to be reduced to their clearest and most specific terms, plans were built around scenarios designed to simulate the actual problems. This approach is intended to avoid an "alert" atmosphere and the attendant precipitous actions that could, for lack of adequate information, result in unnecessary termination of work. The scenarios for which NBS would make preparations are as follows:

TABLE 9

SELECTED EXAMPLES OF VULNERABLE EXPERIMENTS AND EQUIPMENT

Division	Equipment of Activity	Experiment Duration	Power Requirement, kW	Recovery Time
Mechanics	Humidify Standards and CO_2 Storage	2-10 days	4	1-4 days
Heat	High Temperature Gas Thermometry	continuous	5	60 days
Heat	Critical Region PVT Experiments	10 days	3	30 days
Optical Physics	Atomic Constants Determinations	continuous	6	30 days
Analytical Chemistry	Clean Room	continuous	10	30 days
Analytical Chemistry	Isotope Mass Spectrometers	continuous	5-10 each	>7 days
IMR Director	Polymer Crystallization Kinetics	30-60 days		7 days
Polymers	Adhesion Test Experiments	>1 year	2.5	data lost
Inorganic Materials	Crystal Growing	20-30 days	2-5	crystal lost
Metallurgy	Salt baths for heat treatment of metals	3-5 days	10-15	Equipment damaged
Metallurgy	Stress-Rupture	45 days	2	5 days
Physical Chemistry	Thermal desorption spectrometry	14 days	3	5 days
Measurement Engineering	NBS Standard Frequency Generator	continuous	1	5 days

Electricity

Scenario - A request from the power supplier is received to reduce electrical demand during working hours by a recommended percentage with notice of 1-2 hours.

Heating Fuels

Scenario - The natural gas supply is interrupted for an unspecified period and oil delivery time cannot be guaranteed.

The contingency strategy is outlined in figure 16.

To obtain the data and information necessary to complete contingency planning, surveys were carried out on temperature and humidity control, critical experiments, long-range experiments, and major facilities. The plans devised to meet the postulated contingencies are summarized in tables 10, 11 and 12.

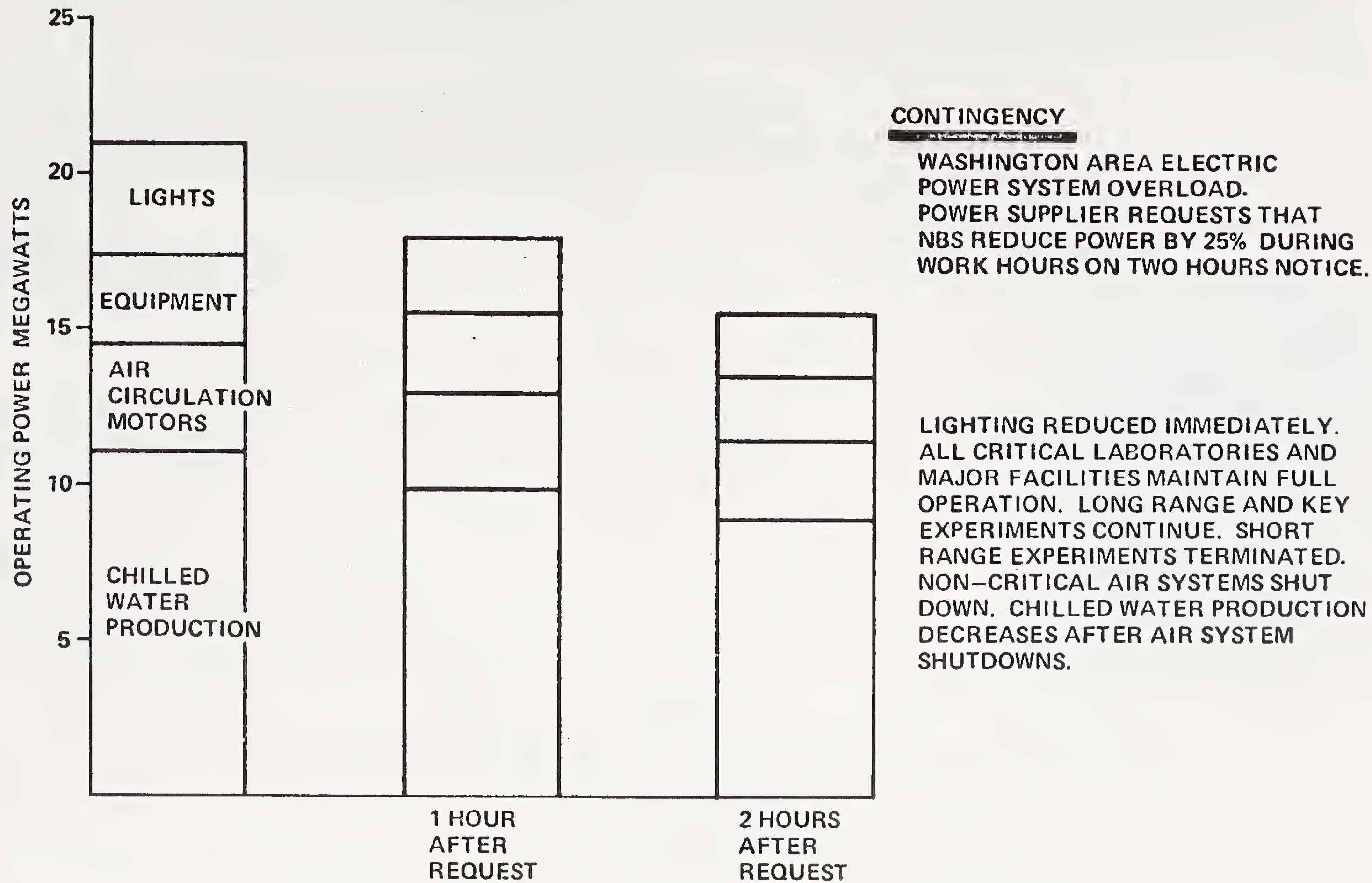

Figure 16. Schematic representation of electricity contingency plan for summer. (NBS, Gaithersburg)

TABLE 10

WINTER CONTINGENCY PLAN

ELECTRICITY

Steps to Effect a One-Day Electricity Demand Reduction on Short Notice (2 hrs.)

Step	Demand %	Reduction Cumulative %	Time hrs.	Remarks
Turn off lights in above-ground outside modules and some laboratories	8-11.5	8-11.5	1	No significant effect on work
Reduction of air circulation in Bldgs. 101, 202, 231, 301, and 304[a]	3.6	11.6-15.1	2	Feasible for short (4-6) periods while building is occupied, indefinitely if building is empty. Some minor employee discomfort.
Terminate interruptible experiments[b]	7-9	18.6-24.1	2	Minor effect on programs. Feasible for up to 1 week.
Terminate major experiments	14[c]	32.6-28.1	2-8	Some major experiments can be shut down for one day or more. Other experiments should only be shut down if long term demand reduction is required (e.g. reactor and computer).
Shut-down of Non-critical air systems in General Purpose Laboratories	7.9	40.5-46.0	2	Serious effect on work, except for key experiments.

