

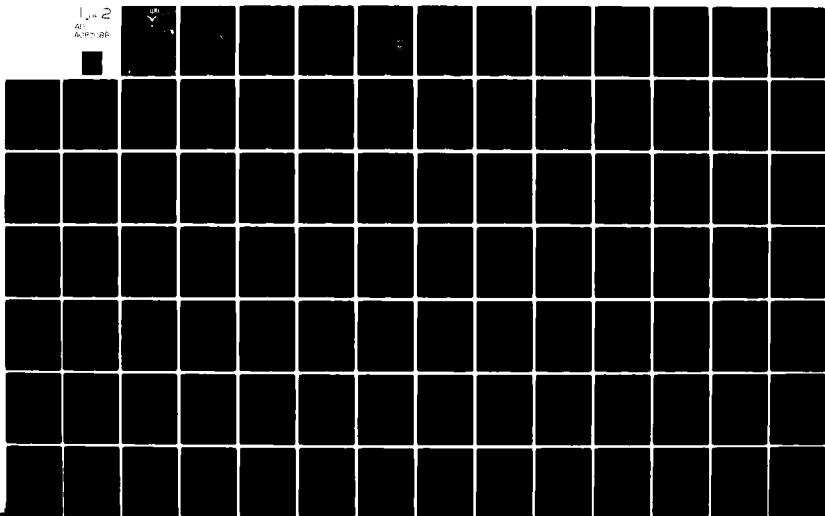
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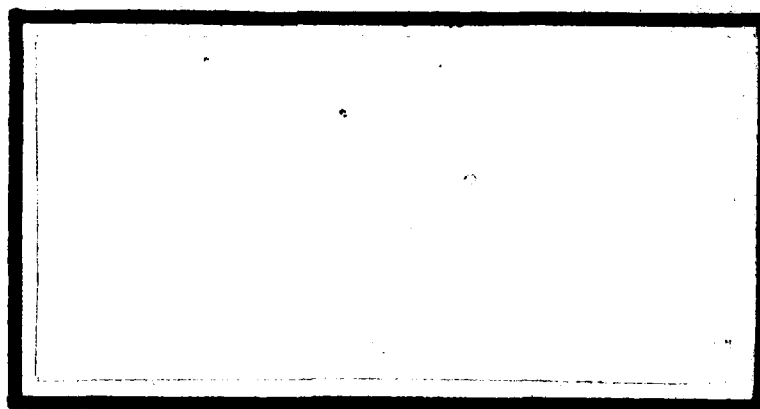
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A STUDY OF FUEL SUPPLIES FOR
EMERGENCY POWER GENERATION AT
AIR LOGISTICS CENTERS,

10 Captain Stephen J. Mott USAF
Captain Sherman D. Nelson USAF

14 AFIT LSSR 17-80

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The uncertainty of the availability of future supplies of petroleum has raised the possibility that a future electrical power curtailment could be accompanied by a simultaneous curtailment of petroleum fuel supplies. During such curtailments the ability of the Air Force Logistics Command's Air Logistics Centers to accomplish the essential operations required by a wartime scenario may depend upon the use of emergency back-up generators to provide electrical power to critical facilities. After obtaining information about the back-up generators at each Air Logistics Center and the quantities of fuel likely to be available for generator use during a supply curtailment, a linear programming computer package is used to determine the maximum length of time each Air Logistics Center can continue to meet its minimum critical operating requirements during a complete curtailment of commercially supplied electrical power and petroleum fuels. After reviewing the results of the computer analyses, the authors conclude that a long-term curtailment may have significant adverse impact on the ability of the Air Logistics Centers to meet critical operating requirements during a wartime scenario.

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A STUDY OF FUEL SUPPLIES FOR EMERGENCY POWER
GENERATION AT AIR LOGISTICS CENTERS

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Facilities Management

By

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June 1980

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Captain Stephen J. Mott

and

Captain Sherman D. Nelson

has been accepted by the undersigned on behalf of the
faculty of the School of Systems and Logistics in partial
fulfillment of the Requirements for the degree of

MASTER OF SCIENCE IN FACILITIES MANAGEMENT

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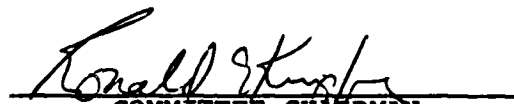

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CHAPTER I

INTRODUCTION

Background

The era of inexpensive and abundant petroleum resources for the United States ended in 1973 when the Organization of Petroleum Exporting Countries decided to drastically curtail exports of crude oil to the United States and other western industrialized nations, and to simultaneously increase to an unprecedented high the price of all exported petroleum. The oil embargo, rather than being a temporary inconvenience, emphasized to Americans the vulnerability of the United States' economy to interruptions in the supplies of foreign crude oil to domestic refineries. Though the impact of the embargo was reflected almost immediately through an increase in gasoline prices and nationwide gasoline allocation problems, the implications for continuing long-term effects on American industry were probably even more disconcerting.

The energy crisis of 1974 surprised most Americans, but a 1974 paper noted that an "energy shortfall was predictable [to what now is evident as good accuracy] from simple arithmetic projections a considerable time ago [26:4]." The turning point apparently occurred in 1969 when

the demand for oil and gas energy in the United States finally outstripped the supply from domestic sources (6:3). Since that time, not only has the United States failed to reduce energy demands to a level capable of being satisfied by domestic suppliers, but has continued to increase the range by which consumption exceeds domestic production. By 1976 annual consumption was exceeding domestic production by 1.6 billion barrels of oil and 12.8 billion cubic feet of natural gas (17:3).

Since approximately 70 percent of United States petroleum imports originate in nations belonging to the Organization of Petroleum Exporting Countries, the potential for another oil embargo is always present. The international political situation may again inspire the use of an oil embargo as a method for influencing foreign policies of the United States. The strategic flexibility of the United States then, has been significantly reduced because of the increased dependence on oil imports (17:8).

The electrical power produced by utilities accounts for approximately 25 percent of total energy requirements in the United States, but will account for 37 percent of the total requirement by 1985 (17:17). Unfortunately, much of this electrical power is produced by utilities with generating plants that burn oil or natural gas, both of which will continue to become more scarce and which will continue to be supplied in part by imports from foreign

countries (17:3). Since oil and natural gas have been available until recently at unrealistically maintained low prices, the use of alternate abundant fuels such as coal and reactor quality fissionable materials has not been vigorously pursued. Concerns about the potential harm to the environment caused by the use of coal and nuclear power plants have also inhibited the development of power plants using these abundant domestic fuels. Consequently, electric utility companies are potentially very vulnerable to another curtailment of petroleum imports. Of course, the breakdown of the reactor cooling system at the Three Mile Island nuclear electric generating plant in the Spring of 1979 made it clear that all power plants are vulnerable to unforeseeable circumstances which may cause losses of electrical power for considerable periods of time. In the case of the accident at Three Mile Island, the power plant will not be in operation again for several years, if it is indeed ever again reactivated.

Though efforts are being increased to make the United States more independent of foreign sources of energy supplies, mainly through conservation and development of alternate domestic resources, for the foreseeable future the United States will still be dependent on foreign energy supplies. A study by the Strategic Studies Institute completed in February 1978 concluded that:

. . . even with increased emphasis on conservation and accelerated development of additional domestic resources, there is little likelihood that the United States can increase its energy self-sufficiency by 1987. The most optimistic of forecasts indicate that the nation is likely to do no better than hold its present position [17:22].

The Defense Advanced Research Projects Agency predicted in 1972 that an energy shortage would "have deleterious effects on national security, in particular in economic, political, and military terms [8:29]." As the increase in energy usage at military facilities paralleled the increased usage in the economy as a whole, the Agency was particularly concerned with the fact that "nearly all U.S. military installations met their energy need through procurement from off-site commercial supplies [8:12]." This being the case, military facilities were not only susceptible to curtailments in the supply of electrical power and petroleum-based fuels caused by oil and gas shortages generated by foreign suppliers, but were also susceptible to curtailments caused by labor strikes, utility plant generating equipment failures, natural disasters, and even price disputes. In addition, military installations are generally not guaranteed an allocation of electricity during an energy shortage, as are police departments, fire departments, hospitals, and other facilities considered critical by the civilian community (19:26).

The deleterious effects of massive curtailments of electrical power were dramatically demonstrated during the

blackout of the northeastern United States in 1965. Regarding that blackout the Department of Defense (DOD) stated:

One of the lessons learned by the DOD and the entire civilian sector from the massive power failure of November 9, 1965 is that there is no substitute for adequate auxiliary electrical power systems in an emergency. The thousands of these systems which are installed by the civilian community in the wake of that great power failure is adequate testimony for this point. Furthermore, during that power failure, which caused a blackout in the entire northeastern United States, the DOD, because of a sound policy of the use of auxiliary electric power, did not suffer any loss of mission essential operations [7:25].

Of the 1.46 quadrillion British thermal units of energy consumed by the Department of Defense in fiscal year 1977, the U.S. Air Force consumed 48 percent of the total (4:3-2). Facility operations accounted for 30 percent of the Air Force's total consumption (4:3-2). As the energy supply situation becomes increasingly more acute in the future, the likelihood of electrical power and petroleum-based fuel curtailments at Air Force installations may increase commensurately. This increases the possibility that facility operations may also be adversely affected more than the past when supplies of electrical power and petroleum fuels were generally plentiful and almost guaranteed.

The Air Force has recognized the need for bases to reduce their dependence of commercially supplied energy, and most efforts have been directed towards reducing total demand through conservation. Alternate energy resources for military installations are also being considered as

future possible partial solutions to the Air Force's facility energy problem. Air Force regulations, however, currently require the use of existing commercial utility sources whenever economically feasible, rather than constructing or expanding Air Force power sources (24:4). According to the Construction Engineering Research Laboratory, an

. . . installation cannot economically compete with a utility company, because the utility company can use its much larger demand base and diversity to obtain large economies of scale [6:10].

Consequently, the dependence of military installations on commercially supplied electrical power will probably continue for many years in the future.

The Air Force regulation establishing the policies for obtaining electrical power from public utilities also recognizes that service interruptions may jeopardize the ability of an Air Force base to perform its mission. This regulation, AFR 91-5, states:

In a local emergency shortage, local utility companies may be forced to curtail or interrupt service to an Air Force base to the extent that it will endanger the mission [24:4].

This regulation also requires the installation commander to take "the necessary conservation action immediately, and make emergency provision for alternate temporary service to meet minimum requirements of the installation [24:4]." The development of a contingency plan for each base to reduce electrical power in an emergency and to use

emergency generators to assume part of the electrical load is also required (22:4). The increased probability of energy supply curtailments in the future makes such a contingency plan even more important.

Problem Statement

A future long-term curtailment of electrical supplies which coincides with a shortage of petroleum fuels could adversely affect the ability of Air Force installations to satisfy their critical operating requirements once initial stocks of emergency fuels have been exhausted. To date, no study has been found which determines the length of time that Air Force installations can operate using emergency power before resupply of fuels becomes imperative.

Justification

A review of the current literature addressing the energy problems of military installations indicates the lack of studies specifically relating to the emergency generator fuel requirements of military installations during periods of energy supply curtailments. The pressing need for energy conservation and the development of alternate sources of energy for the future dominates the attentions of most groups engaged in energy research. Evidence indicates that back-up emergency power capabilities need to be examined however, as problems with some Air Force installations' abilities to provide reliable emergency power do exist.

For example, AFR 91-4 requires annual review of "the generator and system capacity and loads, storage of fuel and lube oil, and the feasibility of shedding nonessential loads [20:16]." This requirement notwithstanding, a 1977 General Accounting Office (GAO) study of the management of emergency power generators by the Department of Defense stated that, in regard to emergency power requirements at Robins Air Force Base, Georgia,

Annual reviews required under Air Force regulations were not being made. Base Civil Engineering informed us that as long as complaints were not received, they considered that all needs were being satisfactorily met [7:30].

At Castle Air Force Base, California the GAO was told that

. . . to determine whether a continuing requirement exists for generators, the Base Civil Engineer each year verbally asks all generator users whether their missions have changed [7:29].

The Department of Defense (DOD) indicated the need for more information regarding potential problems faced by defense installations during an energy shortage in a study in 1978 which stated:

In accomplishing its mission in an energy shortage situation, DOD requires accurate information to assess the energy consequences of its present operations (and conversely), as well as to develop new programs to deal with both energy and mission-related problems [8:B-1].

Delimitation

With over 85 active Air Force installations in the continental United States, a study which attempted to gather

and analyze data from each base within the time constraints imposed would be difficult, if not impossible, to complete. In the attempt to answer the research questions soon to be posed, it is anticipated that a critical and in-depth analysis of the base emergency power requirements and fuel supplies will have to be made. For this reason, the scope of this study will be limited to a small sample of Air Force installations. Since policy at any particular base is generally a reflection of both Air Force and parent command policies, it appears to be sound practice to study bases under a single major air command. The colocation of the Air Force Institute of Technology with a major air command headquarters, that of Air Force Logistics Command (AFLC), permits ready access to data concerning not only the headquarters base, Wright-Patterson Air Force Base, but also other major installations in the command. In regard to the industrial functions performed by AFLC, the Air Logistics Centers (ALCs) represent a census of major AFLC installations, and this study will be limited to the ALCs for this reason. In addition to the contribution of readily accessible data through their headquarters base, the ALCs prove to be excellent elements of study for several other reasons.

First, the diverse locations of the ALCs throughout the United States permit the study of energy systems designed for differing climates, and hence will direct a look at a greater variety of power requirements than would

studying bases located in one particular climatic or geographic area. Second, most major AFLC installations can be classified as industrial power users. The nature of the work accomplished at these installations makes them heavily dependent on electrical power supplies, and consequently an effective contingency plan for restoring electrical power during an emergency is especially important. Third, the fact that the bases are located in different geographic areas of the nation precludes the possibility that several bases are part of the same electrical power grid system, and makes it very unlikely that any of the bases are supplied with power by the same major commercial utility company. Finally, the important role of AFLC bases in maintaining the defensive capability of the United States makes them excellent candidates for study. The inability of major AFLC bases to meet their minimum critical operating requirements during a curtailment of electrical power would most likely have adverse effects on all other major air commands, particularly during wartime.

Research Objective

The objective of this thesis is to determine the maximum length of time that the Air Logistics Centers can continue to meet their critical operating requirements by using emergency back-up generators during a long-term

curtailment of commercially supplied electrical power and petroleum fuels.

Research Questions

1. At each Air Logistics Center, what emergency power sources have been identified as necessary to meet critical operating requirements?
2. What is the fuel consumption rate for each emergency power source at each Air Logistics Center?
3. By type, what quantities of fuel are available at each Air Logistics Center to meet the requirements of back-up emergency power sources?
4. Relating fuel supplies and consumption rates to time, what is the maximum length of time each Air Logistics Center can operate on emergency power during a curtailment of commercially supplied electrical power and petroleum fuels?

CHAPTER II

METHODOLOGY

Introduction

The procedures for satisfactorily obtaining answers to the four research questions outlined in Chapter I can be divided in two general areas--data collection and data analysis. Providing answers to the first three research questions is the principal objective of the data collection effort, and analysis of the data will yield the answer to the fourth research question regarding the maximum length of time each ALC can operate using emergency back-up power during a curtailment of commercially supplied electrical power and petroleum fuels. In this chapter terms to be used in the discussion of the data collection and analysis procedures are defined, the population of interest is specifically identified, the data collection procedure is outlined, the data analysis procedure is discussed, and assumptions made during development of data collection and analysis procedures are summarized.

Definition of Terms

The following terms are used frequently throughout this study, and a thorough understanding of their definitions is essential to the reader. Definitions marked with an

asterisk are taken directly from Air Force Regulation 91-4, Maintenance and Operation of Electrical Power Systems (22:1).

1. *Base generated power--that electrical power generated in-house in support of Air Force facilities.
2. *Commercial power--that electrical power obtained from a commercial utility in support of Air Force facilities.
3. *Emergency power--an alternate source of electrical power available for use in the event of a failure of the primary power source.
4. Fuel consumption rate--the amount of fuel used per unit time (usually expressed in gallons/hour).
5. Load shedding--a reduction in electrical power total demand realized through selective shut-down of non-essential loads.
6. Minimum critical operating requirement--a requirement, as defined by the agency having responsibility for that requirement, which, if not met, will result in serious mission degradation or failure.
7. Mobile generator--a generator designed to be readily transported to location of use. (Includes all generators not identified as real property installed equipment.)
8. Output power rating--the electrical power, measured in kilowatts, that a generator is capable of supplying to a load.

Description of Population

As indicated in Chapter I, this study is limited to the Air Logistics Centers of AFLC. These installations are:

1. McClellan Air Force Base, California
2. Hill Air Force Base, Utah
3. Tinker Air Force Base, Oklahoma
4. Kelly Air Force Base, Texas
5. Robins Air Force Base, Georgia

Results from this study cannot be extended in general to other Air Force installations. The ALCs being studied are not a random sample of any larger population. Consequently, inferences about the larger population of installations which may include all Air Force bases or possibly all Department of Defense installations cannot be made from this study. However, the numerical techniques and method of analysis employed are not limited only to the population under study here and therefore could be used in the study of other installations.

Measurement Parameters and Variables

For each ALC, several parameters will have to be measured or obtained to facilitate the derivation and grouping of variables used in the data analysis. These parameters fall into two categories; those which are characteristics of the emergency power systems and those which are

characteristics of the emergency fuel stocks. Necessary characteristics of the emergency power systems at each ALC and a description of how they are utilized are as follows:

1. Type of system (diesel, gas turbine, spark fired internal combustion, etc.)--necessary to determine the type of fuel required for any particular generator.

2. Power output rating--necessary to determine the fuel consumption of the particular generator in question. Used in conjunction with fuel type and manufacturer/model number to determine fuel consumption rate.

3. Fuel type (gasoline, diesel fuel #2, etc.)--necessary to properly identify each type of fuel which can impact an ALC's ability to provide emergency power. Used in conjunction with manufacturer/model number and power output rating to obtain fuel consumption rate.

4. Fuel consumption rate (R)--determined for each generator and used as an independent variable in the analysis section of this study.

5. Fuel tank capacity (F)--measured in gallons for each generator and used as an independent variable in the analysis section of this study.

6. Associated facility--information to be maintained, for each generator, so that results of this study can later be specified as to particular impact on the ALC in question.

7. Manufacturer/model number--used in conjunction with fuel type and power output rating to determine fuel consumption.

Necessary characteristics of emergency fuel stocks at each ALC and a description of how utilized are as follows:

1. Fuel type (gasoline, diesel fuel #2, etc.)--necessary to identify type of generator to be supplied from a particular fuel stock.

2. Fuel quantity stored (Q)--necessary to determine the supply impact of that particular type of fuel.

The variables necessary for the analysis portion of this study which are derived from the above parameters are:

1. Time (T)--the dependent variable of the analysis procedure of this study which indicates the maximum length of time an ALC can operate on emergency power under a curtailment of commercially supplied electrical power and petroleum fuels.

2. Fuel consumption rate (R)--an independent variable used in the analysis procedure of this study.

3. Fuel supply (S)--an independent variable used in the analysis procedure of this study.

4. Fuel tank capacity (F)--an independent variable used in the analysis procedure of this study.

Obviously, there are other variables that could affect the ability of an ALC to meet its critical operating

requirements. The objective of this study, however, is to isolate only the effects of emergency fuel supplies on the ALC's ability to maintain critical operations. Therefore, several assumptions must be made concerning other factors which may affect this ability. First, it is assumed that sufficient maintenance and support personnel and equipment exist to keep all generators operating. Second, the requirements for emergency power generation in AFLC are, in the worst possible case, based on the necessity to maintain critical operations "during a wartime scenario in which AFLC installations must support overseas operations [20:1]." The 1979 AFLC study which outlined the requirement for emergency power based upon a wartime scenario also required the Air Logistics Centers to determine if generators were being used to support facilities not required during a wartime scenario, and if any facilities critical to operations during a wartime scenario were not being supported with emergency power. Though no facilities currently being supported with emergency generators were identified as being unnecessary during a wartime scenario, additional critical facilities were identified which were not being supported with emergency power (1). All existing emergency generators then are apparently required to support critical operations during a wartime scenario. Since additional generators will be installed in the future to support those critical facilities currently without emergency power, this study

will also include the effect of these additional generators on the length of time the ALCs can maintain critical operations. Further, in the absence of restrictions or operating limitations to the contrary, it is assumed that implicit in a wartime scenario is the demand for continuous support from the ALC. Operationalizing this assumption for the purpose of this study requires examination of emergency generator fuel supplies under conditions of continuous, seven-day-a-week, twenty-four-hour-a-day operation. Consequently, the maximum length of time that the ALCs can maintain critical operations, for the purpose of this study and under the assumptions just outlined, is the maximum length of time that all existing and proposed emergency generators can operate on the ALC's supply of emergency fuel.

Data Collection

The data collection effort is designed to provide information regarding the measurement parameters contained in the summary list of parameters. With minor exceptions, this information will also essentially answer the first three research questions which seek information required to determine the value of the dependent variable, time, in the data analysis section.