[a] In Bldg. 231 operation of paper mill would cease.

[b] Assuming they represent 0.8-1.0 MW demand, i.e. 1/2-2/3 of all small scale experiments.

[c] Assuming approximately one-half of major experiments are terminated.

TABLE 11

SUMMER CONTINGENCY PLAN

ELECTRICITY

Steps to Effect A One-Day Electricity Demand Reduction on Short Notice (2 hrs.)

Step	Demand %	Reduction Cumulative %	Execution Time, hrs.	Remarks
Turn off lights in above-ground outside modules and some laboratories	4.9-7	4.9-7	1	No significant effect on work. Demand reduction up additional 3.9% with retrofit of switches.
Shut off and secure interruptible hoods	8.5	13.4-15.5	1	Minor inconvenience only. Safety precautions necessary. Some hood pooling necessary. Requires retrofit.*
Reduce office air circulation in selected buildings: 101, 202, 231, 301, and 304	12.8	26.2-28.3	1-2	Some employee discomfort. Feasible for short periods (4-6 hrs.) only. May require intermittent resumption.
Terminate interruptible experiments	4-6	30.2-34.3	2	Minor effect on programs. Feasible for up to 1 week.
Terminate major experiments	-8.3	38.5-42.6	2-8	Some major experiments can be shut down for one day or more. Other experiments should only be shut down if long term demand reduction is required (e.g. reactor and computer).
Shut down of additional buildings. (Parts of buildings 220-226) Shutdown of non-critical air systems in General Purpose Laboratories	19	57.5-61.6	2	Serious effect on work except for key experiments.

[a] This retrofit requires detailed mechanical and safety interlock planning, and completion of retrofit by summer is very uncertain.

[b] In Bldg. 231 operation of paper mill would cease.

[c] Assuming they represent 0.8-1.0 MW demand, i.e. 1/2-2/3 of all small scale experiments.

[d] Assuming approximately one-half of major experiments are terminated.

TABLE 12

Contingency Plan

Heating Fuels

Steps to Effect Reduction in Fuel Oil Use During Prolonged Natural Gas Interruption.

Step	Demand %	Reduction Cumulative %	Execution	Remarks
Shut off and secure interruptible hoods.	5-6%	5-6%	1-2 hours	Minor inconvenience. Hood pooling necessary. Safety precautions required.
Shut off air circulation systems in selected buildings during day.	2-3%	7-9%	2-4 hours	Some employee discomfort owing to slightly stale air. Laboratory operations not affected. Major facilities unaffected.
Shut off air circulation systems in parts of some G.P. buildings on nights and weekends	3-5%	10-14%	2-4 hours	Some employee discomfort in early a.m. Laboratory operations not affected. Laboratory temperature may change slightly due to new patterns of air movement.
Shut off all air circulation systems except for critical laboratories until oil resupplied.	5-10%	15-24%	2-4 hours	Standby condition with many experiments stopped and considerable employee discomfort. Administrative leave must be considered. Not recommended unless absolutely necessary. Critical laboratories fully functional. Condition not hazardous but wide range of temperatures likely.

TRANSPORTATION

NBS Gaithersburg

Transportation is considered in two parts: Official travel and employee commuting.

A. Official Travel

Miles driven and gasoline consumed in official travel are given in table 13 and table 14, respectively.

TABLE 13

MILES DRIVEN[a]

NBS Gaithersburg

PERIOD	MILES	PERIOD	MILES	PERCENT CONSERVATION
July-Sept '72	364412	July-Sept '73	364230	0
Oct - Dec '72	423706	Oct - Dec '73	354070	16.4
Jan - Mar '73	433960	Jan - Mar '74	232071	46.5

[a] Includes GSA motor pool vehicles, agency owned commercially leased and rented, and privately owned vehicles used on official travel.

TABLE 14

GASOLINE CONSUMED BY GOVERNMENT OWNED VEHICLES

NBS Gaithersburg

PERIOD	GASOLINE CONSUMED	PERIOD	GASOLINE CONSUMED	PERCENT CONSERVATION
July-Sept '72	19413	July-Sept '73	18858	2.9
Oct - Dec '72	18387	Oct - Dec '73	16178	12.0
Jan - Mar '73	22029	Jan - Mar '74	14731	33.1

The conservation measures taken since July 1973 are listed in table 15. Task Force recommendations concerning official travel are included in table 15. Conservation progress to date is summarized in figures 17 and 18, respectively.

TABLE 15

ACTIONS TAKEN TO REDUCE TRAVEL IN FY 1974

1. Reduction in number of Government owned vehicles (Gov't) by returning three vehicles from the subpool to GSA.

2. Reduction in shuttle services - elimination of three runs from NBS to Commerce.

3. Reduction in special pickups and delivery service.
   a. Limited downtown pickup and delivery.
   b. Elimination of airport, Pentagon, and most Virginia runs.
   c. Elimination of the cars stationed downtown.

4. Mileage Control Program - Reduction in mileage driven by Government owned vehicles and privately owned vehicles. Target reduction assigned all MOU's was 20 percent below miles driven in similar period for the preceding year.

RECOMMENDATION

The Task Force recommends that records of official travel be analyzed on a regular basis to determine the optimum number and optimum scheduling of shuttles that would minimize fuel consumption and discourage the unofficial use of privately owned vehicles by employees conducting official business.