For each Air Logistics Center, the data required are divided into two major areas--emergency power systems and emergency fuel storage tanks. Seven different

parameters are required for each power system, and two parameters are required for each fuel storage tank.

Much of the information regarding both power systems and fuel storage tanks can be obtained from each Air Logistics Center in the form of Annexes to the Civil Engineering Base Recovery Plan (required by AFR 93-2), which is a contingency plan used to facilitate and expedite restoration of installation operations following a variety of potential disasters.

Information regarding the following parameters is located in Annex M, "Alternate or Emergency Power Sources and Lighting Systems:"

1. Each Emergency Power System
2. Each System's Power Output Rating
3. Each System's Fuel Type
4. Each System's Associated Facility
5. The Manufacturer/Model of Each System

The specific format for Annex M is outlined in AFR 93-2, and the Annex contains a complete list of all emergency generators on the installation, and certain information about each generator, not all of which is required by this study. The information on each generator in the Annex is listed in the following format:

1. Priority of Recovery
2. Location
3. Description (Manufacturer/Model)

4. Condition
5. Size (Kw)
6. Fuel (Type)
7. Operation (Manual/Automatic)
8. Approximate Running Time

The associated facility for each generator is determined by its location. The power output rating for each generator corresponds to the size in kilowatts listed in the Annex. The fuel type for each generator and the manufacturer/model are specifically listed.

Since the Base Recovery Plans are usually reaccomplished only yearly, the accuracy and currency of the information in the plans will be verified by examining, for each base, the Generator Status Chart, which "has data on each backup and standby generator maintained by Base Civil Engineering [23:p.2-3]." The format for this chart is located in AFR 85-1. Continuously maintained by the electrical power production shop, the chart includes the following information of interest:

1. Priority
2. Location
3. Manufacturer
4. Kw Rating
5. Maximum Running Time

Notice that both Annex M of the Base Recovery Plan and the Generator Status Chart provide information on

generator running times. Though approximate or maximum running time could be an indirect indicator of both fuel tank capacity and fuel consumption rate, the regulations do not specify a method of computing running time, nor is running time specifically defined in terms of the hours per day that the generators would be operating. The running time in days of a continuously operating generator will obviously be less than the running time in days of the same generator operating only eight hours per day. Consequently, information regarding the specific fuel consumption rates for each emergency power system can be obtained from the manufacturer's technical specifications, which are available from the plant engineering service of the Information Handling Services company. The fuel consumption rate depends upon the manufacturer's model, the type of system, and the system output power rating. The fuel tank capacities for each power system can be obtained from the power production shop at each installation.

In addition to emergency power systems already installed at the ALCs, this study examines the impact of proposed emergency power systems on the length of time the ALCs can maintain critical operations. Information on the parameters for proposed systems can be obtained from the AFLC directorate of engineering in the form of the current Military Construction Project Data for the Command. The format for this data is DD Form 1391, which contains

information regarding only required output power ratings and associated facilities. Fortunately, other parameters can be estimated using a USAF Aeropropulsion Laboratory study of Air Force Ground Power Requirements (5). This study provides average values for the required parameters based on the power system type and power output rating. The majority of emergency power systems use diesel engine generators fueled by No. 2 distillate oil, and an assumption for the thesis is that proposed emergency power systems will be of the diesel engine generator type.

Information regarding emergency fuel storage tanks is contained in Annex P of the Base Recovery Plan. This annex, entitled "POL Storage, Distribution and Emergency Backup," describes "the various POL systems including storage capacity, location of tanks and distribution system, and source of emergency stocks [21:35]."

Data Analysis

Recall that the dependent and independent variables are, respectively, time (T), fuel consumption rate (R), fuel tank capacity (F), and fuel stock allocation (S). For each emergency generator the dependent variable, time, is related to the independent variables by the following simple linear equation:

$$T=F/R+S/R$$

For each generator, the values of the independent variables, F and R , are known after completion of the data collection procedure, and they become constants in the equation. If F/R is defined as equal to constant B , and $1/R$ is defined as equal to the constant M , the equation reduces to what is easily recognized as a standard linear equation form:

$$T=MS+B$$

Thus, with a known fuel tank capacity and fuel consumption rate, the length of time a generator can operate is dependent upon the quantity of fuel allocated to it from the total additional emergency fuel stocks (corresponding to the type of fuel used in the system).

If an installation has an N number of generators using a specific fuel type, the following set of simultaneous equations describes the relationships between time and allocated fuel stocks:

$$\begin{aligned} T_1 &= M_1 S_1 + B_1 \\ T_2 &= M_2 S_2 + B_2 \\ T_3 &= M_3 S_3 + B_3 \\ &\vdots \\ T_N &= M_N S_N + B_N \end{aligned}$$

where $B_i = F_i / R_i$, and $M_i = 1 / R_i$, $i=1$ to N .

Since all generators will be required to operate the same total length of time,

$$T_1 = T_2 = T_3 = \dots = T_N$$

Summing the N simultaneous equations yields:

$$\begin{aligned} NT &= (M_1 S_1 + B_1) + (M_2 S_2 + B_2) \\ &+ (M_3 S_3 + B_3) + \dots + (M_N S_N + B_N) \end{aligned}$$

or

$$\begin{aligned} T &= \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N} \\ &+ \frac{B_1}{N} + \frac{B_2}{N} + \frac{B_3}{N} + \dots + \frac{B_N}{N} \end{aligned}$$

Let:

$$\frac{B_1}{N} + \frac{B_2}{N} + \frac{B_3}{N} + \dots + \frac{B_N}{N} = K$$

Then:

$$T = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N} + K$$

or

$$R - K = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N}$$

Since K is a constant, maximizing the right-hand side of the equation will yield the maximum time T, when K is again added to the right-hand side.

Let a variable $Z=T-K$. Then, also,

$$Z = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N}$$

This equation is in the standard form for solution by the linear programming solution technique known as "Simplex." This is a method for determining the optimal solution to a set of simultaneous linear equations with equality or inequality constraints. In this case, the maximum value of Z is required, subject to the constraint imposed by the finite quantity of emergency fuel at each installation.

The sum of the individual fuel allocations to each generator from emergency fuel stocks cannot exceed the total emergency fuel quantities stored on the installation, or:

$$S_1 + S_2 + S_3 + \dots + S_N \leq S_t,$$

where S_t represents the total available emergency fuel stocks. S_t is determined by summing the quantities of each individual emergency fuel tank on base. For L fuel tanks,

$$S_t = Q_1 + Q_2 + Q_3 + \dots + Q_L,$$

where Q is the quantity of fuel stored in each tank.

The fact that all generators are required to operate the same length of time imposes additional constraints on the system.

Since

$$T_1 = T_2 = T_3 \dots = T_N,$$

and

$$T_i = M_i S_i + B_i \quad i = 1 \text{ to } N,$$

then

$$\begin{aligned} M_1 S_1 + B_1 &= M_2 S_2 + B_2 = M_3 S_3 + B_3 \\ &= \dots = M_N S_N + B_N. \end{aligned}$$

The following is a convenient method for expressing the above equality in a manner suitable for linear programming:

Since

$$M_1 S_1 + B_1 = M_2 S_2 + B_2$$

then

$$M_1 S_1 - M_2 S_2 = B_2 - B_1$$

which is an equality constraint requiring that $T_1 = T_2$.

Likewise,

$$M_2 S_2 - M_3 S_3 = B_3 - B_2$$

or

$$T_2 = T_3.$$

The general expression for the set of $N-1$ constraints required to ensure that all the times are equal is:

$$M_i S_i - M_{i+1} S_{i+1} = B_{i+1} - B_i \quad i=1 \text{ to } N-1.$$

These constraints are generally all that is required to guarantee a feasible solution, except for one specific case. The case occurs when the total quantity of emergency fuel to be allocated is not sufficiently large to ensure that the maximum time, T , will be greater than the time that an individual generator can operate on its attached fuel tank alone. The equality constraints then force one or more of the allocations, S , to be negative, as the system tries to draw fuel from the generator with excess fuel. Since Simplex requires the variables to be greater than zero, the solution is infeasible. Elimination of the generator with excess capacity from the system will allow the Simplex method to optimally allocate the emergency fuel to the remaining generators.

The solution to the problem by the Simplex method will reveal the maximum length of time the generators will operate and the quantities of fuel which should be allocated to each specific generator to attain that maximum. Once the value of Z is maximized, the maximum time, T , is determined by adding the constant K to the value of Z .

Since:

$$Z = T - K$$

Then:

$$T_{\max} = Z + K$$

The equation to be maximized, called the objective function, and the constraints are summarized below:

Objective Function:

$$Z = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N}$$

Constraints:

$$S_1 + S_2 + S_3 + \dots + S_N \leq S_t$$

$$S_1, S_2, S_3, \dots, S_N \geq 0$$

$$M_i S_i - M_{i+1} S_{i+1} = B_{i+1} - B_i \quad i = 1 \text{ to } N-1$$

A separate Simplex problem must be solved for each type of fuel used by emergency power systems at each Air Logistics Center. With five Air Logistics Centers and possibly two or three different fuel types, ten or fifteen Simplex problems must be solved. These Simplex problems were solved using a linear programming computer code known as the Honeywell LP600 Linear Programming Package. An example problem illustrating the validity of the analysis procedure is explained in Appendix P.

The maximum length of time the generators can operate will most likely be different for each type of fuel. Since the operation of all generators is necessary to meet an installation's critical operating requirements, the maximum length of time these requirements can be met will be limited by the type of fuel which is exhausted

first. In other words, given two fuel types, f_1 and f_2 , where $T_{\max}(f_1) < T_{\max}(f_2)$, the maximum length of time that critical operating requirements can be satisfied at that installation will be $T_{\max}(f_1)$.

Though the specific objective of the thesis is to determine the maximum length of time the ALCs can operate using emergency generators and emergency fuel stocks, this maximum is dependent upon the proper allocation of the fuel stocks to the generators. Consequently, each allocation can be expressed in terms of the number of times each generator will be completely filled, and the number of gallons of fuel to be pumped into the generator tank the final time it is refueled. This is determined by dividing each allocation, S , by the associated fuel tank capacity, and expressing the remainder in gallons. A generator allocated 25 gallons, for example, and having a 10-gallon fuel tank, would be refilled completely twice, and would receive a half tank, or 5 gallons, on the final refueling.

Completion of the previously outlined analysis for each Air Logistics Center successfully answers the fourth research question, and fulfills the thesis objective, which was to determine the maximum length of time the Air Logistics Centers could operate using emergency power during a curtailment of electrical power and petroleum fuels.

Summary of Assumptions

1. All information obtained from valid, official Air Force sources is accurate.
2. Commercial sources of emergency power are not available during a supply curtailment.
3. Proposed emergency power systems will be diesel engine generator type.
4. Emergency power systems will be operating continuously during a wartime scenario.
5. All emergency power systems must be operating in order for an installation to meet its minimum critical operating requirements.
6. Maintenance and support, parts and services are adequate to maintain continuous generator operation.

CHAPTER III

DATA COLLECTION

Introduction

This chapter outlines particulars of the actual collection of the program input data specified in Chapter II. Although the actual collection effort closely follows the proposed collection plan, variations in the way that each particular ALC maintained and reported the needed data necessitated a particular approach to data retrieval in each case. This was precipitated by the facts that:

1. In most cases, Annex M of the base recovery plans did not contain all data required by AFR 93-2.
2. Annex P of each of the base recovery plans did not present fuel data in a manner which permitted the determination of the amounts of fuel allocated specifically to emergency back-up power generation.

The effect of the above general circumstances on the actual retrieval of the generator and fuel data from each particular ALC will be detailed in the respective following sections of this chapter. An additional circumstance which became evident during the actual data collection effort was that the study could be condensed to consider only those generators powered by diesel fuel without impacting on the results. For each of the ALCs in question, the number and

size of the gasoline powered generators were so limited as to make it intuitive that their inclusion would not be a controlling factor in the study.

Generator Data

General

A summary listing of the generator data for each ALC is attached as Appendix A of this study. Generators identified by an asterisk in this appendix are those which an AFLC study (1) has indicated are necessary to permit that particular ALC to meet its minimum operating requirements, but that are only proposed at the present time. Data for these generators at each ALC were obtained from DD Forms 1391 of the FY 82 Military Construction Program (2:6,17, 24,36,49) for Hill AFB, Kelly AFB, McClellan AFB, Robins AFB, and Tinker AFB, respectively. As described in Chapter II of this study, these DD Forms 1391 include only required output power rating and associated facility. Fuel consumption rate figures for these proposed generators were determined by interpolation from a chart of fuel consumption versus output power for continuous operation in an Air Force Aeropropulsion Laboratory technical report (5:108). These fuel consumption figures were compared with actual manufacturer data obtained through the Information Handling Services company (10) for generators of corresponding output power and were found to be very highly correlated,

indicating that the interpolated values are reliable predictors of fuel consumption rates for generators of unknown make and model. Generator fuel tank capacities were also not specified for the proposed generators, making it necessary to assume a value for this input parameter for each of the proposed generators. The "USAF Terrestrial Energy Study" accomplished by Air Force Aeropropulsion Laboratory specifies a "design-to" target of a five-day fuel capacity for diesel power systems of 10 MW or less (5:100). As the proposed generators at all five ALCs fall into this category, the generator fuel tank size of each was selected as the quantity which permitted that particular generator to run five days under conditions of continuous operation. This value is simply the interpolated hourly fuel consumption rate multiplied by 120 hours (5 days). These tank capacities and running times are not inconsistent with those of many generators already in place at the ALCs.

Data on Existing Generators

This section identifies the source of the input data by ALC, for the parameters outlined in Chapter II with the exception of fuel consumption rates. As earlier described, the fuel consumption rate of each generator is determined by generator specifications and not the running times listed in the base recovery plans of the various ALCs.

Therefore, consumption rate determination will be detailed in a separate following section.

Hill AFB. Data on the parameters of facility, manufacturer, power rating, fuel type, and tank capacity of installed generators were obtained from the base recovery plan (12:M-1 to M-3). Generator model numbers and tank capacities of mobile generators were obtained from the generator status board and/or records at Hill AFB (16). Base recovery plan data were also confirmed or adjusted as necessary based on these contacts (16).

Kelly AFB. Data on the parameters of facility, power rating, fuel type, and tank capacity were obtained from the base recovery plan (13:M-1). Manufacturer and model number, as well as corroboration of base recovery plan data were obtained via telephone communication (9).

McClellan AFB. Data on the parameters of the facility and power rating only were available from the base recovery plan (14:64-65). Data on manufacturer, model number, fuel type, and tank capacity for each generator was obtained from records and the generator status board at McClellan AFB (3). Contact with personnel at McClellan AFB was also used to verify all data (3).

Robins AFB. All necessary data excepting tank size were available in the base recovery plan (15:M-1-1 to M-2-1).

Data corroboration and tank size were obtained by telephone communication with Robins AFB personnel (11).

Tinker AFB. The base recovery plan for Tinker AFB was under revision and unavailable at the time of the data collection effort. All data were collected via telephone contact with Tinker AFB personnel (18).

Fuel Consumption Rate Determination

Once the parameters of manufacturer (or make), model number, and output power were obtained, fuel consumption rate for any given generator was determined in one of three ways:

1. Generators identified with MB series model numbers are federally stocked generators made by numerous different manufacturers, even for a given particular output rating. Fuel consumption rates for these generators are an adopted standard to insure consistency in planning, and were obtained directly from Air Force records at the ALCs (3; 9; 11; 16; 18). These generators are identified in Appendix A by their associated MB series model numbers.

2. For generators of known make and model, a search of Data Control Services Plant Engineering Series microfilm records was made; where the exact make and model could be located, fuel consumption rate data were taken directly from these records (10). Generators where the data were

obtained in this manner are identified in Appendix A by an (a) following the fuel consumption rate figure.

3. Some generators of known make and model were not locatable through Plant Engineering Series microfilm records. In this instance, the fuel consumption rate used was one of the following:

a. The average rate of all generators of that particular output power by that particular manufacturer, as determined from VSMF Plant Engineering Series microfilm (10).

b. Where less than two generators of the same output rating and manufacturer were locatable, the fuel rate used was one which was equal to the rate of the one generator of that power output that was found.

c. If no generator for that output and by that manufacturer was locatable, the fuel consumption rate used was the average of all generators of the particular output found in the VSMF Plant Engineering Series microfilm records, regardless of manufacturer.

To ensure consistency and the most accurate data possible, this procedure was followed in the order in which it was just described. Generators for which fuel consumption rate data were found in this manner are identified by a (b) following their respective fuel consumption rate figure in Appendix A.

Note that some generators in Appendix A are identified by the same generator number. Those generators with the same number share a common fuel tank, and will share the fuel allocation identified by the linear programming analysis. Also, since the generators share a common fuel tank, the consumption rate associated with that fuel tank and used in the linear program is simply the sum of the consumption rates of all generators sharing that tank.

Fuel Availability Data

As previously stated, Annexes P of the base recovery plans did not present fuel data in a manner which permitted the determination of exact amounts of fuel specifically allocated to emergency back-up power generation. These annexes listed total quantities of fuel from which fuel for back-up power generation was drawn. Therefore, it was necessary to deviate from the original data collection plan specified in Chapter II to obtain the needed data. A proper determination of fuel quantities available for emergency power generation was obtained through the Command Fuels Office at Headquarters AFLC (25). Data needed from this source was in the form of total diesel fuel available and a daily demand rate (DDR) for its use at each ALC. In this form, these fuel figures could be incorporated into the linear programs utilized in this study by treating the daily demand rate as a surrogate generator or fuel user and

treating the fuel available as a source from which all emergency power generators and the surrogate generator at each ALC could draw. The actual data obtained was in the form of barrels of fuel available and daily demand rate expressed in barrels per day. This data is presented in tabulated form for each ALC on the last page of Appendix A. For incorporation into the linear program package used in this study, the data were converted to gallons and gallon per hour rates, as appropriate, to make them consistent with all other generator data. The standard conversion of 42 gallons per barrel was used in these conversions.

CHAPTER IV

RESULTS OF DATA ANALYSIS

Introduction

This chapter discusses the results of the LP600 programs for each Air Logistics Center. The LP600 programs and selected output products for each ALC are contained in the appendices. Prior to discussing the individual results for each installation, the slight change in the analysis procedure resulting from the lack of specifically identified emergency fuel stocks must be discussed. Recall from Chapter III, Data Collection, that information was obtained on the maximum total amount of diesel fuel available at an installation and also the average daily demand rate for diesel fuel at the installation. The total amount of diesel fuel available must supply both the normal requirements of the installation, as represented by the daily demand rate, as well as the added requirements of the emergency generators during an electrical power supply curtailment. Consequently, for the purpose of developing the objective function, daily demand rate can be considered an analogue of the fuel consumption rate associated with each emergency generator. Including the daily demand rate for the installation in the objective function and in the time equality

constraints allows the construction of a fuel supply constraint which has as its limiting parameter the total amount of diesel fuel available on the installation, rather than an amount specifically set aside as an emergency fuel stock. This is a more realistic approximation of the situation as it actually exists at the ALCs, regardless of the implication in the format for Annex P of the Base Recovery Plan that separate emergency fuel stocks for generators do exist.

The problem of one or more individual generators being able to run longer on the attached fuel tanks than the system as a whole can run on the total amount of additional diesel fuel available was discussed in Chapter II. Recall that the Simplex problem is infeasible when this situation exists, and the offending generators must be eliminated from the system before an optimal solution can be found. Since the coefficients of the objective function and the constant K are based, in part, on the number of generators in the system, elimination of generators from the system would seem to require the computation of a new set of coefficients and a new constant each time generators are eliminated. The coefficients, however, maintain the same relative proportions to each other, regardless of the number of generators in the system, and the proper optimal solution can be determined simply by multiplying the optimal value on the computer output by a ratio of the

original number of generators in the system, and the number of generators remaining in the system when the Simplex problem finally becomes feasible.

For a system of N generators the objective function is:

$$Z = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_N S_N}{N}$$

If three generators must be eliminated to produce a feasible problem, a system of $N-3$ generators results. Rather than adjusting each coefficient prior to maximizing the objective function, the computer program is run with the original coefficients and Z is adjusted to account for the change in the number of generators in the system.

The objective function maximized will be:

$$Z = \frac{M_1 S_1}{N} + \frac{M_2 S_2}{N} + \frac{M_3 S_3}{N} + \dots + \frac{M_{N-3} S_{N-3}}{N}$$

The resulting maximized Z is adjusted by a ratio of $\frac{N}{N-3}$.

$$Z_{\text{adjusted}} = \frac{ZN}{N-3}$$

$$\begin{aligned} &= \frac{M_1 S_1 N}{N(N-3)} + \frac{M_2 S_2 N}{N(N-3)} + \frac{M_3 S_3 N}{N(N-3)} + \dots + \frac{M_{N-3} S_{N-3} N}{N(N-3)} \\ &= \frac{M_1 S_1}{N-3} + \frac{M_2 S_2}{N-3} + \frac{M_3 S_3}{N-3} + \dots + \frac{M_{N-3} S_{N-3}}{N-3} \end{aligned}$$

Thus the adjusted Z is the correct optimal value for a system of $N-3$ generators when the objective function

coefficients are not changed each time a generator is eliminated from the system. Examination of the LP600 input programs in Appendix B will illustrate the wisdom of adjusting Z rather than adjusting individual coefficients. The constant K is also computed based on the number of generators remaining in the system when the problem becomes feasible.

Analysis of Robins Air Force Base

The LP600 computer output for Robins AFB is contained in Appendix C. The first page illustrates the 28 successive iterations required to obtain the optimal solution for the objective function. The optimal solution is the value in the functional column at the final iteration. The next page illustrates the slack values in the constraints and the original right-hand-side values for the set of linear equations. Since the only actual resource constraint is that constraint associated with the total amount of fuel available, the program should continue increasing the value of the objective function until the fuel is completely exhausted. Complete allocation of the available fuel is indicated by a slack of zero in the fuel constraint row. The time constraints, since they are equality constraints, also have zero slack. The fuel quantities allocated to each generator are located in the column marked "X-value."

The Robins AFB problem was feasible with all generators in the system, and no adjustment of Z was necessary. From the LP600 computer output:

$$Z = 232.6$$

Recall that the constant $K = \sum \frac{F_i}{R_i N}$ $i = 1$ to N .

Or: $K = 90.3$

Solve for $T_{\max}$: $T_{\max} = Z + K$
 $T_{\max} = 232.6 + 90.3$
 $= 322.9$ Hours
 $= 13.45$ Days

Based on a maximum total quantity of diesel fuel of 101,976 gallons, Robins AFB can operate on emergency power for 13.45 days.

Analysis of Hill Air Force Base

The Hill AFB problem required the elimination of two generators for the problem to be feasible. Both the original program and the modified program are contained in the appendices. Examination of the original program output in Appendix E reveals that all generators in the system were not included in the basis, and thus an optimal solution was not found. The optimal value for Z from the adjusted program output in Appendix F is:

$$Z = 336.1$$

This value of Z must be adjusted by a ratio to account for the change in the number of generators included in the final computer program. The original N was 47. Since two generators were eliminated from the system, the proper ratio is 47/45.

$$\begin{aligned} Z_{\text{adj.}} &= Z(47/45) \\ &= (336.1)(47/45) \\ &= 351 \end{aligned}$$

$$K = 100.4$$

$$\begin{aligned} T_{\text{max}} &= Z_{\text{adj.}} + K \\ &= 351 + 100.4 \\ &= 451.4 \text{ Hours} \\ &= 18.8 \text{ Days} \end{aligned}$$

Based on a maximum total quantity of diesel fuel of 215,712 gallons, Hill AFB can operate on emergency power for 18.8 days. Since the generators eliminated from the system can operate considerably longer than 18.8 days on their attached fuel tanks, all other generators and the air base would run out of fuel before these two generators. Nevertheless, since all generators are required in order to meet minimum critical operating requirements, 18.8 days is the limiting value.

Analysis of McClellan Air Force Base

Since the McClellan AFB problem required the elimination of generators for a feasible problem, the original and adjusted programs are included in the appendices. The optimal solution from the adjusted program (Appendix I) also must be adjusted for the changed value of N.

$$Z = 278.7$$

$$\begin{aligned} Z_{\text{adj.}} &= 278.7(36/31) \\ &= 323.7 \end{aligned}$$

$$K = 55$$

$$\begin{aligned} T_{\text{max}} &= Z_{\text{adj.}} + K \\ &= 278.7 \text{ Hours} \\ &= 15.8 \text{ Days} \end{aligned}$$

Though some generators can operate longer than 15.8 days, with a total quantity of diesel fuel of 122,976 gallons, the installation can operate all critical facilities on emergency power a maximum of 15.8 days.

Analysis of Tinker Air Force Base

Tinker AFB was especially limited by the small quantity of diesel fuel available, 23436 gallons, and 15 generators were eliminated from the system to produce a feasible problem. The optimal value for Z is obtained from the adjusted computer program output in Appendix L.

$$\begin{aligned}
Z &= 58.9 \\
Z_{\text{adj.}} &= 28.9(37/22) \\
&= 99.1 \\
K &= 29.9 \\
T_{\text{max}} &= Z_{\text{adj.}} + K \\
&= 129 \text{ Hours} \\
&= 5.4 \text{ Days}
\end{aligned}$$

To produce a feasible problem, five proposed generators with an assumed running time of 120 hours were eliminated from the system. From previous analysis it seems reasonable to include these generators in the system, but including all five produces an infeasible problem. To include only a few of these five generators in the system would produce a maximum time somewhat less than 129 hours, but still greater than 120 hours. Since these five generators are not yet in existence, 129 hours seems a reasonable enough figure for the maximum length of time Tinker AFB can operate on emergency power with 23,436 gallons of diesel fuel.

Analysis of Kelly Air Force Base

The Kelly AFB problem also required the elimination of numerous generators from the system for a feasible solution. The optimal value for Z is obtained from the adjusted computer program output in Appendix O.

$$\begin{aligned}
 Z &= 29.2 \\
 Z_{\text{adj.}} &= 29.2(38/16) \\
 &= 69.3 \\
 K &= 39.7 \\
 T_{\text{max}} &= Z_{\text{adj.}} + K \\
 &= 109 \text{ Hours} \\
 &= 4.5 \text{ Days}
 \end{aligned}$$

At Kelly AFB, more than half the generators will run longer on attached fuel tanks than the system will run on the additional diesel fuel available. Based on 10,290 gallons of diesel fuel, the base can meet its minimum critical operating requirements for 4.5 days.

Discussion of Results

The results of the analyses are summarized in Table 1.

TABLE 1
SUMMARY OF RESULTS

ALC	Total # of Generators	# of Generators in Linear Program	Fuel Available (Gallons)	T _{max} (Days)
Robins	28	28	101,976	13.45
Hill	47	45	215,712	18.8
McClellan	36	31	122,976	15.8
Tinker	37	22	23,436	5.4
Kelly	38	16	10,290	4.5

The individual fuel allocations to each generator can be obtained from the LP600 output products in the appendices. Using these allocations, expressed in gallons, and the fuel tank sizes in Appendix A, the number of complete fuel tank refills for each generator can be determined using the procedure outlined in Chapter II.

The determination of the maximum length of time that an ALC can operate on emergency power is based on the maximum total quantity of diesel fuel authorized for storage at the ALC. This maximum will be reached only on those occasions when the base has a delivery of diesel fuel from a commercial supplier. Once a delivery is made, the total quantity of fuel available for use during an emergency will decrease each day by an amount approximated by the daily demand rate. Just prior to a new delivery of diesel fuel, depending upon the diesel fuel inventory reorder point at each base, the maximum length of time the base can operate on emergency power will be considerably less than the optimum values listed in Table 1.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The uncertainty of the availability of future supplies of petroleum has raised the possibility that a future electrical power curtailment could be accompanied by a simultaneous curtailment of petroleum fuel supplies. During such curtailments the ability of the ALCs to accomplish the essential operations required by a wartime scenario may depend upon the use of emergency back-up generators to provide electrical power to critical facilities. Using information about the back-up generators at each ALC and the quantities of fuel likely to be available for generator use during a supply curtailment, this study determined the maximum length of time each ALC can continue to meet its minimum critical operating requirements during a complete curtailment of commercially supplied electrical power and petroleum fuels.

Conclusion

The results of the linear programming analysis of the information acquired from each ALC indicate that a long-term curtailment of commercially supplied electrical power and petroleum fuels may have a significant adverse impact

on an ALC's ability to meet its critical operating requirements during a wartime scenario requiring continuous support from the ALC. The maximum length of time the ALCs could operate on emergency power varies from about 4.5 days at Kelly AFB to almost 19 days at Hill AFB.

Whether the results of the analysis are a basis for concern depends upon the extent to which the underlying assumptions of this study accurately reflect the situation as it will actually exist during supply curtailments and a wartime scenario, and whether the probability of the simultaneous occurrence of electrical power and petroleum curtailments and a wartime scenario is great enough to warrant any economic expenditures necessary to prepare for such an eventuality. The major assumptions concerning the operation of the emergency generators during a wartime scenario were that all generators must function to successfully meet critical operating requirements and that the generators must run continuously until restoration of commercial electrical power. Relaxation of either of these assumptions would increase somewhat the length of time the installation could operate on emergency power. At Hill AFB, for example, if all generators were operated an average of 16 hours per day rather than 24, the maximum length of time the installation could operate on emergency power would increase from about 19 days to 28 days. Likewise, if critical operations could be maintained without using all the generators currently

viewed as essential to those operations, the maximum time the installation could operate on emergency power could also be increased.

An implicit assumption for this study is that the emergency power generators will not have access to fuels specifically allocated for other uses. Since the overwhelming majority of emergency generators burn a high grade distillate fuel oil, the possibility exists that other similar petroleum based fuels could be used in an emergency to extend the operating time of the generators. The heating oil used for industrial steam production and facility heating at some installations is similar to the distillate fuel oil used in diesel generators, but contains more impurities. If heating oil could be diverted for use in emergency generators, the maximum length of time that an installation could operate on emergency power would increase an amount commensurate with the quantity of fuel diverted.

Another implicit assumption of this study is that it is generally impractical to remove fuel from the attached fuel tank of a long-running generator and use it to fuel a generator with a short running time. Any fuel which could be removed from generators with extremely large fuel tanks and used in other generators with smaller tanks would, of course, increase somewhat the total length of time the system of generators could be operated. Optimally reallocating the total amount of fuel available, including that in the

individual generator fuel tanks, could increase the length of time the generators could operate to the upper limit which is equal to the total amount of fuel available divided by the sum of the individual fuel consumption rates of all the generators.

The practical problems associated with optimally allocating the available fuel supplies to the emergency generators were not addressed by the LP600 computer analysis. The computer program assumes that each generator will be automatically and instantaneously refueled each time its fuel tank is exhausted, and the appropriate amount of fuel will be pumped into each tank to guarantee the generator system will operate the maximum time. In reality, the refueling of the generators will be constrained by the availability of fuel trucks and personnel, and the effectiveness of the refueling schedule. Determining when individual generators will exhaust their individual fuel tanks and refueling the generators in a timely manner will be a major scheduling problem, especially during the accelerated pace of a wartime scenario. Consequently, the maximum times determined by the computer analysis may be somewhat longer than the maximum times the bases could realistically be expected to operate considering the practical logistics problems associated with generator refueling.

The possibility of simultaneous curtailments of electrical power and petroleum fuel supplies and a wartime

scenario may seem rather remote, but preparation for highly improbable eventualities has become almost a necessity in a world in which the occurrence of improbable and often completely unexpected events has become almost routine. Consequently, adequate preparation for the possible curtailment of electrical power and petroleum fuel supplies at the Air Logistics Centers is probably a reasonably prudent strategy, especially in light of the fact that the ALCs will have an integral role in insuring that American forces are provided adequate logistical support during any future armed conflict.

Recommendations

The Air Logistics Centers should remove most of the uncertainty regarding their ability to meet critical operating requirements during a curtailment of commercially supplied electrical power and petroleum fuels by determining the quantity of fuel required to operate the emergency generators during the specific wartime scenarios which the Centers will be required to support, and by maintaining that quantity of fuel as an emergency stock on the installation.

To insure that only the minimum amount of fuel necessary to maintain essential operations is stored on the installation, each Air Logistics Center should:

1. Determine the minimum critical operations necessary during specific wartime scenarios and the minimum facilities required to support those operations.

2. Determine the number of hours per day and the expected number of days generators supporting the critical facilities will be required to operate during specific wartime scenarios.

3. Based upon the generator fuel consumption rate and the quantity of fuel stored in each generator's attached fuel tank, determine the quantity of additional fuel required to operate the emergency generators for the projected time period.

4. Determine the feasibility of using alternate fuels, such as heating oil, in emergency generators for an extended period of time.

5. Insure that the necessary quantities of primary or appropriate alternate fuels are maintained as either separate emergency fuel stocks, or as additional safety stocks in the standard base fuel supply system.

APPENDICES

APPENDIX A
ALC GENERATOR AND FUEL DATA

Hill AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	221	Enterprise	DSM36	350	2,500	28.0 (a)
2	3		MB-16	100	1,500	8.8
3	10	Waukesha	6NKDBSEU	150	2,000	12.5 (a)
4	771		MB-18	30	500	3.3
5	768		MB-18	30	950	3.3
6	10762		MB-17	60	900	5.1
7	799		MB-18	30	500	3.3
8	776	Kohler		45	1,000	4.0 (b)
9	598	Kohler		45	1,000	4.0 (b)
10	11	Onan	ARS61PG	100	900	8.8 (a)
11	1214		MB-17	60	1,050	5.1
12	9	Caterpillar	D-318	75	300	24.5 (a)
13	774	Cummins	HT-6B1	75	1,000	6.5 (a)
14	Pinedale	General Motors	5034-7101	30	250	3.3 (a)
15	36	Detroit Diesel	1043700	75	70	6.5 (b)
16	593		MB-18	30	500	3.3
17	1102		MB-15	150	1,260	13.5
18	2106		MB-19	15	26.5	2.5
19	260	Waukesha	VERBS	400	18,000	31.5 (a)
20	1286	General Motors	RC	100	2,100	8.8 (a)
21	Lt. Mtn.		MB-15	150	108	13.5
22	1310	Caterpillar	D-333	125		

(a) indicates fuel consumption rate obtained directly from manufacturer's data for that particular generator (see Chapter III).

(b) indicates fuel consumption rate obtained by a method other than specific manufacturer's data (see Chapter III).

Hill AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
23	575	Detroit Diesel	V-71	300	2,000	23.0(a)
24	519	Enterprise	DSM38	500	18,000	35.0(a)
25	2416A	Cummins	KTAl150G	350	2,000	29.0(a)
26	270		MB-16	100	1,000	8.8
27	1847		MB-18	30	500	3.3
28	11300	Allis Chalmers	7000	75	1,050	6.5(b)
29	11301	Caterpillar	D-330	100	2,100	8.8(a)
30	1309	Caterpillar	D-333	110	500	9.0(a)
31	1204	Allis Chalmers	7000	75	1,050	6.5(b)
32	32		MB-17	60	43	5.1
33	32		MB-15	150	108.5	13.5
34	11	Onan	ARS61PG	100	71.5	8.8(a)
35	32		MB-15	150	108.5	13.5
36	32		MB-18	30	26.5	3.3
37	32		MB-18	30	26.5	3.3
38	32		MB-19	15	21.0	2.5
39	32		MB-19	15	21.0	2.5
40	32		MB-16	100	71.5	8.8
41	Wendover		MB-15	150	108.5	13.5
42*	100			400	3,840	32.0
43*	845			350	3,360	28.0
44*	849			1000	9,600	80.0
45*	850			350	3,360	28.0
46*	900			800	7,680	64.0

* indicates proposed generators (see Chapter III).

Kelly AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	1610		MB-17	60	250	5.1
2	375	Waukesha	WDKDY	100	400	8.8 (a)
3	1600	Allis Chalmers	DD 334	40	105	4.0 (b)
4	1650	Stewart-Stevenson	6GD-100	100	250	8.8 (b)
5	2000	General Motors	GM-100-D-18RR	75	200	6.5 (a)
6	2000	General Motors	ATS-60-2	75	200	6.5 (a)
7	2000		MB-15	100	1,500	8.8
8	1740		MB-18	25	300	3.3
9	171		MB-16	100	100	8.8
10	1420		MB-17	60	250	5.1
11	1420	Stewart-Stevenson	2GD-25	20	60	1.7 (b)
12	1620	Caterpillar	34-12CAT	200	500	16.0 (a)
13	809		MB-17	60	100	5.1
14	474	Onan	15RPJC3A	15	250	1.3 (a)
15	1408		MB-19	15	250	2.5
16	1493	Stewart-Stevenson	2GD-35C	30	250	3.3 (b)
17	1499		MB-18	30	500	3.3
18	811		MB-18	30	250	3.3
19	1160		MB-17	60	250	5.1
20	1625	Stewart-Stevenson	2GD-35C	20	250	1.7 (b)
21	1674		MB-16	100	6,700	8.8
22	1674	Caterpillar	D-33069C	100	220	8.8 (a)
23	2213	Stewart-Stevenson	3045C	30	500	3.3 (b)
24	1630		MB-15	150	105	13.5
25*	Unspecified			25	240	2.0
26*	Unspecified			25	240	2.0
27*	1414			100	960	8.0
28*	1470			200	1,920	16.0

Kelly AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
29*	1523			50	480	4.0
30*	1534			50	480	4.0
31*	1534			50	480	4.0
32*	1534			50	480	4.0
33*	1534			50	480	4.0
34*	1534			200	1,920	16.0
35*	1534			200	1,920	16.0
36*	Unspecified			100	960	8.0
37*	1562			50	480	4.0

McClellan AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1	200	Caterpillar	D-353-1A	300	8,000	24.5 (a)
2	1099		MB-15	150	1,000	13.5
3	870	Ohio Numatic	B-3602	350	1,000	28.0 (b)
4	702		MB-18	30	215	3.3
5	701		MB-A	15	250	2.5
6A	262B	White Superior	40-SX-8	440	20,000	34.0 (b)
6B	262B	White Superior	40-SX-8	440		34.0 (b)
6C	262B	White Superior	12Y-711B	200		16.5 (b)
6D	262B	White Superior	40-SX-8	400		34.0 (b)
6E	262B	General Motors	12U-711D	200		16.5 (a)
7A	7	Baldwin-Lima Hamilton	606A	600	50,000	47.0 (b)
7B	7	White Superior	60B-SX-8	650		51.0 (b)
7C	7	Baldwin-Lima Hamilton	606A	600		47.0 (b)
8A	4710	General Motors	16-567-D	1000	75,000	83.0 (a)
8B	4710	General Motors	16-567-D	1000		83.0 (a)
9	20		MB-17	60	2,500	5.1
10	617		MB-19	15	250	2.5
11	4131	General Motors	671	100	5,000	8.8 (a)
12	1071		MB-17	60	43	5.1
13	635		MB-18	30	26	3.3
14	948		MB-19	15	21	2.5
15	1		MB-17	60	43	5.1
16A	7	Consolidated Diesel	76-0189	60	2,500	5.1 (b)
16B	7	Consolidated Diesel	76-0189	60		5.1 (b)

McClellan AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
17	6008	Onan	15-ORDJC-3R	15	500	1.3(a)
18	685		MB-17	60	43	5.1
19	329		MB-16	100	550	8.8
20	251N		MB-17	60	43	5.1
21	685		MB-16	100	70	8.8
22	685		MB-15	150	107	13.5
23	685		MB-16	100	70	8.8
24	685		MB-17	60	150	5.1
25	685		MB-16	100	70	8.8
26	685		MB-15	150	107	13.5
27	251S		MB-18	30	26	3.3
28	685		MB-17	60	43	5.1
29	685		MB-17	60	43	5.1
30	685	Consolidated Diesel	XME-D007A	100	70	8.8(b)
31	685		MB-15	150	107	13.5
32	1106		MB-17	60	43	5.1
33	21		MB-17	60	43	5.1
34	685	Consolidated Diesel	XME-D007A	100	70	8.8(b)
35*				1,000	9,600	80.0

Robins AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1A	2	Pavid	J115PWH-D	115	1,000	9.8(b)
1B	2	Jeta	C010018	100		8.8(b)
2	11	General Motors	6903	60	250	5.1(a)
3A	12	Consolidated	4221	100	1,200	8.8(b)
3B	12	Diesel				
4	12	Caterpillar	3412	450		35.0(a)
5	14	Pavid	G15H3	15	250	1.3(b)
6	25	Onan	D18F6H4	18	150	1.7(a)
7	38	Caterpillar	D-330	60	1,000	5.1(a)
8A	80	Pavid	J150WHD	15	300	1.3(b)
8B	107	Jeta	CD10018	100	59	8.8(b)
9	107	Jeta	CD10018	100		8.8(b)
10	110	Caterpillar		200	250	16.0(b)
11	ILS#1	Pavid	G2581	25	50	3.0(b)
12	ILS#1	Pavid	G2581	25	50	3.0(b)
13	37		MB-17	60	1,000	5.1
14	78	Porter	4820	30	500	3.3(b)
15	210	Caterpillar	D-330	60	250	5.1(a)
16	214	Katolite	6NKDB	150	2,000	12.5(a)
17	225	Caterpillar	D-343	250	5,000	19.0(a)
18	263	Pavid	J35DWH-D	30	300	3.3(b)
19	272	Pavid	J65DWH-D	65	250	5.5(b)
20	376	Onan	150RDJ6	15	250	1.3(a)
21	377	John Deere	500DEE	50	250	4.5(b)
22A	644		MB-15	150	250	13.5
	700	Katolite	D100MPZ4E	100	2,500	8.8(a)