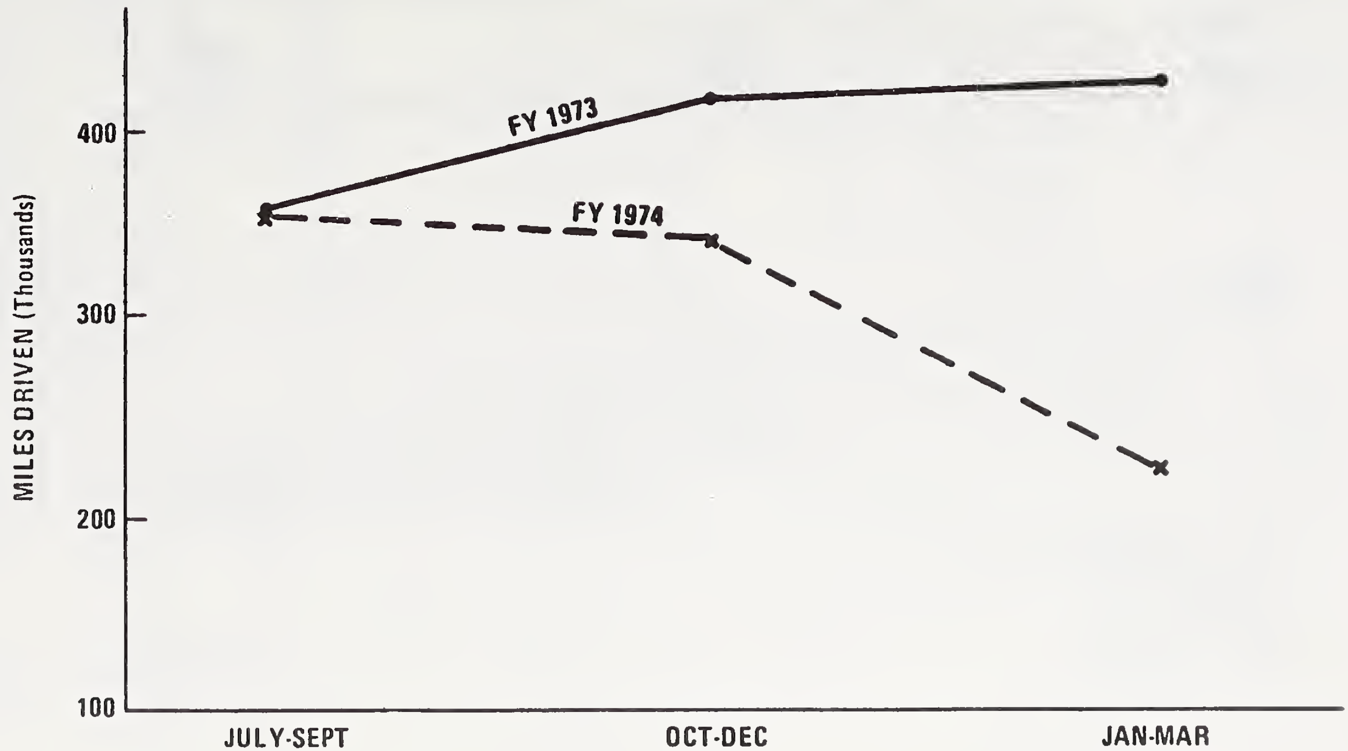

Figure 17. Miles driven in government vehicles - FY 1973 vs FY 1974. (NBS, Gaithersburg)

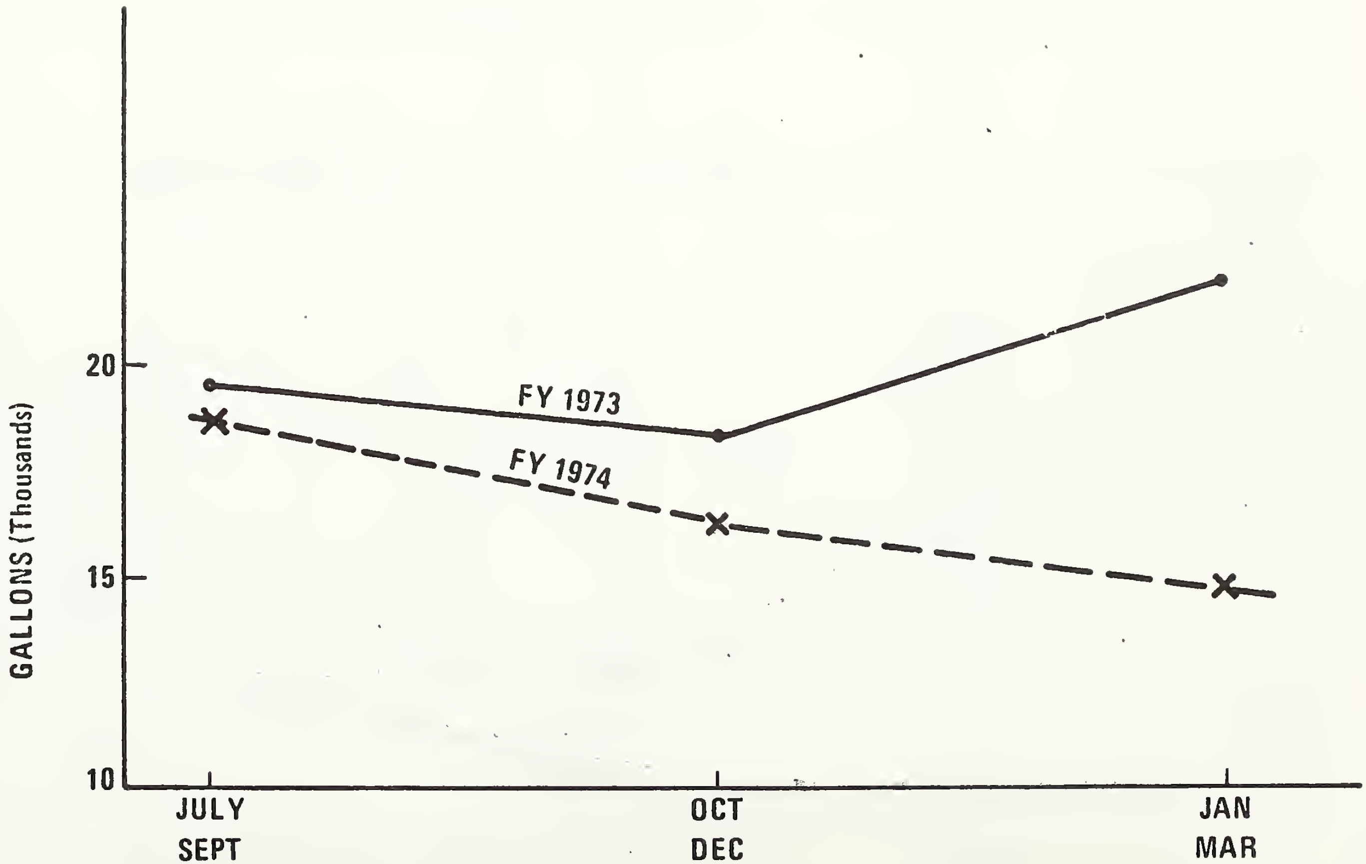

Figure 18. Gasoline consumption in government owned vehicles - FY 1973 vs FY 1974 (NBS, Gaithersburg)

B. Employee Commuting

Travel by employees in commuting is summarized in table 16.

TABLE 16

EMPLOYEE COMMUTING DATA

Area	No. of People	Avg. Miles from NBS (one way)	Daily Travel Mileage
Gaithersburg-Rockville	974	5	9,740
Outlying Mont. County	163	15	4,890
NE D.C. to Rockville	955	20	38,200
Frederick Area	238	26	12,376
SW D.C.-Bltwy-Fx Cty	152	26	7,904
SE D.C.-Pr. Geo.	132	35	9,240
Outlying Areas	127	50	12,700
	2,742		95,050
Add 15 percent (incomplete data base)			110,000

An analysis of staff travel is given in table 17.