Robins AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
22B	700	Katolite	D100MPZ4E	100	2,500	8.8 (a)
23	54		MB-16	100	200	8.8
24	158	Caterpillar	D-330	60	250	5.1 (a)
25	162		MB-16	60	250	5.1
26	177	Caterpillar	D-412	450	1,200	35.0 (a)
27*	Unspecified			2615	25,104	209.2

Tinker AFB Generator Data

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
1A	3001	King Knight	12V71	200	20,000	16.0 (b)
1B	3001	King Knight	12V71	200		16.0 (b)
1C	3001	White Superior	40-SX-8	440		34.0 (b)
1D	3001	White Superior	40-SX-8	440		34.0 (b)
1E	3001	White Superior	40-SX-8	440		34.0 (b)
2	240	Caterpillar		350	500	28.0 (b)
3	Tacan	Eseco	135DK	30	275	3.3 (b)
4	928	Kohler	20R0P61	20	287	1.7 (a)
5	930	Kohler	D2300X188	25	287	3.0 (a)
6	932	Kohler	125RCOP61	12.5	275	1.3 (a)
7	935	Fermont	NHC-4-B1G	60	275	5.1 (b)
8	1100	Fermont	NH200-B1G	100	500	8.8 (b)
9	1111	Kohler	20R0P61	20	275	1.7 (a)
10A	5802	Waukesha	148DKB	100	12,000	8.8 (a)
10B	5802	Waukesha	148DKB	100		8.8 (a)
11	260	Fermont	NH220-B1G	100	69.5	8.8 (b)
12	4029	Fermont	NH220-B1G	100	500	8.8 (b)
13	20288	Fermont	NRTO-6B1	150	107	13.5 (b)
14	23702	Fermont	NRTO-6B	150	107	13.5 (b)
15	23720	Fermont	NRTO-6B1G	150	107	13.5 (b)
16	441	Fermont	D298ER	30	26.5	3.3 (b)
17	435	Federal Electric	NHC-4-B1	60	155	5.1 (b)
18A	284	Waukesha	F2896DS1U	400	10,000	31.5 (a)
18B	284	Waukesha	L1616DSU	175		14.5 (a)
19	1124	Fermont	NHC-4-B1G	60	300	5.1 (b)
20	933	Katolite	D200X99	20	350	1.7 (a)

Tinker AFB Generator Data--Continued

Gen. No.	Facility/ Bldg. No.	Make	Model	Power Output (KW)	Fuel Tank Capacity (Gallons)	Fuel Consumption Rate (Gal/Hr)
21	942	Katolite	D200X99	20	350	1.7(a)
22	487	Caterpillar	D-399C	500	3,500	35.0(a)
23	230	John Deere	42190F01	30	1,000	3.3(b)
24	2125	Pavid	D2300X207	30	12	3.3(b)
25A	3001E	Caterpillar	3406DI	210	20,000	16.5(a)
25B	2001E	Caterpillar	3406DI	210		16.5(a)
26	906	Pavid	D4800X127	75	250	19.0(b)
27	414	Fermont	NH-220-B1G	100	69.5	8.8(b)
28	414	Fermont	NH-220-B1G	100	69.5	8.8(b)
29	414	Fermont	NHC-4-B1G	60	43.5	5.1(b)
30	414	Fermont	D198ER	15	21	1.3(b)
31	414	Federal Electric	D298ER	30	26.5	3.3(b)
32*	260			300	2,880	24.0
33*	416			100	960	8.0
34*	506			1,000	9,600	80.0
35*	3001			1,000	9,600	80.0
36*	3001G			500	4,800	40.0

AFLC Fuel Availability Data

ALC	Diesel Fuel Available (BBLs)	Daily Demand Rate (BBLs/Day)
Hill AFB	5136	10.0
Kelly AFB	245	7.0
McClellan AFB	2928	3.0
Robins AFB	2428	10.0
Tinker AFB	558	39.0

APPENDIX B
ROBINS AFB INPUT PROGRAM

10#WS,R(SL) : ,8,16;;,16
 15#:IDENT:WP1186, MOTT/NELSON THESIS
 20#:USERID:80A053#KR79
 25#:PROGRAM:RLHS
 30#:LIMITS:10,39K,,5K
 35#:PRMFL:H*,R,R,AF.LIB/LP.PAC
 40#:REMOTE:S0,SL
 45#:DISC:AA,A1,10R
 50#:DISC:AB,A2,10R
 55#:DISC:AC,A3,10R
 60#:DISC:AD,A4,10R
 65#:DISC:AE,A5,10R
 70#:DATA:IN
 75FILE:ELEC
 80**** RUBINS AFB FUEL PLAN ****
 85**** ****
 90**** CONSTRAINT MATRIX ****
 95**** ****
 100**** FUEL QUANTITY CONSTRAINT ****
 105MATRIX:FUEL(P),S1(P)=1
 110:,S2(P)=1
 115:,S3(P)=1
 120:,S4(P)=1
 125:,S5(P)=1
 130:,S6(P)=1
 135:,S7(P)=1
 140:,S8(P)=1
 145:,S9(P)=1
 150:,S10(P)=1
 155:,S11(P)=1
 160:,S12(P)=1
 165:,S13(P)=1
 170:,S14(P)=1
 175:,S15(P)=1
 180:,S16(P)=1
 185:,S17(P)=1
 190:,S18(P)=1
 195:,S19(P)=1
 200:,S20(P)=1
 205:,S21(P)=1
 210:,S22(P)=1
 215:,S23(P)=1
 220:,S24(P)=1
 225:,S25(P)=1
 230:,S26(P)=1
 235:,S27(P)=1
 240:,S28(P)=1

245**** TIME EQUALITY CONSTRAINTS ****

250MATRIX:TC1(Z),S1=.0538

255:,S2=-.1961

260A:TC2(Z),S2=.1961

265:,S3=-.0228

270A:TC3(Z),S3=.0228

275:,S4=-.7692

280A:TC4(Z),S4=.7692

285:,S5=-.5882

290A:TC5(Z),S5=.5882

295:,S6=-.1961

300A:TC6(Z),S6=.1961

305:,S7=-.7692

310A:TC7(Z),S7=.7692

315:,S8=-.0568

320A:TC8(Z),S8=.0568

325:,S9=-.0625

330A:TC9(Z),S9=.0625

335:,S10=-.3333

340A:TC10(Z),S10=.3333

345:,S11=-.3333

350A:TC11(Z),S11=.3333

355:,S12=-.1961

360A:TC12(Z),S12=.1961

365:,S13=-.3030

370A:TC13(Z),S13=.3030

375:,S14=-.1961

380A:TC14(Z),S14=.1961

385:,S15=-.08

390A:TC15(Z),S15=.08

395:,S16=-.0526

400A:TC16(Z),S16=.0526

405:,S17=-.3030

410A:TC17(Z),S17=.3030

415:,S18=-.1818

420A:TC18(Z),S18=.1818

425:,S19=-.7692

430A:TC19(Z),S19=.7692

435:,S20=-.2222

440A:TC20(Z),S20=.2222

445:,S21=-.0740

450A:TC21(Z),S21=.0740

455:,S22=-.0568

460A:TC22(Z),S22=.0568

465:,S23=-.1136

470A:TC23(Z),S23=.1136

475:,S24=-.1961

480A:TC24(Z),S24=.1961

485:,S25=-.1961

490A:TC25(Z),S25=.1961

495:,S26=-.0286
 500A:TC26(Z),S26=.0286
 505:,S27=-.0048
 510A:TC27(Z),S27=.0048
 515:,S28=-.0571
 520:***
 525**** OBJECTIVE FUNCTION
 530****
 535MATRIX:TIME(FREE),S1=-.00700
 540:,S2=-.00700
 545:,S3=-.00082
 550:,S4=-.02747
 555:,S5=-.02101
 560:,S6=-.00700
 565:,S7=-.02747
 570:,S8=-.00203
 575:,S9=-.00223
 580:,S10=-.01190
 585:,S11=-.01190
 590:,S12=-.00700
 595:,S13=-.01082
 600:,S14=-.00700
 605:,S15=-.00286
 610:,S16=-.00188
 615:,S17=-.01082
 620:,S18=-.00649
 625:,S19=-.02747
 630:,S20=-.00794
 635:,S21=-.00265
 640:,S22=-.00203
 645:,S23=-.00406
 650:,S24=-.00700
 655:,S25=-.00700
 660:,S26=-.00102
 665:,S27=-.00017
 670:,S28=-.00204


```

675****
680**** RIGHT HAND SIDE VALUES ****
685****
690**** FUEL QUANTITY CONSTRAINT ****
695RHS:FUEL,RHSV=101976
700**** TIME EQUALITY CONSTRAINTS ****
705:TC1=-4.775
710:TC2=-21.665
715:TC3=164.94
720:TC4=-104.07
725:TC5=107.87
730:TC6=34.66
735:TC7=-27.4088
740:TC8=12.2738
745:TC9=1.0417
750:TC10=0
755:TC11=179.4333
760:TC12=-44.6
765:TC13=-102.475
770:TC14=110.975
775:TC15=103.1575
780:TC16=-172.2575
785:TC17=-45.4455
790:TC18=146.8455
795:TC19=-136.7444
800:TC20=-37.0371
805:TC21=123.5267
810:TC22=-119.3179
815:TC23=26.2977
820:TC24=0
825:TC25=-14.7393
830:TC26=85.7143
835:TC27=-120
840END***
845$DATA:I*
850:PREPRO
855:TITLE:GENERATOR FUEL ALLOCATION PLAN
860:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
865:SETUP:SOURCE=GFP
870:SET:OBJ=TIME,RHS=RHSV
875:PICTURE
880:PRIMAL
885:OUTPUT
890:ENDLP
895$ENDJOB
900***EOF

```

APPENDIX C
ROBINS AFB OPTIMAL OUTPUT

PRIME 01 04/16/80																			
GENERATOR FUEL ALLOCATION PLAN																			
PRIME=PRIMAL PAGE 17																			
FUNCTION= 3.71720123, ORIGIN= 1																			
ITEM	ETA	MIN	FUNCTIONAL	MINES	NDJS	VALUES	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	GCT	VPC	ACT	NCT	FCI	A-TIM
1	1	1	3.71720123	24	5	2419.14000	S1	1	1	P	345	ZINININ	51	1	8	1A	1	6	.114
2	2	2	4.40643180	23	5	1905.80000	S1	1	1	P	325	ZINININ	31	2	1A	1	6	.21	
3	3	3	4.93315070	22	5	1971.25338	S0	1	1	P	375	ZINININ	91	3	1A	1	6	.17	
4	4	4	5.27731891	21	5	1961.70334	S2	1	1	P	315	ZINININ	21	4	1A	1	4	.17	
5	5	5	6.03526602	20	5	1756.75338	S14	1	1	P	435	ZINININ	141	1	7	1A	1	11	.38
6	6	6	6.5121403	19	5	1739.75338	S13	1	1	P	425	ZINININ	151	2	1A	1	11	.10	
7	7	7	7.134105128	18	5	1667.54339	S15	1	1	P	445	ZINININ	131	3	1A	1	11	.17	
8	8	8	8.134105128	17	5	1665.40000	S9	1	1	P	385	ZINININ	181	4	1A	1	11	.28	
9	9	9	9.134105128	16	5	1665.40000	S11	1	1	P	405	ZINININ	111	5	1A	1	11	.12	
10	10	10	10.17721457	15	5	1545.40000	S20	1	1	P	575	ZINININ	281	1	13	1A	1	16	.39
11	11	11	11.19440852	14	5	1454.57800	S10	1	1	P	475	ZINININ	1A1	2	1A	1	16	.17	
12	12	12	12.20770137	13	5	1380.50479	S21	1	1	P	505	ZINININ	211	3	1A	1	16	.15	
13	13	13	13.21660730	12	5	1377.90939	S23	1	1	P	525	ZINININ	241	4	1A	1	16	.15	
14	14	14	14.21660730	11	5	1295.43878	S26	1	1	P	555	ZINININ	261	5	1A	1	16	.12	
15	15	15	15.17814100	10	5	939.544103	S10	1	1	P	395	ZINININ	121	1	20	2A	2	21	.43
16	16	16	16.558540740	9	5	734.704103	S17	1	1	P	465	ZINININ	191	2	2A	2	21	.17	
17	17	17	17.512420212	8	5	563.781000	S20	1	1	P	495	ZINININ	221	3	2A	2	21	.15	
18	18	18	18.71444292	7	5	494.46000	S12	1	1	P	415	ZINININ	81	4	2A	2	21	.15	
19	19	19	19.990690219	6	5	355.905004	S1	1	1	P	385	ZINININ	41	1	20	3A	2	26	.43
20	20	20	20.100128098	5	5	352.165004	S4	1	1	P	335	ZINININ	61	2	20	3A	2	26	.16
21	21	21	21.118434577	4	5	317.505005	S6	1	1	P	355	ZINININ	71	1	20	4A	1	31	.52
22	22	22	22.131754432	3	5	285.107400	S7	1	1	P	365	ZINININ	161	2	20	4A	1	31	.19
23	23	23	23.131754432	2	3	245.107400	S24	1	1	P	535	ZINININ	251	1	20	5A	1	34	.19
24	24	24	24.131754432	1	3	143.157497	S25	1	1	P	545	ZINININ	271	2	20	5A	1	34	.13
25	25	25	25.1461199709	0	1	121.112299	S27	1	1	P	565	ZINININ	231	1	20	6A	1	35	.33
26	26	26	26.162240714	0	1	70.6575001	S22	1	1	P	515	ZINININ	201	1	20	7A	1	36	.33
27	27	27	27.192500052	0	1	70.6575001	S19	1	1	P	485	ZINININ	171	1	20	8A	1	37	.33
28	28	28	28.23260273	0	1	65.7544100	S16	1	1	P	455	P	11	1	20	9A	1	38	.18
14 DINV	INVEPT																	32950	11
15 CURRT	CUMPRNT																	32982	12
45	PRIMAL																	32982	13
														DEMAND	36527				

OPTIMAL SOLUTION

Robins AFB Iterations

FUEL ALLOCATIONS

Robins AFB Fuel Allocations

APPENDIX D
HILL AFB INPUT PROGRAMS

Hill AFB Original Input Program

```
10#HS,R(I) :.8,16;;.16
15#:IDENT:WP1186. MOTT/NELSON THESIS
20#:USERID:80A053#KR79
25#:PROGRAM:RLHS
30#:LIMITS:10,39K,,5K
35#:PRMFL:H*,R,R,AF.LIB/LP.PAC
40#:REMOTE:S0,SL
45#:DISC:AA,A1,10R
50#:DISC:AB,A2,10R
55#:DISC:AC,A3,10R
60#:DISC:AD,A4,10R
65#:DISC:AE,A5,10R
70#:DATA:IN
75FILE:ELEC
80**** HILL AFB FUEL PLAN ****
85****          ****
90**** CONSTRAINT MATRIX ****
95****          ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110: ,S2(P)=1
115: ,S3(P)=1
120: ,S4(P)=1
125: ,S5(P)=1
130: ,S6(P)=1
135: ,S7(P)=1
140: ,S8(P)=1
145: ,S9(P)=1
150: ,S10(P)=1
155: ,S11(P)=1
160: ,S12(P)=1
165: ,S13(P)=1
170: ,S14(P)=1
```

175: ,S15(P)=1
 180: ,S16(P)=1
 185: ,S17(P)=1
 190: ,S18(P)=1
 195: ,S19(P)=1
 200: ,S20(P)=1
 205: ,S21(P)=1
 210: ,S22(P)=1
 215: ,S23(P)=1
 220: ,S24(P)=1
 225: ,S25(P)=1
 230: ,S26(P)=1
 235: ,S27(P)=1
 240: ,S28(P)=1
 245: ,S29(P)=1
 250: ,S30(P)=1
 255: ,S31(P)=1
 260: ,S32(P)=1
 265: ,S33(P)=1
 270: ,S34(P)=1
 275: ,S35(P)=1
 280: ,S36(P)=1
 285: ,S37(P)=1
 290: ,S38(P)=1
 295: ,S39(P)=1
 300: ,S40(P)=1
 305: ,S41(P)=1
 310: ,S42(P)=1
 315: ,S43(P)=1
 320: ,S44(P)=1
 325: ,S45(P)=1
 330: ,S46(P)=1
 335: ,S47(P)=1
 340*** TIME EQUALITY CONSTRAINTS ***
 345MATRIX:TC1(Z),S1=.0357
 350: ,S2=-.1136
 355A:TC2(Z),S2=.1136
 360: ,S3=-.08
 365A:TC3(Z),S3=.08
 370: ,S4=-.303
 375A:TC4(Z),S4=.303
 380: ,S5=-.303
 385A:TC5(Z),S5=.303
 390: ,S6=-.1961
 395A:TC6(Z),S6=.1961
 400: ,S7=-.303
 405A:TC7(Z),S7=.303
 410: ,S8=-.25
 415A:TC8(Z),S8=.25
 420: ,S9=-.25
 425A:TC9(Z),S9=.25

430: .S10=-.1136
 435A: TC10(Z), S10=.1136
 440: .S11=-.1961
 445A: TC11(Z), S11=.1961
 450: .S12=-.0408
 455A: TC12(Z), S12=.0408
 460: .S13=-.1538
 465A: TC13(Z), S13=.1538
 470: .S14=-.303
 475A: TC14(Z), S14=.303
 480: .S15=-.1538
 485A: TC15(Z), S15=.303
 490: .S16=-.303
 495A: TC16(Z), S16=.303
 500: .S17=-.0741
 505A: TC17(Z), S17=.0741
 510: .S18=-.4
 515A: TC18(Z), S18=.4
 520: .S19=-.0317
 525A: TC19(Z), S19=.0317
 530: .S20=-.1136
 535A: TC20(Z), S20=.1136
 540: .S21=-.0741
 545A: TC21(Z), S21=.0741
 550: .S22=-.1
 555A: TC22(Z), S22=.1
 560: .S23=-.0435
 565A: TC23(Z), S23=.0435
 570: .S24=-.0286
 575A: TC24(Z), S24=.0286
 580: .S25=-.0345
 585A: TC25(Z), S25=.0345
 590: .S26=-.1136
 595A: TC26(Z), S26=.1136
 600: .S27=-.303
 605A: TC27(Z), S27=.303
 610: .S28=-.1538
 615A: TC28(Z), S28=.1538
 620: .S29=-.1136
 625A: TC29(Z), S29=.1136
 630: .S30=-.1111
 635A: TC30(Z), S30=.1111
 640: .S31=-.1538
 645A: TC31(Z), S31=.1538
 650: .S32=-.1961
 655A: TC32(Z), S32=.1961
 660: .S33=-.0741
 665A: TC33(Z), S33=.0741
 670: .S34=-.1136
 675A: TC34(Z), S34=.1136
 680: .S35=-.0741

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685A:TC35(Z),S35=.0741
690: S36=-.3030
695A:TC36(Z),S36=.3030
700: S37=-.3030
705A:TC37(Z),S37=.3030
710: S38=-.4
715A:TC38(Z),S38=.4000
720: S39=-.4
725A:TC39(Z),S39=.4000
730: S40=-.1136
735A:TC40(Z),S40=.1136
740: S41=-.0741
745A:TC41(Z),S41=.0741
750: S42=-.0313
755A:TC42(Z),S42=.0313
760: S43=-.0357
765A:TC43(Z),S43=.0357
770: S44=-.0125
775A:TC44(Z),S44=.0125
780: S45=-.0357
785A:TC45(Z),S45=.0357
790: S46=-.0156
795A:TC46(Z),S46=.0156
800: S47=-.05714
805****
810**** OBJECTIVE FUNCTION
815****
820MATRIX:TIME(FREE),S1=-.00076
825: S2=-.00242
830: S3=-.00170
835: S4=-.00645
840: S5=-.00645
845: S6=-.00417
850: S7=-.00645
855: S8=-.00532
860: S9=-.00532
865: S10=-.00242
870: S11=-.00417
875: S12=-.00087
880: S13=-.00327
885: S14=-.00645
890: S15=-.00327
895: S16=-.00645
900: S17=-.00158
905: S18=-.00851
910: S19=-.00068
915: S20=-.00242
920: S21=-.00158
925: S22=-.00213
930: S23=-.00093
935: S24=-.00061

```

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*****
*****
*****

```

940: .S25=-.00073
 945: .S26=-.00242
 950: .S27=-.00645
 955: .S28=-.00327
 960: .S29=-.00242
 965: .S30=-.00236
 970: .S31=-.00327
 975: .S32=-.00417
 980: .S33=-.00158
 985: .S34=-.00242
 990: .S35=-.00158
 995: .S36=-.00645
 1000: .S37=-.00645
 1005: .S38=-.00851
 1010: .S39=-.00851
 1015: .S40=-.00242
 1020: .S41=-.00158
 1025: .S42=-.00066
 1030: .S43=-.00076
 1035: .S44=-.00027
 1040: .S45=-.00076
 1045: .S46=-.00033
 1050: .S47=-.00122
 1055****
 1060**** RIGHT HAND SIDE VALUES ****
 1065****
 1070**** FUEL QUANTITY CONSTRAINT ****
 1075RHS:FUEL,RHSV=215712
 1080**** TIME EQUALITY CONSTRAINTS ****
 1085:TC1=81.1688
 1090:TC2=-10.4545
 1095:TC3=-8.4848
 1100:TC4=136.3636
 1105:TC5=-111.4082
 1110:TC6=-24.9554
 1115:TC7=98.4848
 1120:TC8=0
 1125:TC9=147.7273
 1130:TC10=103.6097
 1135:TC11=-193.6375
 1140:TC12=141.6013
 1145:TC13=-78.0886
 1150:TC14=-64.9884
 1155:TC15=140.746
 1160:TC16=-58.1818
 1165:TC17=-82.7334
 1170:TC18=560.8286
 1175:TC19=-332.7922
 1180:TC20=-246.6364
 1185:TC21=42
 1190:TC22=36.9565