TABLE 17

ANALYSIS OF STAFF TRAVEL

Staff Travel to and from work

	11/27/73	2/28/74	Diff.	% Chg.
Total cars	2250	2026	224	-10
Total people in cars	2920	2892	28	- 1
People/Car	1.29	1.42	-.13	+10
Cars w/two or more people	469	550	81	+17
Total people in cars	973	1408	435	+45
People/Car	2.07	2.56	.49	+24

In January 1974 a staff transportation survey was conducted to determine staff transportation needs and to establish an accurate data base for a carpool locator system. The results of this survey are given in table 18.

TABLE 18

STAFF TRANSPORTATION SURVEY RESULTS[a]

			Number	Percent
I.	Drive Alone		1295	52
	Carpool		1085	44.0
	Walk		23	0.9
	Metrobus		11	0.4
	Other		45	1.8
II.	Desire Carpool List		1077	43
III.	Address Change in Past 10 Months		367	15
IV.	Will Share Carpool Driving	Yes	1448	58
		No	770	31
V.	Will Ride Only		375	25
VI.	Will Drive Only and Pick Up Riders		345	14
	Bus Service			
VII.	(2482) May Use if Available		1077	43
	Definitely Use if Convenient		588	24
	Not Interested		651	26
VIII.	(2059) Walk Only		615	30
	Travel w/Safe Parking		870	42
	Travel w/o Regard to Parking		62	3
IX.	Maximum Round Trip (1226)	$1.00	540	44
		2.00	512	42
		3.00	146	12
		4.00	20	2
		5.00	4	0.3
	Train Service (2482)			
X.	Use North-South AM if Approved		193	8
XI.	Use South-North AM		476	20

[a]Based on 2482 Responses

Based primarily on the results of the Transportation Survey, the Task Force undertook several actions intended to improve the commuting picture for employees. Because of strong interest expressed in carpooling, a carpool locator system was devised to provide participants with the names of persons who live in their immediate area and who also wish to form carpools. The locator system is based on x, y grid coordinates and lends itself to any strategy that would utilize actual point locations of employee residences. Initially, more than 1000 employees sought and received assistance with carpool formation and requests continue to be received.

The Task Force also investigated improved bus and train service as alternatives to use of private vehicles. Cost and route information for charter bus service was obtained. Daily costs were found to range from $2.25 to more than $3.00 based on a 100 percent load factor. The lack of legal authority for NBS to provide commuter subsidy and the failure experienced by other local organizations with unsubsidized bus service coupled with the fact that 86 percent of NBS employees specified $2.00 as the limit to how much they would pay for such service led to the dropping of charter service from consideration as a Task Force priority. Rather, Task Force members participated in local efforts to secure improved public transportation. The 70S Corridor Group with representation from NBS, from major industrial groups and from other governmental agencies located along Route 70S, met regularly and served as a focal point for joint efforts to secure stable and realistic solutions to local transportation problems. The Montgomery County Department of Transportation received the results of the NBS Transportation Survey and seeks similar data from other potential user groups. The effort to improve the public transportation system in the Gaithersburg-Rockville area continues.

The interest expressed by NBS employees in train service (28 percent) should bolster the effort to achieve two-way commuter service of the B&O Railroad. Dr. Roberts wrote to the State of Maryland to underscore NBS interest in train service. Based on the NBS response, it would appear that train service is a viable option to private vehicles. However, transportation to and from the train station would pose a problem if employees avail themselves of train service.

Recommendations

The Task Force Recommends that:

NBS actively encourage employee carpooling and maintain an updated locator system based on x, y grid coordinates. Maintenance of the locator system should be made the responsibility of the Management and Organization Division.

While encouraging carpooling, no actions be taken such as altering parking zones or roadways that would limit access to NBS parking areas by visitors, participants in conferences of those attending other mission-related activities.

NBS continue to cooperate with agencies and organizations in the Gaithersburg area to acquire additional bus routes and improved service.

NBS actively support the State of Maryland with efforts to initiate additional commuter service by the B&O Railroad.

NBS seek to obtain authority to establish shuttle service to and from the railroad station should commuter train service become available.

NBS continue to support local efforts to modify existing roadways and traffic light timing to facilitate motor vehicle traffic flow and safe passage of bicycles.

SUMMARY OF

RESULTS OF TRANSPORTATION SURVEY

Present Means of Getting to Work		(a) Drive Alone	52%
		(b) Carpool	44
		(c) Other	4
Want Carpool List			43
Address Change in Past 10 Months			15
Bus Service		May Use	43
		Definitely Use	24
	Will Pay:	$1.00	44
		2.00	42
		3.00	12
		4.00	2
		5.00	0.3
Train Service			
Use existing line with improved service (N-S [AM])			8
Use D.C.-Gaithersburg Service (S-N[AM])			20

BOULDER LABORATORIES

The Department of Commerce Boulder Laboratories comprise 14 buildings on a 205 acre site. The Laboratories house three agencies: The National Bureau of Standards, Office of Telecommunications, and the National Oceanographic and Atmospheric Administration. The NBS work includes research in lasers, electromagnetic properties of materials, time and frequency, radiative processes in the upper atmosphere, and engineering measurements at very low temperature. The Office of Telecommunications is concerned with the development of system performance measurements and standards of practice for telecommunications systems, studies radio system characteristics and operating techniques affecting use of the spectrum and research on electromagnetic wave propagation, noise and interference and efficient use of electrospace for telecommunications. NOAA maintains earth science laboratories, atmospheric chemistry and physics laboratories, a space environment laboratory, and an aeronomy and wave propagation laboratory. Work carried out by NOAA includes cloud physics, precipitation processes, weather modification, solar and related geophysical disturbances, remote sensing of environment, seismology and geodesy.

The Boulder Laboratories use natural gas and electricity. The natural gas service is non-interruptible and the supply appears secure. New electric power plants in Colorado significantly increase previous capacity in that area.

ELECTRICITY

NBS BOULDER

Electricity use since July, 1972 is given in table 19.

TABLE 19

ELECTRICAL ENERGY CONSUMPTION

NBS, Boulder

(July, 1972 - May, 1974)

	kWh		kWh
July (1972)	1,012,800	July (1973)	1,089,600
Aug.	1,224,000	Aug.	1,136,400
Sept.	1,027,200	Sept.	1,041,600
Oct.	974,400	Oct.	882,000
Nov.	902,400	Nov.	852,600
Dec.	782,400	Dec.	646,800
Jan. (1973)	816,000	Jan. (1974)	613,200
Feb.	883,200	Feb.	701,400
Mar.	763,200	Mar.	613,200
Apr.	921,600	Apr.	714,000
May	964,800	May	760,200
June	1,012,800		
	11,284,800		

Measures taken to conserve electricity are listed in table 20. Progress in conservation of electricity is summarized in table 21 and figure 19.

TABLE 20

CONSERVATION MEASURES

ELECTRICITY

NBS, Boulder

1 - Reduction in air conditioning

2 - Reduction of lighting in corridors, offices, and laboratories

3 - Reduction of ventilation on nights and weekends

RECOMMENDATIONS

1 - Replace some lights by mercury-vapor lamps of lower power

2 - Install return air ducts

3 - Reduce air circulation rates

TABLE 21

CONSERVATION PROGRESS

(FY 74 vs FY 73)

ELECTRICITY USE

NBS, Boulder

kWh

Quarter	FY 73	FY 74	Conservation (%)
1	3264000	3267600	-0.1
2	2659200	2381400	10.4
3	2462400	1927800	12.7
April	921600	714000	
May	964800	760200	
Cumulative	10272000	9051000	11.9

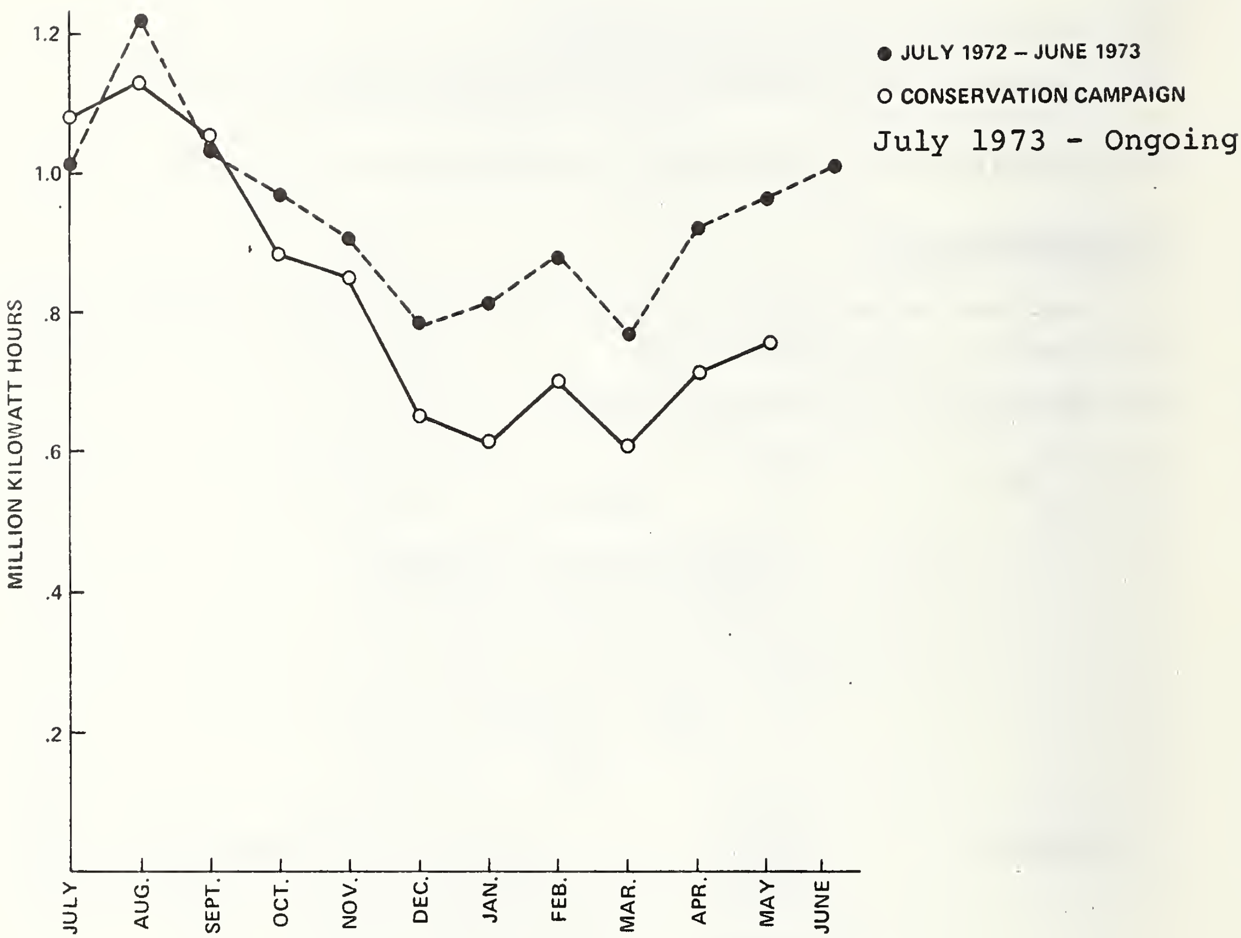

Figure 19. Electricity use from July 1972 to May 1974. (NBS, Boulder)

HEATING FUELS

NBS Boulder

Heating fuel use since July, 1972 is given in table 22.

TABLE 22

HEATING FUEL CONSUMPTION

NBS, Boulder

(July, 1971 - May, 1974)

	Billion BTU		Billion BTU
July (1972)	4.02	July (1973)	3.46
Aug.	3.35	Aug.	3.06
Sept.	4.71	Sept.	3.57
Oct.	6.67	Oct.	6.59
Nov.	11.75	Nov.	9.71
Dec.	16.58	Dec.	10.81
Jan. (1973)	14.46	Jan. (1974)	12.10
Feb.	13.18	Feb.	9.37
Mar.	10.78	Mar.	8.47
Apr.	11.27	Apr.	7.89
May	9.09	May	4.68
June	5.22		
	111.08		

Measures taken to conserve heating fuel are listed in table 23. Progress in conservation of heating fuel is summarized in table 24 and figure 20.

TABLE 23

CONSERVATION MEASURES

HEATING FUEL

NBS, Boulder

1 - Reduce thermostat settings from 70° F to 68° F during daytime.

2 - Nighttime and weekend setbacks of thermostats from 68° F to 60° F.

3 - Reduce thermostat setting in vestibule to 60° F.

4 - Installation of plastic foam on high top windows.

RECOMMENDATIONS

1 - Improve insulation in Liquifier Building and basement of Cryogenics Building

2 - Install thermally insulation glass in lobby and library.

3 - Lower ceiling in Cryogenic Shops to reduce heat loss and improve work area temperature.

4 - Install storm doors and tighten door closers.

Weather in Boulder in FY 74 has been milder than during the base year (FY '73) and this contributed significantly to reduced fuel use. However, figure 21 shows that heating fuel use, corrected for the weather, is considerably below previous consumption levels.