1195:TC23=427.3292
1200:TC24=-445.3202
1205:TC25=44.6709
1210:TC26=37.8788
1215:TC27=10.0233
1220:TC28=77.0979
1225:TC29=-183.0808
1230:TC30=105.9829
1235:TC31=-153.1071
1240:TC32=-.3944
1245:TC33=.088
1250:TC34=-.088
1255:TC35=-.2289
1260:TC36=0
1265:TC37=.367
1270:TC38=0
1275:TC39=-.275
1280:TC40=-.088
1285:TC41=111.963
1290:TC42=0
1295:TC43=0
1300:TC44=0
1305:TC45=0
1310:TC46=-120
1315END***
1320\$:DATA:I*
1325:PREPRO
1330:TITLE:GENERATOR FUEL ALLOCATION PLAN
1335:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1340:SETUP:SOURCE=GFP
1345:SET:OBJ=TIME,RHS=RHSV
1350:PICTURE
1355:PRIMAL
1360:OUTPUT
1365:ENDLP
1370\$:ENDJOB
1375***EOF

AD-A087 088

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 15/5
A STUDY OF FUEL SUPPLIES FOR EMERGENCY POWER GENERATION AT ATR --ETC(U)
JUN 80 S J MOTT, S D NELSON
AFIT-LSSR-17-80

UNCLASSIFIED

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2, 2
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END
DATE
FILMED
9-80
DTIC

Hill AFB Adjusted Input Program

10##S,R(SL) :,8,16;;,16
15\$:IDENT:WP1186, MOTT/NELSON THESIS
20\$:USERID:80A053\$KR79
25\$:PROGRAM:RLHS
30\$:LIMITS:10,39K,,5K
35\$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40\$:REMOTE:S0,SL
45\$:DISC:AA,A1,10R
50\$:DISC:AB,A2,10R
55\$:DISC:AC,A3,10R
60\$:DISC:AD,A4,10R
65\$:DISC:AE,A5,10R
70\$:DATA:IN
75FILE:ELEC
80**** HILL AFB FUEL PLAN ****
85**** ****.
90**** CONSTRAINT MATRIX ****
95**** ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1

120:,S4(P)=1
 125:,S5(P)=1
 130:,S6(P)=1
 135:,S7(P)=1
 140:,S8(P)=1
 145:,S9(P)=1
 150:,S10(P)=1
 155:,S11(P)=1
 160:,S12(P)=1
 165:,S13(P)=1
 170:,S14(P)=1
 175:,S15(P)=1
 180:,S16(P)=1
 185:,S17(P)=1
 190:,S18(P)=1
 195:,S20(P)=1
 200:,S21(P)=1
 205:,S22(P)=1
 210:,S23(P)=1
 215:,S25(P)=1
 220:,S26(P)=1
 225:,S27(P)=1
 230:,S28(P)=1
 235:,S29(P)=1
 240:,S30(P)=1
 245:,S31(P)=1
 250:,S32(P)=1
 255:,S33(P)=1
 260:,S34(P)=1
 265:,S35(P)=1
 270:,S36(P)=1
 275:,S37(P)=1
 280:,S38(P)=1
 285:,S39(P)=1
 290:,S40(P)=1
 295:,S41(P)=1
 300:,S42(P)=1
 305:,S43(P)=1
 310:,S44(P)=1
 315:,S45(P)=1
 320:,S46(P)=1
 325:,S47(P)=1
 330*** TIME EQUALITY CONSTRAINTS ****
 335MATRIX:TC1(Z),S1=.0357
 340:,S2=-.1136
 345A:TC2(Z),S2=.1136
 350:,S3=-.08
 355A:TC3(Z),S3=.08
 360:,S4=-.303
 365A:TC4(Z),S4=.303
 370:,S5=-.303

375A:TC5(Z),S5=.303
 380:,S6=-.1961
 385A:TC6(Z),S6=.1961
 390:,S7=-.303
 395A:TC7(Z),S7=.303
 400:,S8=-.25
 405A:TC8(Z),S8=.25
 410:,S9=-.25
 415A:TC9(Z),S9=.25
 420:,S10=-.1136
 425A:TC10(Z),S10=.1136
 430:,S11=-.1961
 435A:TC11(Z),S11=.1961
 440:,S12=-.0408
 445A:TC12(Z),S12=.0408
 450:,S13=-.1538
 455A:TC13(Z),S13=.1538
 460:,S14=-.303
 465A:TC14(Z),S14=.303
 470:,S15=-.1538
 475A:TC15(Z),S15=.303
 480:,S16=-.303
 485A:TC16(Z),S16=.303
 490:,S17=-.0741
 495A:TC17(Z),S17=.0741
 500:,S18=-.4
 505A:TC18(Z),S18=.4
 510:,S20=-.1136
 515A:TC20(Z),S20=.1136
 520:,S21=-.0741
 525A:TC21(Z),S21=.0741
 530:,S22=-.1
 535A:TC22(Z),S22=.1
 540:,S23=-.0435
 545A:TC23(Z),S23=.0435
 550:,S25=-.0345
 555A:TC25(Z),S25=.0345
 560:,S26=-.1136
 565A:TC26(Z),S26=.1136
 570:,S27=-.303
 575A:TC27(Z),S27=.303
 580:,S28=-.1538
 585A:TC28(Z),S28=.1538
 590:,S29=-.1136
 595A:TC29(Z),S29=.1136
 600:,S30=-.1111
 605A:TC30(Z),S30=.1111
 610:,S31=-.1538
 615A:TC31(Z),S31=.1538
 620:,S32=-.1961
 625A:TC32(Z),S32=.1961

630:,S33=-.0741
 635A:TC33(Z),S33=.0741
 640:,S34=-.1136
 645A:TC34(Z),S34=.1136
 650:,S35=-.0741
 655A:TC35(Z),S35=.0741
 660:,S36=-.3030
 665A:TC36(Z),S36=.3030
 670:,S37=-.3030
 675A:TC37(Z),S37=.3030
 680:,S38=-.4
 685A:TC38(Z),S38=.4000
 690:,S39=-.4
 695A:TC39(Z),S39=.4000
 700:,S40=-.1136
 705A:TC40(Z),S40=.1136
 710:,S41=-.0741
 715A:TC41(Z),S41=.0741
 720:,S42=-.0313
 725A:TC42(Z),S42=.0313
 730:,S43=-.0357
 735A:TC43(Z),S43=.0357
 740:,S44=-.0125
 745A:TC44(Z),S44=.0125
 750:,S45=-.0357
 755A:TC45(Z),S45=.0357
 760:,S46=-.0156
 765A:TC46(Z),S46=.0156
 770:,S47=-.05714
 775****
 780**** OBJECTIVE FUNCTION
 785****
 790MATRIX:TIME(FREE),S1=-.00076
 795:,S2=-.00242
 800:,S3=-.00170
 805:,S4=-.00645
 810:,S5=-.00645
 815:,S6=-.00417
 820:,S7=-.00645
 825:,S8=-.00532
 830:,S9=-.00532
 835:,S10=-.00242
 840:,S11=-.00417
 845:,S12=-.00087
 850:,S13=-.00327
 855:,S14=-.00645
 860:,S15=-.00327
 865:,S16=-.00645
 870:,S17=-.00158
 875:,S18=-.00851
 880:,S20=-.00242

885:,S21=-.00158
 890:,S22=-.00213
 895:,S23=-.00093
 900:,S25=-.00073
 905:,S26=-.00242
 910:,S27=-.00645
 915:,S28=-.00327
 920:,S29=-.00242
 925:,S30=-.00236
 930:,S31=-.00327
 935:,S32=-.00417
 940:,S33=-.00158
 945:,S34=-.00242
 950:,S35=-.00158
 955:,S36=-.00645
 960:,S37=-.00645
 965:,S38=-.00851
 970:,S39=-.00851
 975:,S40=-.00242
 980:,S41=-.00158
 985:,S42=-.00066
 990:,S43=-.00076
 995:,S44=-.00027
 1000:,S45=-.00076
 1005:,S46=-.00033
 1010:,S47=-.00122
 1015****
 1020**** RIGHT HAND SIDE VALUES ****
 1025****
 1030**** FUEL QUANTITY CONSTRAINT ****
 1035RHS:FUEL,RHSV=215712
 1040**** TIME EQUALITY CONSTRAINTS ****
 1045:TC1=81.1688
 1050:TC2=-10.4545
 1055:TC3=-8.4848
 1060:TC4=136.3636
 1065:TC5=-111.4082
 1070:TC6=-24.9554
 1075:TC7=98.4848
 1080:TC8=0
 1085:TC9=147.7273
 1090:TC10=103.6097
 1095:TC11=-193.6375
 1100:TC12=141.6013
 1105:TC13=-78.0886
 1110:TC14=-64.9884
 1115:TC15=140.746
 1120:TC16=-58.1818
 1125:TC17=-82.7334
 1130:TC18=228.0364
 1135:TC20=-246.6364

1140:TC21=42
1145:TC22=36.9565
1150:TC23=-17.991
1155:TC25=44.6709
1160:TC26=37.8788
1165:TC27=10.0233
1170:TC28=77.0979
1175:TC29=-183.0808
1180:TC30=105.9829
1185:TC31=-153.1071
1190:TC32=-.3944
1195:TC33=.088
1200:TC34=-.088
1205:TC35=-.2289
1210:TC36=0
1215:TC37=.367
1220:TC38=0
1225:TC39=-.275
1230:TC40=-.088
1235:TC41=111.963
1240:TC42=0
1245:TC43=0
1250:TC44=0
1255:TC45=0
1260:TC46=-120
1265END***
1270\$:DATA:1*
1275:PREPRO
1280:TITLE:GENERATOR FUEL ALLOCATION PLAN
1285:CONVERT:SOURCE=ELEC/IN,IDENT=6FP
1290:SETUP:SOURCE=6FP
1295:SET:OBJ=TIME,RHS=RHSV
1300:PICTURE
1305:PRIMAL
1310:OUTPUT
1315:ENDLP
1320\$:ENDJOB
1325***EOF

APPENDIX E
HILL AFB SUBOPTIMAL OUTPUT

GENERATOR FUEL ALLOCATION PLAN																			VERB= PRIMAL PAGE 17	
C244T 01 08/14/80																				
PPHMM=OFF																				
FUNCT= 1.727963240 OBJ=TIME																				
ITER	ETA	MUR	FUNCTIONAL	MINFS	MBJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	-CT	MCT	FCT	A.TIM	
1	1	1	1.77993240	34	5	4338.66235-	51	1	1	1	405	2L	405	1	18	1A	1	6	1.144	
2	2	2	2.274519285	37		4288.75158-	57	1	1	1	595	7L	595	2	1	1A	1	4	1.34	
3	3	3	3.43089808	36		4271.74198-	54	1	1	1	525	4L	525	2	3	1A	1	6	1.19	
4	4	4	4.43089808	36		4271.74198-	59	1	1	1	575	9L	575	4	4	1A	1	6	1.19	
5	5	5	5.45624500	35	5	3088.57037-	512	1	1	1	645	13L	645	2	11	1A	1	11	1.44	
6	6	6	6.84899155	34		3795.55792-	515	1	1	1	635	15L	635	2	14	1A	1	11	1.44	
7	7	7	7.84811467	33		3638.04112-	518	1	1	1	665	16L	665	3	11	1A	1	11	1.28	
8	8	8	8.11878458	32		3513.72751-	517	1	1	1	685	17L	685	4	14	1A	1	11	1.28	
9	9	9	9.11878458	31		3429.72751-	521	1	1	1	695	22L	695	5	14	1A	1	11	1.15	
10	10	10	10.147283945	30	5	3217.76172-	538	1	1	1	785	31L	785	2	9	1A	1	16	1.41	
11	11	11	11.151716348	29		3128.41997-	525	1	1	1	735	24L	735	2	14	1A	1	16	1.28	
12	12	12	12.16788233	28		3052.46232-	524	1	1	1	745	27L	745	3	14	1A	1	16	1.28	
13	13	13	13.18352431	27		2978.74933-	522	1	1	1	785	23L	785	4	14	1A	1	16	1.28	
14	14	14	14.18991823	26		2958.78273-	527	1	1	1	755	28L	755	5	14	1A	1	16	1.25	
15	15	15	15.189988587	25	5	2958.78273-	533	1	1	1	815	34L	815	2	7	1A	1	21	1.48	
16	16	16	16.215581867	24	5	2838.52878-	537	1	1	1	895	47L	895	1	10	1A	1	26	1.48	
17	17	17	17.215488631	23		2838.52878-	541	1	1	1	895	47L	895	2	10	1A	1	26	1.48	
18	18	18	18.22918953	22	6	2582.98893-	523	1	1	1	715	21L	715	1	23	2A	2	21	1.54	
19	19	19	19.35426638	21		2355.93213-	54	1	1	1	545	AL	545	2	31	2A	2	31	1.28	
20	20	20	20.35453988	20		2335.82313-	53	1	1	1	515	3L	515	2	31	2A	2	31	1.28	
21	21	21	21.361199422	19		2315.85721-	514	1	1	1	625	16L	625	4	17	2A	2	36	1.51	
22	22	22	22.426941123	18	6	2161.66148-	528	1	1	1	765	29L	765	2	17	2A	2	36	1.51	
23	23	23	23.427858348	17		2161.11142-	548	1	1	1	885	49L	885	2	24	2A	2	36	1.51	
24	24	24	24.527819848	16	6	2043.68212-	52	1	1	1	585	5L	585	1	15	3A	2	41	1.52	
25	25	25	25.559259168	15		1967.92852-	84	1	1	1	585	6L	585	2	19	3A	2	41	1.52	
26	26	26	26.786757154	14	7	1448.63894-	528	1	1	1	685	24L	685	2	28	3A	3	46	1.54	
27	27	27	27.981191538	13		1235.86657-	516	1	1	1	645	14L	645	2	34	3A	3	46	1.27	
28	28	28	28.981191538	13		1235.86657-	536	1	1	1	645	14L	645	3	34	3A	3	46	1.27	
29	29	29	29.11178159	12	7	1126.81986-	55	1	1	1	535	18L	535	1	16	4A	3	51	1.54	
30	30	30	30.11178159	12		1125.56827-	537	1	1	1	535	18L	535	2	16	4A	3	51	1.54	
31	31	31	31.122167127	11	10	971.88834-	513	1	1	1	615	12L	615	1	47	5A	2	56	1.67	
32	32	32	32.144718481	9		867.398338-	518	1	1	1	585	35L	585	2	47	5A	2	56	1.67	
33	33	33	33.144718481	8		867.398338-	535	1	1	1	585	35L	585	3	47	5A	2	56	1.67	
34	34	34	34.144724824	8		867.398338-	519	1	1	1	585	35L	585	4	47	5A	2	56	1.67	
35	35	35	35.184724824	7	8	698.953682-	511	1	1	1	595	19L	595	1	47	5A	2	56	1.67	
36	36	36	36.184724824	6		698.953682-	534	1	1	1	595	19L	595	2	47	6A	1	41	1.64	
37	37	37	37.184724824	5	7	698.953682-	536	1	1	1	595	19L	595	2	47	6A	1	41	1.64	
38	38	38	38.207813455	4	7	667.653473-	532	1	1	1	665	33L	665	1	47	7A	2	66	1.61	
39	39	39	39.207813455	4	6	667.653473-	542	1	1	1	665	33L	665	2	47	7A	2	66	1.61	
40	40	40	40.207813455	4	5	667.653473-	543	1	1	1	665	33L	665	1	47	9A	2	76	1.44	
41	41	41	41.207813455	4	4	667.653473-	544	1	1	1	665	33L	665	2	47	10A	1	76	1.44	
42	42	42	42.207813455	4	1	667.653473-	545	1	1	1	665	33L	665	1	47	11A	1	76	1.44	
43	43	43	43.228843510	3	3	425.89883-	845	1	1	1	935	46L	935	1	94	13A	89	1.66		
44	44	44	44.251598834	2	1	348.792183-	531	1	1	1	945	37L	945	1	47	14A	98	1.66		
45	45	45	45.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	2	47	15A	91	1.49		
46	46	46	46.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
47	47	47	47.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
48	48	48	48.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
49	49	49	49.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
50	50	50	50.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
51	51	51	51.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
52	52	52	52.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
53	53	53	53.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
54	54	54	54.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
55	55	55	55.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
56	56	56	56.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
57	57	57	57.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
58	58	58	58.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
59	59	59	59.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
60	60	60	60.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
61	61	61	61.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
62	62	62	62.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
63	63	63	63.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
64	64	64	64.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
65	65	65	65.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
66	66	66	66.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
67	67	67	67.358988455	2	1	145.758882-	520	1	1	1	775	1L	775	1	47	16A	92	1.53		
68	68	68	68.358988455	2	1	145.758882-	520	1	1											

GENERATOR FUEL ALLOCATION PLAN

FUNCT= 350.984455. OBJ=TIME

RMS=RMSV

ROWS

SLACK VALUES



ROW	RJ	TYPE	FUEL	ROW NAME	LOGICAL	INDIC.	L-VALUE	PI	RHS
1	PLUS								
2	ZERO	TC1							215712.00000000
3	ZERO	TC2							81.16679940
4	ZERO	TC3							10.45450000
5	ZERO	TC4							8.48490010
6	ZERO	TC5							136.36359977
7	ZERO	TC6							111.40820026
8	ZERO	TC7							24.95540073
9	ZERO	TC8							98.40470030
10	ZERO	TC9							
11	ZERO	TC10							147.72720073
12	ZERO	TC11							103.60940025
13	ZERO	TC12							103.63750076
14	ZERO	TC13							141.60120079
15	ZERO	TC14							78.00000016
16	ZERO	TC15							64.90440046
17	ZERO	TC16							140.74500030
18	ZERO	TC17							50.10100036
19	ZERO	TC18							82.73340034
20	ZERO	TC19							568.92050007
21	ZERO	TC20							332.70220199
22	ZERO	TC21							246.63640022
23	ZERO	TC22							45.88000000
24	ZERO	TC23							36.95640057
25	ZERO	TC24							427.33910093
26	ZERO	TC25							44.67800007
27	ZERO	TC26							37.07070001
28	ZERO	TC27							10.82370093
29	ZERO	TC28							77.09700043
30	ZERO	TC29							103.00000101
31	ZERO	TC30							105.90200066
32	ZERO	TC31							153.10710144
33	ZERO	TC32							3.94400000
34	ZERO	TC33							0.00000000
35	ZERO	TC34							0.00000000
36	ZERO	TC35							0.00000000
37	ZERO	TC36							0.00000000
38	ZERO	TC37							0.00000000
39	ZERO	TC38							0.00000000
40	ZERO	TC39							0.00000000
41	ZERO	TC40							0.00000000
42	ZERO	TC41							0.00000000
43	ZERO	TC42							0.00000000
44	ZERO	TC43							0.00000000
45	ZERO	TC44							0.00000000

Hill AFB Slack Values, N=47

C2447 81 84/14/80
 PRNAN=CFP
 GENERATOR FUEL ALLOCATION PLAN
 FUNCT= 358.984455 OBJ=TIME 1

RMS=RHSV 1

SLACK VALUES



ROWS

ROW	KJ	TYPE	ROW NAME	LOGICAL	INDIC.	L-VALUE	PI	RHS
46	ZERO	TC45					.20593278	
47	ZERO	TC46					.84416405	
48	FREE	TIME				358.98445511		120.88888888
					•BASIS			

Hill AFB Slack Values, N=47

REGENERATOR FUEL ALLOCATION PLAN

FUNCTION 350.984455. ORJ=TIME :

! ! ASRG=SHR

C2447 01 04/14/00

PR14M-05P 1

COLONY

Generator #

Abstract

COL	KJ	TYPE	COLUMN NAME
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
14	14	14	14
15	15	15	15
16	16	16	16
17	17	17	17
18	18	18	18
19	19	19	19
20	20	20	20
21	21	21	21
22	22	22	22
23	23	23	23
24	24	24	24
25	25	25	25
26	26	26	26
27	27	27	27
28	28	28	28
29	29	29	29
30	30	30	30
31	31	31	31
32	32	32	32
33	33	33	33
34	34	34	34
35	35	35	35
36	36	36	36
37	37	37	37
38	38	38	38
39	39	39	39
40	40	40	40
41	41	41	41
42	42	42	42
43	43	43	43
44	44	44	44
45	45	45	45
46	46	46	46
47	47	47	47
48	48	48	48
49	49	49	49
50	50	50	50
51	51	51	51
52	52	52	52
53	53	53	53
54	54	54	54
55	55	55	55
56	56	56	56
57	57	57	57
58	58	58	58
59	59	59	59
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62	62	62	62
63	63	63	63
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67	67	67	67
68	68	68	68
69	69	69	69
70	70	70	70
71	71	71	71
72	72	72	72
73	73	73	73
74	74	74	74
75	75	75	75
76	76	76	76
77	77	77	77
78	78	78	78
79	79	79	79
80	80	80	80
81	81	81	81
82	82	82	82
83	83	83	83
84	84	84	84
85	85	85	85
86	86	86	86
87	87	87	87
88	88	88	88
89	89	89	89
90	90	90	90
91	91	91	91
92	92	92	92
93	93	93	93
94	94	94	94
95	95	95	95
96	96	96	96
97	97	97	97
98	98	98	98
99	99	99	99
100	100	100	100

INAPIC.