TABLE 24

CONSERVATION PROGRESS

FY 74 vs FY 73

HEATING FUEL USE

NBS, Boulder

Billion BTU

Quarter	FY 73	FY 74	Conservation
1	12.08	10.09	16.5%
2	35.00	27.11	22.5
3	38.42	29.94	22.1
April	11.27	7.89	
May	9.09	4.68	
Cumulative	105.86	79.71	24.7

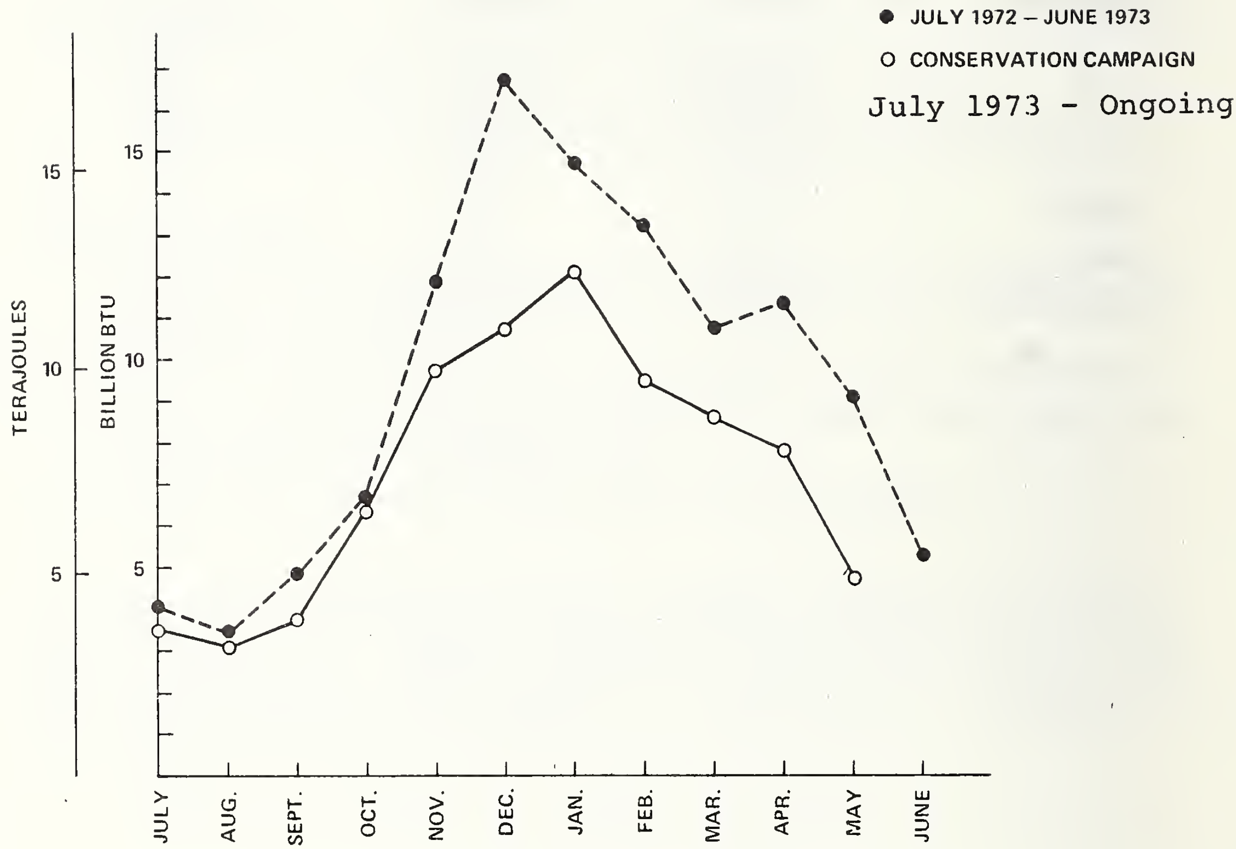

Figure 20. Heating fuel use from July 1972 to May 1974. (NBS, Boulder)

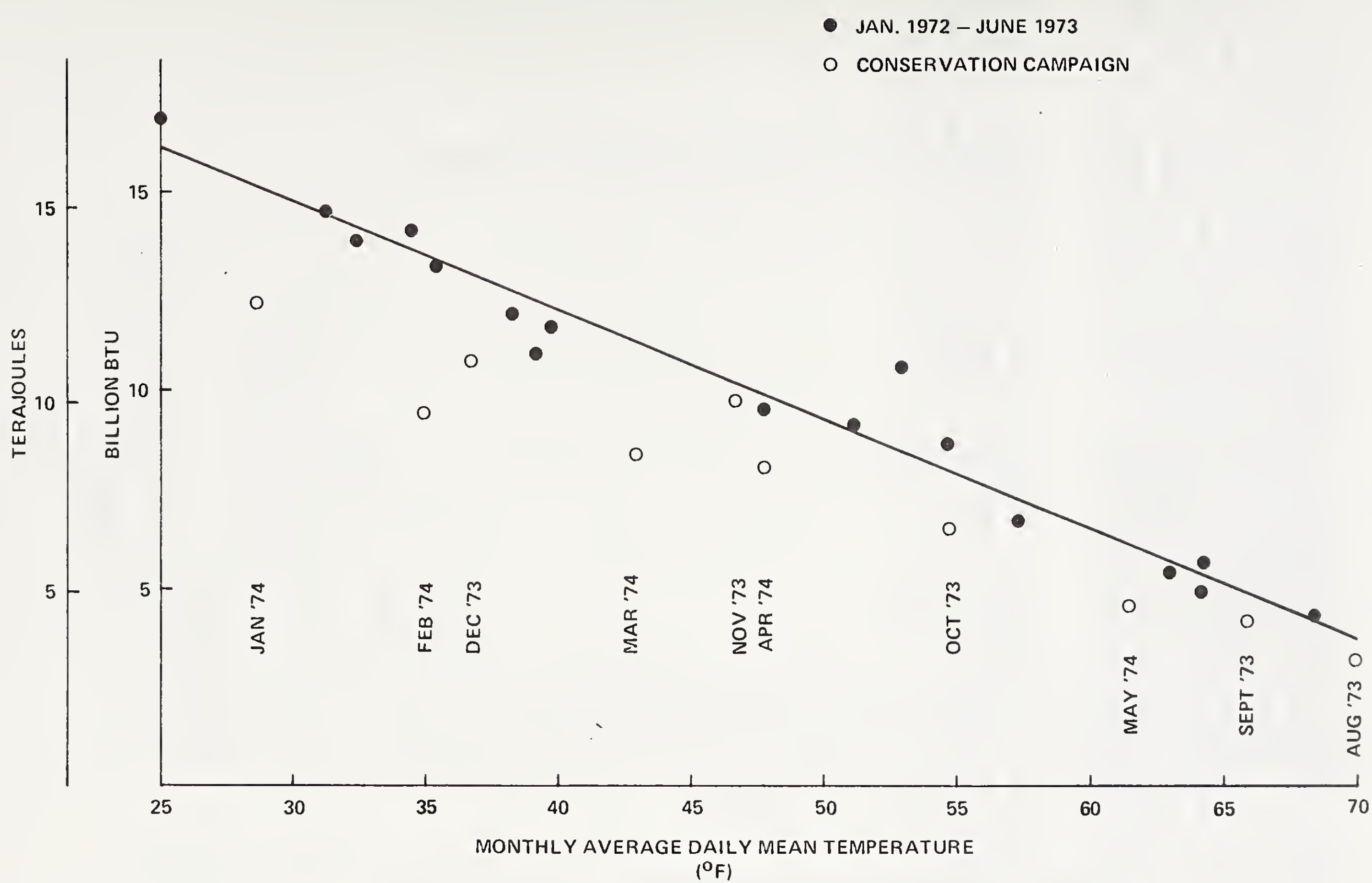

Figure 21. Heating fuel use vs outdoor temperature from January 1972 to May 1974. (NBS, Boulder)

TRANSPORTATION

NBS Boulder

The Task Force conducted a transportation survey of Department of Commerce employees at the Boulder Laboratories. Of the 1330 full and part-time employees at the several working locations within Boulder, 387 responded to the questionnaire. The distribution of employees by commuting distance is shown in figure 22. The average round-trip distance for employees is approximately 9 miles. The responses to other key questions on the transportation survey are shown in figures 23 and 24.

In addition to private vehicle use in commuting, respondents to the questionnaire indicated that they use their vehicles an average of $\sim$1.8 miles per day for lunch or personal business and an average $\sim$0.7 miles per day on official business.

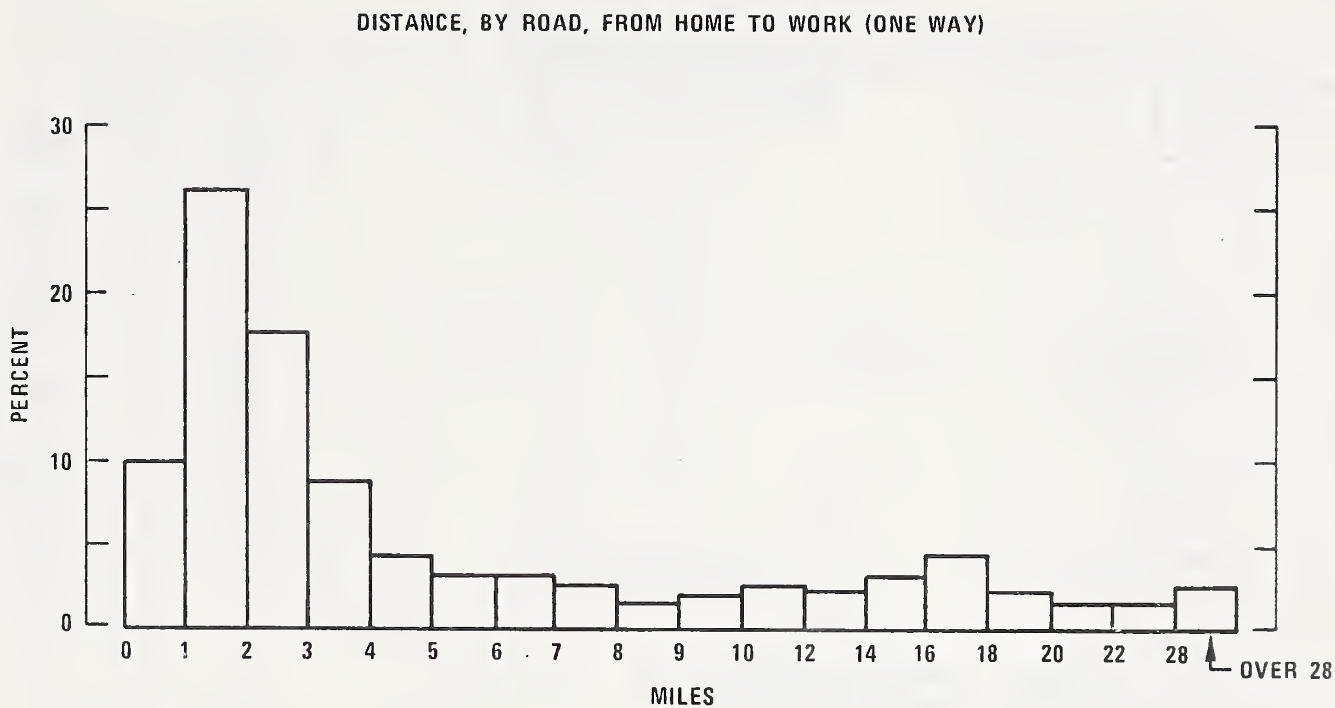

Figure 22. Distribution of employees by distance from work. (NBS, Boulder)