X-VALUE

23

31835-1503

FUEL ALLOCATIONS

9016.65340640.
Hill AFB Fuel Allocations, N=47

FUNCTION 350.904055+ OBJ=TIME ; RMS=RHSV ;

FUEL ALLOCATIONS



COLUMNS	Generator #	STRICT.
---------	-------------	---------

COL	RJ	TYPE	COLUMN NAME	INDIC.	N-VALUE	DJ	COST/SCALE
94	PLUS	S46		0BASIS	28634.26440713	.	.00333000
95	PLUS	S47		0BASIS	7733.54061122	.	.00122000
96	RHS	RMS4				145.75803338	.

Hill AFB Fuel Allocations, N=47

APPENDIX F
HILL AFB OPTIMAL OUTPUT

ITER	ETA	MUR	FUNCTIONAL	MINFS	NOJS	VALUE	INCOMING	VECT	NAME	IN	KJ	DUT	RJ	CCT	VPC	ACT	MC1	FCT	AL-TIM
1	1	1	1.72706324	36	5	2818.41058	51	1	1	P	475	IN	2L	1	10	1A	1	4	1.144
2	2	2	2.25519285	35	5	2768.57479	57	1	1	P	535	IN	7L	2	10	1A	1	4	1.24
3	3	3	2.41060608	34	5	2741.43918	54	1	1	P	585	IN	4L	3	10	1A	1	4	1.14
4	4	4	2.43080908	34	5	2741.53918	59	1	1	P	585	IN	4L	4	10	1A	1	4	1.17
5	5	5	5.45924848	33	5	2469.34658	515	1	1	P	585	IN	13L	1	10	1A	1	11	1.21
6	6	6	4.81695155	32	5	2275.31517	515	1	1	P	415	IN	19L	2	10	1A	1	11	1.21
7	7	7	2.68114467	31	5	2189.84933	518	1	1	P	645	IN	18L	3	10	1A	1	11	1.24
8	8	8	8.11095459	30	5	1993.48472	517	1	1	P	635	IN	17L	4	10	1A	1	11	1.17
9	9	9	9.11095459	29	5	1989.48472	521	1	1	P	635	IN	21L	5	10	1A	1	11	1.15
10	10	10	10.14263945	28	5	1697.51892	538	1	1	P	745	IN	29L	1	8	1A	1	16	1.38
11	11	11	11.15931743	27	5	1693.64595	527	1	1	P	745	IN	22L	2	10	1A	1	16	1.10
12	12	12	12.1122513	26	5	1587.87393	528	1	1	P	695	IN	23L	3	10	1A	1	16	1.28
13	13	13	13.1411297	25	5	1587.87393	533	1	1	P	775	IN	32L	1	7	1A	1	21	1.41
14	14	14	14.16746278	24	5	1487.44792	547	1	1	P	45L	IN	45L	1	10	1A	1	26	1.45
15	15	15	15.187481343	23	5	1487.23192	541	1	1	P	39L	IN	39L	2	10	1A	1	26	1.19
16	16	16	16.18769419	22	5	1378.21312	56	1	1	P	525	IN	8L	1	14	2A	1	31	1.47
17	17	17	17.22316462	21	5	1299.38412	53	1	1	P	495	IN	3L	2	2A	2A	1	31	1.19
18	18	18	18.22562185	20	5	1299.38412	514	1	1	P	605	IN	16L	3	2A	2A	1	31	1.18
19	19	19	19.24343459	19	5	1148.79518	516	1	1	P	625	IN	19L	1	28	2A	2	36	1.54
20	20	20	20.24343459	18	5	1485.43538	521	1	1	P	685	IN	24L	2	2A	2A	2	36	1.28
21	21	21	21.321155499	17	5	1305.43538	534	1	1	P	685	IN	39L	3	2A	2A	2	36	1.16
22	22	22	22.32373128	16	6	1894.88538	546	1	1	P	38L	IN	38L	1	10	2A	2	41	1.44
23	23	23	23.32373128	15	6	1894.88538	537	1	1	P	415	IN	34L	2	2A	2A	2	41	1.23
24	24	24	24.32373128	14	6	977.00264	52	1	1	P	485	IN	5L	1	26	3A	2	46	1.57
25	25	25	25.32373128	13	6	981.249603	526	1	1	P	705	IN	25L	2	2A	3A	2	46	1.26
26	26	26	26.32373128	12	6	875.488806	58	1	1	P	545	IN	4L	3	3A	3A	2	46	1.18
27	27	27	27.32373128	11	11	651.745508	528	1	1	P	715	IN	26L	4	45	3A	2	46	1.16
28	28	28	28.32373128	10	11	651.745508	528	1	1	P	715	IN	27L	4	45	4A	2	51	1.50
29	29	29	29.32373128	9	11	541.397182	55	1	1	P	515	IN	18L	2	4A	4A	2	51	1.28
30	30	30	30.32373128	8	11	541.397182	535	1	1	P	795	IN	33L	3	4A	4A	2	51	1.17
31	31	31	31.32373128	7	11	541.397182	539	1	1	P	795	IN	37L	4	4A	4A	2	51	1.14
32	32	32	32.32373128	6	8	437.611408	510	1	1	P	565	IN	11L	4	38	5A	3	56	1.55
33	33	33	33.32373128	5	7	437.611408	534	1	1	P	785	IN	34L	2	4A	5A	3	56	1.24
34	34	34	34.32373128	4	7	436.904688	534	1	1	P	625	IN	31L	1	45	6A	2	61	1.57
35	35	35	35.32373128	3	7	214.311191	532	1	1	P	765	IN	48L	1	45	7A	2	66	1.63
36	36	36	36.32373128	2	6	214.311191	547	1	1	P	605	IN	48L	1	45	8A	2	71	1.59
37	37	37	37.32373128	1	5	214.311191	543	1	1	P	605	IN	42L	1	45	9A	1	76	1.42
38	38	38	38.32373128	0	4	214.311191	544	1	1	P	605	IN	43L	1	45	10A	1	82	1.41
39	39	39	39.32373128	0	4	214.311191	545	1	1	P	605	IN	44L	1	45	11A	1	84	1.41
40	40	40	40.32373128	0	4	214.311191	546	1	1	P	605	IN	45L	1	45	12A	1	85	1.40
41	41	41	41.32373128	0	3	95.449816	531	1	1	P	755	IN	28L	1	45	13A	1	86	1.47
42	42	42	42.32373128	0	2	179.449816	528	1	1	P	755	IN	28L	1	45	14A	1	87	1.53
43	43	43	43.32373128	0	1	52.8361955	528	1	1	P	455	IN	14L	1	45	15A	1	88	1.44
44	44	44	44.32373128	0	1	1.93888883	513	1	1	P	575	IN	12L	1	45	16A	1	89	1.53
45	45	45	45.32373128	0	1	1.38936688	511	1	1	P	575	IN	11L	1	45	17A	1	90	1.44
14 RING INVERT																			
15 RING INVERT																			
16 RING INVERT																			
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31 RING INVERT																			
32 RING INVERT																			
33 RING INVERT																			
34 RING INVERT																			
35 RING INVERT																			

FUNC= 336.131266 OBJ=TIME

08MAN=OFF

RHS=RHSV

UNUS

SLACK VALUES



ROW	KJ	TYPE	FUEL	ROW NAME	LOGICAL	INDIC.	L-VALUE	PI	RMS
1	PLUS								
2	7800	IC1							215712.00000000
3	7800	IC2							81.16879940
4	7800	IC3							18.45458880
5	7800	IC4							8.46488810
6	7800	IC5							136.13350077
7	7800	IC6							111.48828876
8	7800	IC7							74.95548873
9	7800	IC8							98.44479038
10	7800	IC9							
11	7800	IC10							147.72729873
12	7800	IC11							183.40969925
13	7800	IC12							193.63758876
14	7800	IC13							141.68129028
15	7800	IC14							78.98068816
16	7800	IC15							44.98840640
17	7800	IC16							148.74599938
18	7800	IC17							58.18188836
19	7800	IC18							82.73348834
20	7800	IC19							228.83639084
21	7800	IC20							246.83648872
22	7800	IC21							42.88888880
23	7800	IC22							36.95449957
24	7800	IC23							17.99188817
25	7800	IC24							44.87889997
26	7800	IC25							37.87879991
27	7800	IC26							18.87329993
28	7800	IC27							77.80789943
29	7800	IC28							103.80888181
30	7800	IC29							105.98289046
31	7800	IC30							153.18718144
32	7800	IC31							
33	7800	IC32							394.488880
34	7800	IC33							88.878880
35	7800	IC34							88.888880
36	7800	IC35							228.888880
37	7800	IC36							
38	7800	IC37							367.888880
39	7800	IC38							
40	7800	IC39							275.888880
41	7800	IC40							88.888880
42	7800	IC41							111.98289934
43	7800	IC42							
44	7800	IC43							
45	7800	IC44							
46	7800	IC45							
47	7800	IC46							120.88888880

Hill AFB Slack Values, N=45

APPENDIX G
McCLELLAN AFB INPUT PROGRAMS

MCClellan AFB Adjusted Input Program

10NNS,R(SL) :,8,16;:,16
15\$:IDENT:UP1186, MOTT/NELSON THESIS
20\$:USERID:80A053\$KR79
25\$:PROGRAM:RLHS
30\$:LIMITS:10,39K,,5K
35\$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40\$:REMOTE:SD,SL
45\$:DISC:AA,A1,10R
50\$:DISC:AB,A2,10R
55\$:DISC:AC,A3,10R
60\$:DISC:AD,A4,10R
65\$:DISC:AE,A5,10R
70\$:DATA:IN
75FILE:ELEC
80**** MCCLELLAN AFB FUEL PLAN ****
85**** ****
90**** CONSTRAINT MATRIX ****
95**** ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S2(P)=1
110:,S3(P)=1
115:,S4(P)=1
120:,S5(P)=1
125:,S6(P)=1
130:,S10(P)=1
135:,S11(P)=1
140:,S12(P)=1
145:,S13(P)=1
150:,S14(P)=1
155:,S15(P)=1
160:,S16(P)=1
165:,S18(P)=1
170:,S19(P)=1
175:,S20(P)=1
180:,S21(P)=1
185:,S22(P)=1
190:,S23(P)=1
195:,S24(P)=1
200:,S25(P)=1
205:,S26(P)=1
210:,S27(P)=1
215:,S28(P)=1
220:,S29(P)=1
225:,S30(P)=1
230:,S31(P)=1
235:,S32(P)=1
240:,S33(P)=1
245:,S34(P)=1
250:,S35(P)=1
255:,S36(P)=1

260*** TIME EQUALITY CONSTRAINTS ***

265MATRIX:TC2(Z),S2=.0741

270:,S3=-.0357

275A:TC3(Z),S3=.0357

280:,S4=-.3030

285A:TC4(Z),S4=.3030

290:,S5=-.4

295A:TC5(Z),S5=.4000

300:,S6=-.0074

305A:TC6(Z),S6=.0074

310:,S10=-.4

315A:TC10(Z),S10=.4000

320:,S11=-.0568

325A:TC11(Z),S11=.0568

330:,S12=-.1961

335A:TC12(Z),S12=.1961

340:,S13=-.3030

345A:TC13(Z),S13=.3030

350:,S14=-.4

355A:TC14(Z),S14=.4000

360:,S15=-.1961

365A:TC15(Z),S15=.1961

370:,S16=-.0980

375A:TC16(Z),S16=.0980

380:,S18=-.1961

385A:TC18(Z),S18=.1961

390:,S19=-.1136

395A:TC19(Z),S19=.1136

400:,S20=-.1961

405A:TC20(Z),S20=.1961

410:,S21=-.1136

415A:TC21(Z),S21=.1136

420:,S22=-.0741

425A:TC22(Z),S22=.0741

430:,S23=-.1136

435A:TC23(Z),S23=.1136

440:,S24=-.1961

445A:TC24(Z),S24=.1961

450:,S25=-.1136

455A:TC25(Z),S25=.1136

460:,S26=-.0741

465A:TC26(Z),S26=.0741

470:,S27=-.3030

475A:TC27(Z),S27=.3030

480:,S28=-.1961

485A:TC28(Z),S28=.1961

490:,S29=-.1961

495A:TC29(Z),S29=.1961

500:,S30=-.1136

505A:TC30(Z),S30=.1136

510:,S31=-.0741

```

515A:TC31(Z),S31=.0741
520:,S32=-.1961
525A:TC32(Z),S32=.1961
530:,S33=-.1961
535A:TC33(Z),S33=.1961
540:,S34=-.1136
545A:TC34(Z),S34=.1136
550:,S35=-.0125
555A:TC35(Z),S35=.0125
560:,S36=-.1905
565****
570**** OBJECTIVE FUNCTION
575****
580MATRIX:TIME(FREE),S2=-.00206
585:,S3=-.00099
590:,S4=-.00842
595:,S5=-.01111
600:,S6=-.000206
605:,S10=-.01111
610:,S11=-.00158
615:,S12=-.00545
620:,S13=-.00842
625:,S14=-.01111
630:,S15=-.00545
635:,S16=-.00272
640:,S18=-.00546
645:,S19=-.00316
650:,S20=-.00545
655:,S21=-.00316
660:,S22=-.00206
665:,S23=-.00316
670:,S24=-.00545
675:,S25=-.00316
680:,S26=-.00206
685:,S27=-.00842
690:,S28=-.00545
695:,S29=-.00545
700:,S30=-.00316
705:,S31=-.00216
710:,S32=-.00545
715:,S33=-.00545
720:,S34=-.00316
725:,S35=-.00035
730:,S36=-.00529
735****
740**** RIGHT HAND SIDE VALUES
745****
750**** FUEL QUANTITY CONSTRAINT
755RHS:FUEL,RHSV=122976
760**** TIME EQUALITY CONSTRAINTS
765:TC2=-38.3598

```

770:TC3=29.4372
775:TC4=34.8485
780:TC5=48.1481
785:TC6=-48.1481
790:TC10=184.0909
795:TC11=-275.6595
800:TC12=-.5526
805:TC13=.5212
810:TC14=.0314
815:TC15=236.6667
820:TC16=-236.6666
825:TC18=54.0660
830:TC19=-33.0882
835:TC20=-21.4573
840:TC21=-.0286
845:TC22=.0286
850:TC23=13.5028
855:TC24=-13.5028
860:TC25=-.0286
865:TC26=-.0471
870:TC27=.5526
875:TC28=0
880:TC29=-.4769
885:TC30=-.0289
890:TC31=.5055
895:TC32=0
900:TC33=-.4769
905:TC34=112.0455
910:TC35=-120
915END***
920*:DATA:I*
925:PREPRO
930:TITLE:GENERATOR FUEL ALLOCATION PLAN
935:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
940:SETUP:SOURCE=GFP
945:SET:OBJ=TIME,RHS=RHSV
950:PICTURE
955:PRIMAL
960:OUTPUT
965:ENDLP
970*:ENDJOB
975***EOF

McClellan AFB Original Input Program

```
10#HS.R(J) : ,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:SD,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** MCCLELLAN AFB FUEL PLAN ****
85**** ****
90**** CONSTRAINT MATRIX ****
95**** ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110: ,S2(P)=1
115: ,S3(P)=1
120: ,S4(P)=1
125: ,S5(P)=1
130: ,S6(P)=1
135: ,S7(P)=1
140: ,S8(P)=1
145: ,S9(P)=1
150: ,S10(P)=1
155: ,S11(P)=1
160: ,S12(P)=1
165: ,S13(P)=1
170: ,S14(P)=1
175: ,S15(P)=1
180: ,S16(P)=1
185: ,S17(P)=1
190: ,S18(P)=1
195: ,S19(P)=1
200: ,S20(P)=1
205: ,S21(P)=1
210: ,S22(P)=1
215: ,S23(P)=1
220: ,S24(P)=1
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225:,S25(P)=1
 230:,S26(P)=1
 235:,S27(P)=1
 240:,S28(P)=1
 245:,S29(P)=1
 250:,S30(P)=1
 255:,S31(P)=1
 260:,S32(P)=1
 265:,S33(P)=1
 270:,S34(P)=1
 275:,S35(P)=1
 280:,S36(P)=1
 285*** TIME EQUALITY CONSTRAINTS ***
 290MATRIX:TC1(Z),S1=.0408
 295:,S2=-.0741
 300A:TC2(Z),S2=.0741
 305:,S3=-.0357
 310A:TC3(Z),S3=.0357
 315:,S4=-.3030
 320A:TC4(Z),S4=.3030
 325:,S5=-.4
 330A:TC5(Z),S5=.4000
 335:,S6=-.0074
 340A:TC6(Z),S6=.0074
 345:,S7=-.0069
 350A:TC7(Z),S7=.0069
 355:,S8=-.0060
 360A:TC8(Z),S8=.0060
 365:,S9=-.1961
 370A:TC9(Z),S9=.1961
 375:,S10=-.4
 380A:TC10(Z),S10=.4000
 385:,S11=-.0568
 390A:TC11(Z),S11=.0568
 395:,S12=-.1961
 400A:TC12(Z),S12=.1961
 405:,S13=-.3030
 410A:TC13(Z),S13=.3030
 415:,S14=-.4
 420A:TC14(Z),S14=.4000
 425:,S15=-.1961
 430A:TC15(Z),S15=.1961
 435:,S16=-.0980
 440A:TC16(Z),S16=.0980
 445:,S17=-.7692
 450A:TC17(Z),S17=.7692
 455:,S18=-.1961
 460A:TC18(Z),S18=.1961
 465:,S19=-.1136
 470A:TC19(Z),S19=.1136
 475:,S20=-.1961

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480A:TC20(Z),S20=.1961
485:,S21=-.1136
490A:TC21(Z),S21=.1136
495:,S22=-.0741
500A:TC22(Z),S22=.0741
505:,S23=-.1136
510A:TC23(Z),S23=.1136
515:,S24=-.1961
520A:TC24(Z),S24=.1961
525:,S25=-.1136
530A:TC25(Z),S25=.1136
535:,S26=-.0741
540A:TC26(Z),S26=.0741
545:,S27=-.3030
550A:TC27(Z),S27=.3030
555:,S28=-.1961
560A:TC28(Z),S28=.1961
565:,S29=-.1961
570A:TC29(Z),S29=.1961
575:,S30=-.1136
580A:TC30(Z),S30=.1136
585:,S31=-.0741
590A:TC31(Z),S31=.0741
595:,S32=-.1961
600A:TC32(Z),S32=.1961
605:,S33=-.1961
610A:TC33(Z),S33=.1961
615:,S34=-.1136
620A:TC34(Z),S34=.1136
625:,S35=-.0125
630A:TC35(Z),S35=.0125
635:,S36=-.1905
640****
645**** OBJECTIVE FUNCTION
650****
655MATRIX:TIME(FREE),S1=-.00113
660:,S2=-.00206
665:,S3=-.00099
670:,S4=-.00842
675:,S5=-.01111
680:,S6=-.000206
685:,S7=-.000192
690:,S8=-.000167
695:,S9=-.00545
700:,S10=-.01111
705:,S11=-.00158
710:,S12=-.00545
715:,S13=-.00842
720:,S14=-.01111
725:,S15=-.00545
730:,S16=-.00272

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735:,S17=-.02137
740:,S18=-.00546
745:,S19=-.00316
750:,S20=-.00545
755:,S21=-.00316
760:,S22=-.00206
765:,S23=-.00316
770:,S24=-.00545
775:,S25=-.00316
780:,S26=-.00206
785:,S27=-.00842
790:,S28=-.00545
795:,S29=-.00545
800:,S30=-.00316
805:,S31=-.00216
810:,S32=-.00545
815:,S33=-.00545
820:,S34=-.00316
825:,S35=-.00035
830:,S36=-.00529
835****
840****    RIGHT HAND SIDE VALUES    ****
845****
850****    FUEL QUANTITY CONSTRAINTS    ****
855RHS:FUEL,RHSV=122976
860****    TIME EQUALITY CONSTRAINTS    ****
865:TC1=-252.4565
870:TC2=-38.3598
875:TC3=29.4372
880:TC4=34.8485
885:TC5=48.1481
890:TC6=196.6795
895:TC7=106.9796
900:TC8=38.3889
905:TC9=-390.1961
910:TC10=184.0909
915:TC11=-275.6595
920:TC12=-.5526
925:TC13=.5212
930:TC14=.0314
935:TC15=236.6667
940:TC16=139.5174
945:TC17=-376.1840
950:TC18=54.0660
955:TC19=-33.0882
960:TC20=-21.4573
965:TC21=-.0286
970:TC22=.0286
975:TC23=13.5028
980:TC24=-13.5028
985:TC25=-.0286

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990:TC26=-.0471
995:TC27=.5526
1000:TC28=0
1005:TC29=-.4769
1010:TC30=-.0289
1015:TC31=.5055
1020:TC32=0
1025:TC33=-.4769
1030:TC34=112.0455
1035:TC35=-120
1040END***
1045\$:DATA:I*
1050:PREPKO
1055:TITLE:GENERATOR FUEL ALLOCATION PLAN
1060:CONVERT:SOURCE=ELEC/IN.IDENT=GFP
1065:SETUP:SOURCE=GFP
1070:SET:OBJ=TIME,RHS=RHSV
1075:PICTURE
1080:PRIMAL
1085:OUTPUT
1090:ENDLP
1095\$:ENDJOB
1100***EOF

APPENDIX H
McCLELLAN SUBOPTIMAL OUTPUT

McClellan AFB Iterations, N=36--Suboptimal Solution

GENERATOR FUEL ALLOCATION PLAN

CS90T 01 04/14/80

FUNCT= 292.312317. OBJ.TIME 1

PENALTY=0P 1

RMS=MSV 1

ROWS

SLACK VALUES

ROW	RJ	TYPE	FUEL	ROW NAME	LOGICAL	INDIC.	L-VALUE	PI	RMS
1	PLUS								
2	ZERO	TC1						.00403204	122976.00000000
3	ZERO	TC2						.11032245	414.21830963
4	ZERO	TC3						.18364277	36.35968634
5	ZERO	TC4						.31499308	29.43710983
6	ZERO	TC5						.33494005	34.84540077
7	ZERO	TC6						.34787106	48.14809998
8	ZERO	TC7						.10000000	196.67940867
9	ZERO	TC8						.10000000	186.97950995
10	ZERO	TC9						.10000000	38.38889980
11	ZERO	TC10						.10000000	398.19610214
12	ZERO	TC11						.08791098	184.89880851
13	ZERO	TC12						.08284821	275.55950812
14	ZERO	TC13						.07828888	.55260000
15	ZERO	TC14						.06226887	.52119999
16	ZERO	TC15						.05018857	.83140000
17	ZERO	TC16						.02553984	236.66669845
18	ZERO	TC17						.77623330	139.51730883
19	ZERO	TC18						1.05128371	376.18488192
20	ZERO	TC19						1.02656361	54.84590998
21	ZERO	TC20						.08402742	33.88820889
22	ZERO	TC21						.95939671	21.45738810
23	ZERO	TC22						.01685112	.02888888
24	ZERO	TC23						.05164136	.02888888
25	ZERO	TC24						.00918577	13.58279999
26	ZERO	TC25						.78446586	13.58280810
27	ZERO	TC26						.74192947	.07888888
28	ZERO	TC27						.67671971	.04718888
29	ZERO	TC28						.66872374	.55259999
30	ZERO	TC29						.63613167	.55259999
31	ZERO	TC30						.01149886	.47698888
32	ZERO	TC31						.56895536	.02888888
33	ZERO	TC32						.58374568	.58549999
34	ZERO	TC33						.47918489	.47698888
35	ZERO	TC34						.45446418	.47698888
36	ZERO	TC35						.01192858	112.84549988
37	FREE	TIME						.02536586	128.88888888
							292.31231729		

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McClellan AFB Slack Values, N=36

COL	RJ	TYPE	COLUMN NAME	STRUCT.	INDIC.	X-VALUE	DJ	COST+SCALE
14	PLUS	S1				14A32P.3A1693A9+	-	-.00113000-
39	PLUS	S2				2576.91348909+	-	-.00286400-
40	PLUS	S3				6473.26587952+	-	-.00890000-
41	PLUS	S4				659.64885533+	-	-.00A47000-
42	PLUS	S5				412.56214913+	-	-.01111000-
43	PLUS	S6				15794.15663567+	-	-.00A20600-
44	PLUS	S7				.	00403204+	-.00019200-
45	PLUS	S8				.	00403204+	-.00A16700-
46	PLUS	S9				.	30783204+	-.00545000-
47	PLUS	S10				711.37874441+	-	-.01111000-
48	PLUS	S11				1769.79054112+	-	-.0015A000-
49	PLUS	S12				1018.32796109+	-	-.00545000-
50	PLUS	S13				1243.35546690+	-	-.00A27000-
51	PLUS	S14				948.57875807+	-	-.01111000-
52	PLUS	S15				1918.32798224+	-	-.00545000-
53	PLUS	S16				1423.64693785+	21633920+	-.00272000-
54	PLUS	S17				1018.32739093+	-	-.02137000-
55	PLUS	S18				2035.54524108+	-	-.00546000-
56	PLUS	S19				1811.35244720+	-	-.00A1A000-
57	PLUS	S20				3315.60923748+	-	-.00545000-
58	PLUS	S21				5003.43398764+	-	-.00A316000-
59	PLUS	S22				3315.60966062+	-	-.00A2A000-
60	PLUS	S23				1051.51576333+	-	-.0031A000-
61	PLUS	S24				3315.60961212+	-	-.00545000-
62	PLUS	S25				5803.56331546+	-	-.00A316000-
63	PLUS	S26				1243.36358651+	-	-.00206000-
64	PLUS	S27				1018.34046597+	-	-.00A47000-
65	PLUS	S28				1018.34046597+	-	-.00545000-
66	PLUS	S29				3315.60943062+	-	-.00545000-
67	PLUS	S30				5803.56740958+	-	-.00A316000-
68	PLUS	S31				1018.34191940+	-	-.00216000-
69	PLUS	S32				1018.34191940+	-	-.00545000-
70	PLUS	S33				1018.34191940+	-	-.00545000-
71	PLUS	S34				3315.78194873+	-	-.00A316000-
72	PLUS	S35				21169.45915063+	-	-.00A35000-
73	PLUS	S36				2018.09933725+	-	-.00529000-
74	RMS	RMSV					338.79182459+	-.00529000-

McClellan AFB Fuel Allocations, N=36

APPENDIX I
McCLELLAN AFB OPTIMAL OUTPUT

ITP	ETA	MUH	FUNCTIONAL	NIMFS	MOJS	VALUE2	INCRIND	VECTOR	NAME	IN	KJ	OUT	PJ	CCT	VPC	ACT	MCT	FCT	A-TIM
1	1	1	1.58355625	27	5	1304.0738	S18	1	P	P	455	Z	14L	1	13	1A	1	1	.37A
2	2	2	2.44266972	24	24	1200.53069	S18	1	P	P	345	Z	6L	1	2	1A	1	1	.37
3	3	3	3.65309545	25	25	1200.66420	S13	1	P	P	345	Z	3L	1	3	1A	1	1	.6
4	4	4	4.67767896	24	24	1200.87188	S13	1	P	P	415	Z	18L	1	4	1A	1	1	.6
5	5	5	5.67522368	22	22	1200.95907	S14	1	P	P	425	Z	11L	1	5	1A	1	1	.6
6	6	6	6.68448055	21	21	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
7	7	7	7.69079018	20	20	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
8	8	8	8.69764403	19	19	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
9	9	9	9.69143508	17	17	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
10	10	10	10.69242577	16	16	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
11	11	11	11.69242577	15	15	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
12	12	12	12.69242577	14	14	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
13	13	13	13.69242577	13	13	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
14	14	14	14.69242577	12	12	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
15	15	15	15.69242577	11	11	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
16	16	16	16.69242577	10	10	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
17	17	17	17.69242577	9	9	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
18	18	18	18.69242577	8	8	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
19	19	19	19.69242577	7	7	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
20	20	20	20.69242577	6	6	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
21	21	21	21.69242577	5	5	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
22	22	22	22.69242577	4	4	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
23	23	23	23.69242577	3	3	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
24	24	24	24.69242577	2	2	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
25	25	25	25.69242577	1	1	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
26	26	26	26.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
27	27	27	27.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
28	28	28	28.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
29	29	29	29.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
30	30	30	30.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
31	31	31	31.69242577	0	0	1200.95907	S14	1	P	P	615	Z	20L	1	16	1A	1	1	.11
14 RINV	INVERT																		
15 CURT	CURRENT																		
45	PRIMAL																		

OPTIMAL SOLUTION



GENERATOR FUEL ALLOCATION PLAN

FORM 41 04/16/80

FUNCTION= 279.654552 OBJ=TIME I RMS=BNSV I

ROWS

SLACK VALUES

RIGHT-HAND
SIDE VALUES

ROW	RJ	TYPE	FUEL	ROW NAME	LOGICAL	INDIC.	L-VALUE	P1	RHS
1	PLUS	IC2						.00193420	122976.00000000
2	ZERO	IC3						.00169779	30.35900034
3	ZERO	IC4						.02475043	29.43710003
4	ZERO	IC5						.03334515	34.04049977
5	ZERO	IC6						.01950435	40.14000000
6	ZERO	IC7						.21394006	48.14010017
7	ZERO	IC8						.10100056	104.09000051
8	ZERO	IC9						.19724246	275.45950012
9	ZERO	IC10						.17931385	.55260000
10	ZERO	IC11						.13740057	.57119999
11	ZERO	IC12						.13496007	.03140000
12	ZERO	IC13						.11704046	236.66649045
13	ZERO	IC14						.10902200	236.66640110
14	ZERO	IC15						.09101240	54.06500000
15	ZERO	IC16						.00075100	33.00020009
16	ZERO	IC17						.06232336	21.45730010
17	ZERO	IC18						.05153206	.02060000
18	ZERO	IC19						.04003515	.07060000
19	ZERO	IC20						.03064064	13.50279999
20	ZERO	IC21						.02111003	13.50200010
21	ZERO	IC22						.01032553	.02060000
22	ZERO	IC23						.00062701	.04710000
23	ZERO	IC24						.01277747	.55259999
24	ZERO	IC25						.03070000	.00000000
25	ZERO	IC26						.04063000	.47090000
26	ZERO	IC27						.05942519	.07000000
27	ZERO	IC28						.06747244	.50549999
28	ZERO	IC29						.00040105	.00000000
29	ZERO	IC30						.09032967	.47090000
30	ZERO	IC31						.10012017	112.04549000
31	ZERO	IC32						.01761575	120.00000000
32	FREE	TIME					270.64455403	1.00000000	.

*BASIS

McClellan AFB Slack Values, N=31

APPENDIX J
TINKER AFB INPUT PROGRAMS

Tinker AFB Original Input Program

```
10WNS,R(SL) :,8,16;;,16
20$:IDENT:UP1186, NOTT/NELSON THESIS
30$:USERID:80A053$KR79
40$:PROGRAM:RLHS
50$:LIMITS:10,39K,5K
60$:PRMFL:H*,R,R,AF.LIB/LP.PAC
70$:REMOTE:SO,SL
80$:DISC:AA,A1,10R
90$:DISC:AB,A2,10R
100$:DISC:AC,A3,10R
110$:DISC:AD,A4,10R
120$:DISC:AE,A5,10R
130$:DATA:IN
140$FILE:ELEC
150****      TINKER AFB FUEL PLAN      ****
155****      ****
160****      CONSTRAINT MATRIX
165****      ****
170****      FUEL QUANTITY CONSTRAINT  ****
180MATRIX:FUEL(P),S1(P)=1
185:,S2(P)=1
190:,S3(P)=1
195:,S4(P)=1
200:,S5(P)=1
205:,S6(P)=1
210:,S7(P)=1
215:,S8(P)=1
220:,S9(P)=1
225:,S10(P)=1
230:,S11(P)=1
235:,S12(P)=1
240:,S13(P)=1
245:,S14(P)=1
250:,S15(P)=1
255:,S16(P)=1
260:,S17(P)=1
265:,S18(P)=1
270:,S19(P)=1
275:,S20(P)=1
280:,S21(P)=1
285:,S22(P)=1
290:,S23(P)=1
295:,S24(P)=1
300:,S25(P)=1
305:,S26(P)=1
310:,S27(P)=1
315:,S28(P)=1
```

320:,S29(P)=1
 325:,S30(P)=1
 330:,S31(P)=1
 335:,S32(P)=1
 340:,S33(P)=1
 345:,S34(P)=1
 350:,S35(P)=1
 355:,S36(P)=1
 360:,S37(P)=1
 430*** TIME EQUALITY CONSTRAINTS ****
 435MATRIX:TC1(Z),S1=.00746
 440:,S2=-.0357
 445A:TC2(Z),S2=.0357
 450:,S3=-.303
 455A:TC3(Z),S3=.303
 460:,S4=-.5882
 465A:TC4(Z),S4=.5882
 470:,S5=-.3333
 475A:TC5(Z),S5=.3333
 480:,S6=-.7692
 485A:TC6(Z),S6=.7692
 490:,S7=-.1961
 495A:TC7(Z),S7=.1961
 500:,S8=-.1136
 510A:TC8(Z),S8=.1136
 515:,S9=-.5882
 520A:TC9(Z),S9=.5882
 525:,S10=-.0568
 530A:TC10(Z),S10=.0568
 535:,S11=-.11364
 540A:TC11(Z),S11=.11364
 545:,S12=-.11364
 550A:TC12(Z),S12=.11364
 555:,S13=-.0741
 565A:TC13(Z),S13=.0741
 570:,S14=-.0741
 575A:TC14(Z),S14=.0741
 580:,S15=-.0741
 585A:TC15(Z),S15=.0741
 590:,S16=-.303
 595A:TC16(Z),S16=.303
 600:,S17=-.1961
 605A:TC17(Z),S17=.1961
 610:,S18=-.0217
 615A:TC18(Z),S18=.0217
 620:,S19=-.1961
 625A:TC19(Z),S19=.1961
 630:,S20=-.588
 635A:TC20(Z),S20=.588
 640:,S21=-.588
 645A:TC21(Z),S21=.588

650:,S22=-.0286
 655A:TC22(Z),S22=.0286
 660:,S23=-.303
 665A:TC23(Z),S23=.303
 670:,S24=-.303
 675A:TC24(Z),S24=.303
 680:,S25=-.0303
 685A:TC25(Z),S25=.0303
 690:,S26=-.05263
 695A:TC26(Z),S26=.05263
 700:,S27=-.11364
 710A:TC27(Z),S27=.11364
 715:,S28=-.11364
 720A:TC28(Z),S28=.11364
 725:,S29=-.19608
 730A:TC29(Z),S29=.19608
 735:,S30=-.7692
 740A:TC30(Z),S30=.7692
 745:,S31=-.303
 750A:TC31(Z),S31=.303
 755:,S32=-.0417
 760A:TC32(Z),S32=.0417
 765:,S33=-.1250
 770A:TC33(Z),S33=.1250
 775:,S34=-.0125
 780A:TC34(Z),S34=.0125
 785:,S35=-.0125
 790A:TC35(Z),S35=.0125
 795:,S36=-.025
 800A:TC36(Z),S36=.025
 805:,S37=-.01465
 995****
 1000*** OBJECTIVE FUNCTION
 1005***
 1010MATRIX:TIME(FREE),S1=-.00202
 1020:,S2=-.00097
 1025:,S3=-.00819
 1030:,S4=-.0159
 1035:,S5=-.009
 1040:,S6=-.02079
 1045:,S7=-.0053
 1050:,S8=-.00307
 1055:,S9=-.0159
 1060:,S10=-.00154
 1065:,S11=-.00307
 1070:,S12=-.00307
 1075:,S13=-.002
 1080:,S14=-.002
 1085:,S15=-.002
 1090:,S16=-.00819
 1095:,S17=-.0053

1100: S18=-.00059	
1105: S19=-.0053	
1110: S20=-.0159	
1115: S21=-.00077	
1120: S22=-.00819	
1125: S23=-.00819	
1130: S24=-.00082	
1135: S25=-.00142	
1140: S26=-.00307	
1145: S27=-.00307	
1150: S28=-.0053	
1155: S29=-.02079	
1160: S30=-.00819	
1165: S31=-.001126	
1170: S32=-.00338	
1175: S33=-.00034	
1180: S34=-.00034	
1185: S35=-.00034	
1190: S36=-.00068	
1195: S37=-.0004	
1300***	****
1305***	****
1310***	****
1315***	****
1320RHS:FUEL,RHSV=23436	
1325***	****
1330:TC1=-131.397	
1335:TC2=65.476	
1340:TC3=85.491	
1345:TC4=-73.158	
1350:TC5=115.872	
1355:TC6=-157.616	
1360:TC7=2.8962	
1365:TC8=164.947	
1370:TC9=520.053	
1375:TC10=-673.92	
1380:TC11=48.9202	
1385:TC12=-48.8923	
1390:TC13=0	
1395:TC14=0	
1400:TC15=.1044	
1405:TC16=22.3617	
1410:TC17=186.999	
1415:TC18=-158.567	
1420:TC19=147	
1425:TC20=0	
1430:TC21=-105.88	
1435:TC22=203.03	
1440:TC23=-299.394	
1445:TC24=602.4236	
1450:TC25=-592.902	

1455:TC26=-5.2603
1460:TC27=0
1465:TC28=.6317
1470:TC29=7.6246
1475:TC30=-8.1237
1480:TC31=111.9697
1485:TC32=0
1490:TC33=0
1495:TC34=0
1500:TC35=0
1505:TC36=-120
1600END***
1615\$:DATA:I*
1620:PREPRO
1625:TITLE:GENERATOR FUEL ALLOCATION PLAN
1630:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1635:SETUP:SOURCE=GFP
1640:SET:OBJ=TIME,RHS=RHSV
1645:PICTURE
1650:PRIMAL
1655:OUTPUT
1660:ENDLP
1665\$:ENDJOB
1670***EOF

Tinker AFB Adjusted Input Program

```
10WWS,R(SL) : ,8,16;;,16
15%:IDENT:WP1186, MOTT/NELSON THESIS
20%:USERID:80A053$KR79
25%:PROGRAM:RLHS
30%:LIMITS:10,39K,5K
35%:PRMFL:H*,R,R,AF.LIB/LP.PAC
40%:REMOTE:SO,SL
45%:DISC:AA,A1,10R
50%:DISC:AB,A2,10R
55%:DISC:AC,A3,10R
60%:DISC:AD,A4,10R
65%:DISC:AE,A5,10R
70%:DATA:IN
75FILE:ELEC
80****      TINKER AFB FUEL PLAN      ****
85****      ****
90****      CONSTRAINT MATRIX
95****      ****
100****     FUEL QUANTITY CONSTRAINT    ****
105MATRIX:FUEL(P),S2(P)=1
110: ,S3(P)=1
115: ,S5(P)=1
120: ,S7(P)=1
125: ,S8(P)=1
130: ,S11(P)=1
135: ,S12(P)=1
140: ,S13(P)=1
145: ,S14(P)=1
150: ,S15(P)=1
155: ,S16(P)=1
160: ,S17(P)=1
165: ,S19(P)=1
170: ,S22(P)=1
175: ,S24(P)=1
180: ,S26(P)=1
185: ,S27(P)=1
190: ,S28(P)=1
195: ,S29(P)=1
200: ,S30(P)=1
205: ,S31(P)=1
210: ,S37(P)=1
215****     TIME EQUALITY CONSTRAINTS    ****
220MATRIX:TC2(Z),S2=.0357
225: ,S3=-.303
230A:TC3(Z),S3=.303
235: ,S5=-.3333
240A:TC5(Z),S5=.3333
245: ,S7=-.1961
```

```

500:,S17=-.0053
505:,S19=-.0053
510:,S22=-.00819
515:,S24=-.00082
520:,S26=-.00307
525:,S27=-.00307
530:,S28=-.0053
535:,S29=-.02079
540:,S30=-.00819
545:,S31=-.001126
550:,S37=-.0004
555***
560***      RIGHT HAND SIDE VALUES
565***
570***      FUEL QUANTITY CONSTRAINT
575RHS:FUEL,RHSV=23436
580***      TIME EQUALITY CONSTRAINTS
585:TC2=65.476
590:TC3=12.333
595:TC5=-41.744
600:TC7=2.8962
605:TC8=-48.9202
610:TC11=48.9202
615:TC12=-48.8923
620:TC13=0
625:TC14=0
630:TC15=.1044
635:TC16=22.3617
640:TC17=28.432
645:TC19=41.176
650:TC22=-96.3636
655:TC24=9.5216
660:TC26=-5.2603
665:TC27=0
670:TC28=.6317
675:TC29=7.6246
680:TC30=-8.1237
685:TC31=-8.0303
690END***
695$:DATA:I*
700:PREPRO
705:TITLE:GENERATOR FUEL ALLOCATION PLAN
710:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
715:SETUP:SOURCE=GFP
720:SET:OBJ=TIME,RHS=RHSV
725:PICTURE
730:PRIMAL
735:OUTPUT
740:ENDLP
745$:ENDJOB
750***EOF

```

APPENDIX K
TINKER AFB SUBOPTIMAL OUTPUT