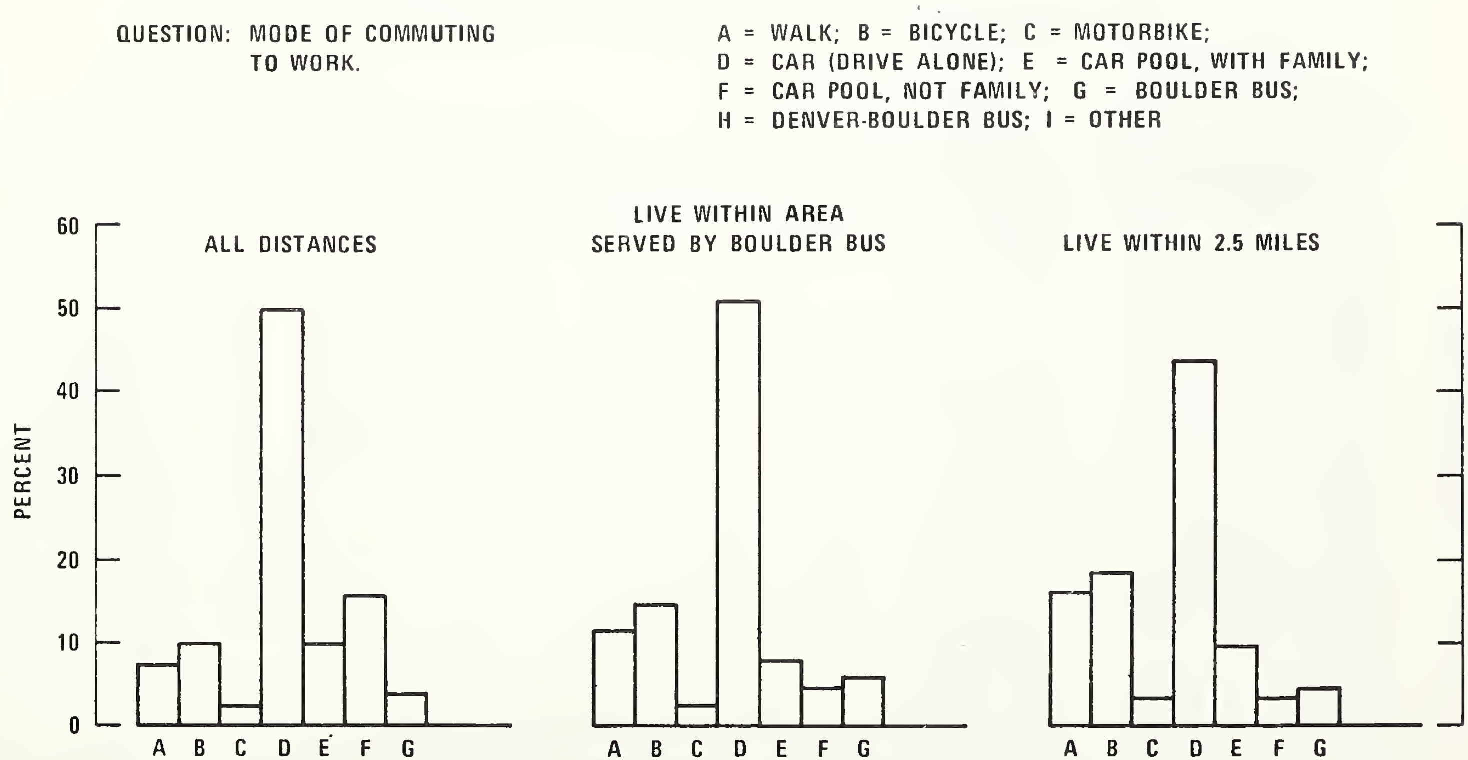

Figure 23. Mode of commuting to work by employees. (NBS, Boulder)

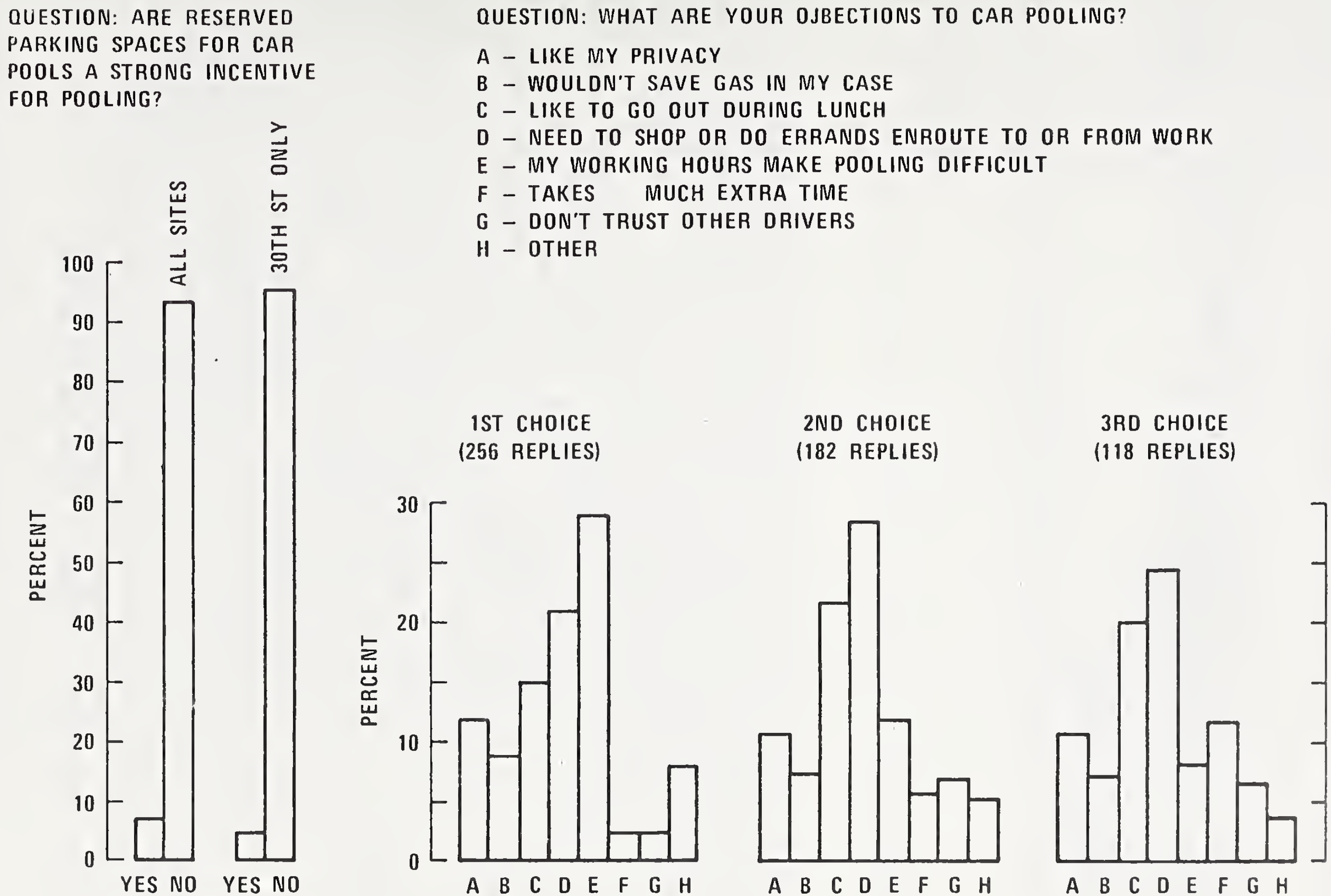

Figure 24. Responses by employees to carpooling questions in transportation questionnaire. (NBS, Boulder)

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

An Energy Task Force was established at NBS to effect energy conservation, to develop contingency plans to keep the Laboratories functioning in the event of reduced energy supply and to assist employees with transportation problems. The NBS Laboratories use a total of ~115 million kWh of electricity and ~780 billion BTU of heating fuel annually to power equipment and to provide a reliable environment. The Task Force conducted a systems analysis of energy use and found that 85% of the energy is used in climate control. A mathematical model for the climate control system was developed that affords an accurate comparison between observed and calculated energy use. As part of the analysis of energy use, conservation measures were identified and implemented. These measures include lighting reductions, building and zone shut-downs, thermostat adjustments, and changes in cooling coil control parameters. The conservation actions resulted in a reduction of ~12% in electricity and ~18% in heating fuel. The Task Force formulated contingency plans to reduce energy use on short notice in preparation to respond to area-wide energy problems. These plans provide for a set of priorities to produce a reduction of 2-5 megawatts in electrical demand and for an effective doubling in oil storage capacity. Task Force recommendations address all phases of energy use and implementation of them will increase electricity conservation to ~15% and heating fuel conservation to ~21%.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Contingency Plans; Electricity; Energy conservation; Heating fuels; Humidity control; Transportation

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