```

FUNC= 70.7566061+ 00J=TIME 1 1
ANS=ANSV 1 1

```

STUDY

SLACK VALUES

[illegible]

Tinker AFB Slack Values

07117 01 04/29/80 GENERATOR FUEL ALLOCATION PLAN
 PDNAM=QFP : : FUNCT= 78.7560041- OBJ=TIME : : RNSRMSV : :
 COLUMNS

FUEL ALLOCATIONS

Generator #

COL	KJ	TYPE	COLUMN NAME	STRUCT.	INDIC.	X-VALUE	DJ	COST+SCALE
39	PLUS	S1				3600.58823397	.04582616	.00202000-
40	PLUS	S2				217.56105295	.	.00097000-
41	PLUS	S3				.	.11942790	.00019000-
42	PLUS	S4				.	.	.01500000-
43	PLUS	S5				219.49595117	.50511090	.00900000-
44	PLUS	S6				.	.	.02870000-
45	PLUS	S7				803.75319171	.	.00530000-
46	PLUS	S8				1361.97005057	.04319622	.00307000-
47	PLUS	S9				.	.15670622	.00154000-
48	PLUS	S10				.	.	.01590000-
49	PLUS	S11				430.48398640	.00307000-	.00307000-
50	PLUS	S12				.	.00639243	.00200000-
51	PLUS	S13				303.10624431	.	.00200000-
52	PLUS	S14				303.10624050	.	.00200000-
53	PLUS	S15				303.10623669	.	.00200000-
54	PLUS	S16				73.00009065	.	.00019000-
55	PLUS	S17				.	.02189900	.00530000-
56	PLUS	S18				.	.00393026	.00530000-
57	PLUS	S19				800.60275934	.	.01590000-
58	PLUS	S20				19.67176819	.	.00070000-
59	PLUS	S21				19.67176794	.	.00070000-
60	PLUS	S22				4184.53043840	.	.00019000-
61	PLUS	S23				.	.00639244	.00019000-
62	PLUS	S24				900.09900311	.10370622	.00142000-
63	PLUS	S25				.	.	.00307000-
64	PLUS	S26				605.64044532	.	.00307000-
65	PLUS	S27				326.70010312	.	.00530000-
66	PLUS	S28				326.70010844	.	.00530000-
67	PLUS	S29				106.17156328	.	.02870000-
68	PLUS	S30				37.94530220	.	.00019000-
69	PLUS	S31				122.1211745	.	.00112000-
70	PLUS	S32				.	.00409622	.00330000-
71	PLUS	S33				.	.04319622	.00034000-
72	PLUS	S34				.	.04319622	.00034000-
73	PLUS	S35				.	.04319622	.00034000-
74	PLUS	S36				.	.11690900	.00060000-
75	PLUS	S37				8191.19026887	.	.00640000-
76	RMS	RMSV				.	2495.90398262	.

Tinker AFB Fuel Allocations, N=37

APPENDIX L
TINKER AFB OPTIMAL OUTPUT

FOJIT 01 04/25/00																				GENERATOR FUEL ALLOCATION PLAN																				VERB= PRIMAL PAGE 17																			
PRNAME=0PP 1																				FUNCT= 1.32150503 OBJ=TIME 1																				RMS=RMSV 1																			
ITER	ETA	MUR	FUNCTIONAL	MINFS	MDJS	VALUE2	INCOMING	VECTOR	NAME	IN	KJ	OUT	KJ	CCT	VPC	ACT	MCT	FCT	A.TIM																																								
1	1	1	1.32150503	17	5	398.971397	- S11	1	1	P	295	1	7L	1	0	1A	1	6	.101																																								
2	2	2	3.18662568	14	5	333.495399	- S2	1	1	P	245	2	2L	2	0	1A	1	6	.20																																								
3	3	3	3.76908126	15	5	321.162399	- S3	1	1	P	295	3	3L	3	0	1A	1	6	.11																																								
4	4	4	3.84735694	14	5	315.169999	- S7	1	1	P	275	4	4L	4	0	1A	1	6	.14																																								
5	5	5	3.84735694	14	5	315.169999	- S13	1	1	P	315	5	5L	5	0	1A	1	6	.12																																								
6	6	6	3.87312495	13	5	296.326797	- S24	1	1	P	305	6	6L	6	10	1A	1	11	.31																																								
7	7	7	4.00236231	12	5	288.296497	- S37	1	1	P	455	7	7L	7	21	2A	1	16	.39																																								
8	8	8	4.34437803	11	5	288.172798	- S31	1	1	P	445	8	8L	8	15	3A	1	21	.47																																								
9	9	9	4.34437803	11	5	288.172798	- S14	1	1	P	325	9	9L	9	22	4A	1	26	.40																																								
10	10	10	4.35282331	10	5	279.964088	- S15	1	1	P	335	10	10L	10	2	4A	1	26	.16																																								
11	11	11	6.74792639	9	4	235.248598	- S16	1	1	P	345	11	11L	11	22	5A	1	30	.30																																								
12	12	12	18.3162133	8	4	182.380202	- S17	1	1	P	395	12	12L	12	22	6A	1	34	.39																																								
13	13	13	18.3162133	7	4	182.380202	- S12	1	1	P	385	13	13L	13	2	6A	1	34	.15																																								
14	14	14	18.6728446	6	3	178.376598	- S8	1	1	P	285	14	14L	14	22	7A	1	37	.36																																								
15	15	15	28.7762444	5	3	104.692886	- S19	1	1	P	365	15	15L	15	22	8A	1	40	.38																																								
16	16	16	22.2089566	4	3	100.350688	- S5	1	1	P	265	16	16L	16	22	9A	1	43	.37																																								
17	17	17	22.2089566	4	2	106.350688	- S27	1	1	P	405	17	17L	17	22	10A	1	45	.32																																								
18	18	18	22.3194838	3	3	99.8952885	- S28	1	1	P	415	18	18L	18	22	10A	1	45	.12																																								
19	19	19	23.1771588	2	1	89.0308083	- S29	1	1	P	425	19	19L	19	22	11A	1	46	.20																																								
20	20	20	23.4083555	1	1	83.0459997	- S24	1	1	P	395	20	20L	20	22	12A	1	47	.29																																								
21	21	21	47.5753894	1	1	749280842	- S30	1	1	P	435	21	21L	21	22	13A	1	48	.43																																								
22	22	22	58.9535384	1	1	.028314015	- S22	1	1	P	375	22	22L	22	22	14A	1	49	.36																																								
14 RINV											RQINV																																																
15 CURT																					DEMAND 36527																																						
45																					40110 11																																						
																					40113 12																																						
																					40113 12																																						

OPTIMAL SOLUTION

Tinker AFB Iterations, N=22

GENERATOR FUEL ALLOCATION PLAN

FILE 01 04/25/80

FUNC= 90.9933304 OBJ=TIME I I RMS=0MSV I I

FUEL ALLOCATIONS



Generator # STRUCT.

COLUMNS

COL	RJ	TYPE	COLUMN NAME	INDIC.	X-VALUE	DJ	COST-SCALE
24	PLUS	S2		0BASIS	2047.37023021	.	.00097000-
25	PLUS	S3		0BASIS	95.01957698	.	.00019000-
26	PLUS	S5		0BASIS	50.10600570	.	.00000000-
27	PLUS	S7		0BASIS	298.03338932	.	.00530000-
28	PLUS	S8		0BASIS	400.90007770	.	.00307000-
29	PLUS	S11		0BASIS	919.29100816	.	.00307000-
30	PLUS	S12		0BASIS	400.00707400	.	.00307000-
31	PLUS	S13		0BASIS	1409.45246654	.	.00200000-
32	PLUS	S14		0BASIS	1409.45246652	.	.00200000-
33	PLUS	S15		0BASIS	1409.45245115	.	.00200000-
34	PLUS	S16		0BASIS	344.34331709	.	.00190000-
35	PLUS	S17		0BASIS	410.02330750	.	.00530000-
36	PLUS	S19		0BASIS	273.03507120	.	.00530000-
37	PLUS	S22		0BASIS	432.30006620	.	.00190000-
38	PLUS	S24		0BASIS	350.04403361	.	.00020000-
39	PLUS	S26		0BASIS	1085.01409390	.	.00307000-
40	PLUS	S27		0BASIS	919.20446437	.	.00307000-
41	PLUS	S28		0BASIS	919.20446403	.	.00530000-
42	PLUS	S29		0BASIS	529.56405030	.	.00200000-
43	PLUS	S30		0BASIS	129.00101094	.	.00019000-
44	PLUS	S31		0BASIS	344.34320495	.	.00112600-
45	PLUS	S32		0BASIS	7070.05503442	.	.00040000-
46	RMS	RMSV			50.99333000	.	.

Tinker AFB Fuel Allocations, N=22

APPENDIX M
KELLY AFB INPUT PROGRAMS

Kelly AFB Original Input Program

10WWS,R(J) :,8,16;;,16
15%:IDENT:WP1186, MOTT/NELSON THESIS
20%:USERID:80A053%KR79
25%:PROGRAM:RLHS
30%:LIMITS:10,39K,,5K
35%:PRMFL:H*,R,R,AF.LIB/LP.PAC
40%:REMOTE:SD,SL
45%:DISC:AA,A1,10R
50%:DISC:AB,A2,10R
55%:DISC:AC,A3,10R
60%:DISC:AD,A4,10R
65%:DISC:AE,A5,10R
70%:DATA:IN
75FILE:ELEC
80**** KELLY AFB FUEL PLAN ****
85**** ****
90**** CONSTRAINT MATRIX ****
95**** ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S1(P)=1
110:,S2(P)=1
115:,S3(P)=1
120:,S4(P)=1
125:,S5(P)=1
130:,S6(P)=1
135:,S7(P)=1
140:,S8(P)=1
145:,S9(P)=1
150:,S10(P)=1
155:,S11(P)=1
160:,S12(P)=1
165:,S13(P)=1
170:,S14(P)=1
175:,S15(P)=1
180:,S16(P)=1
185:,S17(P)=1
190:,S18(P)=1
195:,S19(P)=1
200:,S20(P)=1
205:,S21(P)=1
210:,S22(P)=1
215:,S23(P)=1
220:,S24(P)=1
225:,S25(P)=1
230:,S26(P)=1
235:,S27(P)=1
240:,S28(P)=1
245:,S29(P)=1
250:,S30(P)=1
255:,S31(P)=1
260:,S32(P)=1

265:,S33(P)=1
 270:,S34(P)=1
 275:,S35(P)=1
 280:,S36(P)=1
 285:,S37(P)=1
 290:,S38(P)=1
 295**** TIME EQUALITY CONSTRAINTS ****
 300MATRIX:TC1(Z),S1=.1961
 305:,S2=-.1136
 310A:TC2(Z),S2=.1136
 315:,S3=-.2500
 320A:TC3(Z),S3=.2500
 325:,S4=-.1136
 330A:TC4(Z),S4=.1136
 335:,S5=-.1538
 340A:TC5(Z),S5=.1538
 345:,S6=-.1538
 350A:TC6(Z),S6=.1538
 355:,S7=-.1136
 360A:TC7(Z),S7=.1136
 365:,S8=-.3030
 370A:TC8(Z),S8=.3030
 375:,S9=-.1136
 380A:TC9(Z),S9=.1136
 385:,S10=-.1961
 390A:TC10(Z),S10=.1961
 395:,S11=-.5882
 400A:TC11(Z),S11=.5882
 405:,S12=-.0625
 410A:TC12(Z),S12=.0625
 415:,S13=-.1961
 420A:TC13(Z),S13=.1961
 425:,S14=-.7692
 430A:TC14(Z),S14=.7692
 435:,S15=-.4
 440A:TC15(Z),S15=.4000
 445:,S16=-.3030
 450A:TC16(Z),S16=.3030
 455:,S17=-.3030
 460A:TC17(Z),S17=.3030
 465:,S18=-.3030
 470A:TC18(Z),S18=.3030
 475:,S19=-.1961
 480A:TC19(Z),S19=.1961
 485:,S20=-.5882
 490A:TC20(Z),S20=.5882
 495:,S21=-.1136
 500A:TC21(Z),S21=.1136
 505:,S22=-.1136
 510A:TC22(Z),S22=.1136
 515:,S23=-.3030

520A:TC23(Z),S23=.3030
 525:,S24=-.0741
 530A:TC24(Z),S24=.0741
 535:,S25=-.5
 540A:TC25(Z),S25=.5
 545:,S26=-.5
 550A:TC26(Z),S26=.5
 555:,S27=-.125
 560A:TC27(Z),S27=.125
 565:,S28=-.0625
 570A:TC28(Z),S28=.0625
 575:,S29=-.25
 580A:TC29(Z),S29=.25
 585:,S30=-.25
 590A:TC30(Z),S30=.25
 595:,S31=-.25
 600A:TC31(Z),S31=.25
 605:,S32=-.25
 610A:TC32(Z),S32=.25
 615:,S33=-.25
 620A:TC33(Z),S33=.25
 625:,S34=-.0625
 630A:TC34(Z),S34=.0625
 635:,S35=-.0625
 640A:TC35(Z),S35=.0625
 645:,S36=-.125
 650A:TC36(Z),S36=.125
 655:,S37=-.25
 660A:TC37(Z),S37=.25
 665:,S38=-.0816
 670****
 675**** OBJECTIVE FUNCTION
 680****
 685MATRIX:TIME(FREE),S1=-.00516
 690:,S2=-.00299
 695:,S3=-.00658
 700:,S4=-.00299
 705:,S5=-.00405
 710:,S6=-.00405
 715:,S7=-.00299
 720:,S8=-.00797
 725:,S9=-.00299
 730:,S10=-.00516
 735:,S11=-.01548
 740:,S12=-.001645
 745:,S13=-.00516
 750:,S14=-.02024
 755:,S15=-.01053
 760:,S16=-.00797
 765:,S17=-.00797
 770:,S18=-.00797


```

775:,S19=-.00516
780:,S20=-.01548
785:,S21=-.00299
790:,S22=-.00299
795:,S23=-.00797
800:,S24=-.00195
805:,S25=-.01316
810:,S26=-.01316
815:,S27=-.003289
820:,S28=-.001645
825:,S29=-.00658
830:,S30=-.00658
835:,S31=-.00658
840:,S32=-.00658
845:,S33=-.00658
850:,S34=-.001645
855:,S35=-.001645
860:,S36=-.00329
865:,S37=-.00658
870:,S38=-.00215
875:****
880:**** RIGHT HAND SIDE VALUES ****
885:****
890:**** FUEL QUANTITY CONSTRAINT ****
895RHS:FUEL,RHSV=10290
900:**** TIME EQUALITY CONSTRAINTS ****
905:TC1=-194.81
910:TC2=-19.19
915:TC3=2.15
920:TC4=2.36
925:TC5=0.0
930:TC6=139.64
935:TC7=-79.5
940:TC8=-79.54
945:TC9=228.89
950:TC10=-204.958
955:TC11=-4.042
960:TC12=64.85
965:TC13=96.2
970:TC14=-92.3
975:TC15=-24.25
980:TC16=75.75
985:TC17=-75.75
990:TC18=164.5
995:TC19=-93.2
1000:TC20=614.07
1005:TC21=-736.128
1010:TC22=126.508
1015:TC23=-143.7222
1020:TC24=112.2222
1025:TC25=0

```

1030:TC26=0
1035:TC27=0
1040:TC28=0
1045:TC29=0
1050:TC30=0
1055:TC31=0
1060:TC32=0
1065:TC33=0
1070:TC34=0
1075:TC35=0
1080:TC36=0
1085:TC37=-120
1090END***
1095\$:DATA:I*
1100:PREPRO
1105:TITLE:GENERATOR FUEL ALLOCATION PLAN
1110:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
1115:SETUP:SOURCE=GFP
1120:SET:OBJ=TIME,RHS=RHSV
1125:PICTURE
1130:PRIMAL
1135:OUTPUT
1140:ENDLP
1145\$:ENDJOB
1150***EOF

Kelly AFB Adjusted Input Program

```
10##S,R(SL) : ,8,16;;,16
15$:IDENT:WP1186, MOTT/NELSON THESIS
20$:USERID:80A053$KR79
25$:PROGRAM:RLHS
30$:LIMITS:10,39K,,5K
35$:PRMFL:H*,R,R,AF.LIB/LP.PAC
40$:REMOTE:S0,SL
45$:DISC:AA,A1,10R
50$:DISC:AB,A2,10R
55$:DISC:AC,A3,10R
60$:DISC:AD,A4,10R
65$:DISC:AE,A5,10R
70$:DATA:IN
75FILE:ELEC
80**** KELLY AFB FUEL PLAN ****
85****                      ****
90**** CONSTRAINT MATRIX ****
95****                      ****
100**** FUEL QUANTITY CONSTRAINT ****
105MATRIX:FUEL(P),S2(P)=1
110:,S3(P)=1
115:,S4(P)=1
120:,S5(P)=1
125:,S6(P)=1
130:,S8(P)=1
135:,S9(P)=1
140:,S11(P)=1
145:,S12(P)=1
150:,S13(P)=1
155:,S15(P)=1
160:,S16(P)=1
165:,S18(P)=1
170:,S22(P)=1
175:,S24(P)=1
180:,S38(P)=1
185**** TIME EQUALITY CONSTRAINTS ****
190MATRIX:TC2(Z),S2=.1136
195:,S3=-.2500
200A:TC3(Z),S3=.2500
205:,S4=-.1136
210A:TC4(Z),S4=.1136
215:,S5=-.1538
220A:TC5(Z),S5=.1538
225:,S6=-.1538
230A:TC6(Z),S6=.1538
235:,S8=-.3030
240A:TC8(Z),S8=.3030
245:,S9=-.1136
250A:TC9(Z),S9=.1136
255:,S11=-.5882
```

```

260A:TC11(Z),S11=.5882
265:,S12=-.0625
270A:TC12(Z),S12=.0625
275:,S13=-.1961
280A:TC13(Z),S13=.1961
285:,S15=-.4
290A:TC15(Z),S15=.4000
295:,S16=-.3030
300A:TC16(Z),S16=.3030
305:,S18=-.3030
310A:TC18(Z),S18=.3030
315:,S22=-.1136
320A:TC22(Z),S22=.1136
325:,S24=-.0741
330A:TC24(Z),S24=.0741
335:,S38=-.0816
340****
345**** OBJECTIVE FUNCTION ****
350****
355MATRIX:TIME(FREE),S2=.00299
360:,S3=-.00658
365:,S4=-.00299
370:,S5=-.00405
375:,S6=-.00405
380:,S8=-.00797
385:,S9=-.00299
390:,S11=-.01548
395:,S12=-.001645
400:,S13=-.00516
405:,S15=-.01053
410:,S16=-.00797
415:,S18=-.00797
420:,S22=-.00299
425:,S24=-.00195
430:,S38=-.00215
435****
440**** RIGHT HAND SIDE VALUES ****
445****
450**** FUEL QUANTITY CONSTRAINT ****
455RHS:FUEL,RHSV=10290
460**** TIME EQUALITY CONSTRAINTS ****
465:TC2=-19.19
470:TC3=2.15
475:TC4=2.36
480:TC5=0.0
485:TC6=60.14
490:TC8=-79.54
495:TC9=23.932
500:TC11=-4.042
505:TC12=64.85
510:TC13=3.9

```

515:TC15=-24.25
520:TC16=0
525:TC18=-50.758
530:TC22=-17.2142
535:TC24=-7.7778
540END***
545\$:DATA:I*
550:PREPRO
555:TITLE:GENERATOR FUEL ALLOCATION PLAN
560:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
565:SETUP:SOURCE=GFP
570:SET:OBJ=TIME,RHS=RHSV
575:PICTURE
580:PRIMAL
585:OUTPUT
590:ENDLP
595\$:ENDJOB
600***EOF

APPENDIX N
KELLY AFB SUBOPTIMAL OUTPUT

APPENDIX O
KELLY AFB OPTIMAL OUTPUT

GENERATOR FUEL ALLOCATION PLAN

ITER	ETA	HUB	FUNCTIONAL	MINFS	NRJS	VALUE2	INCRING	VECTOR	NAME	IM	KJ	OUT	KJ	IN	PG	ACT	MGT	FCT	A.TIN
1	1	1	620988351	12	5	312.23098	S9	1	1	P	245	2	245	P	10	1A	1	6	68
2	2	2	736285791	11	11	384.15598	S12	1	1	P	245	2	245	P	10	1A	1	6	10
3	3	3	792473792	18	18	299.85598	S3	1	1	P	245	2	245	P	10	1A	1	6	22
4	4	4	792473792	10	10	299.85598	S6	1	1	P	245	2	245	P	10	1A	1	6	12
5	5	5	4.19357032	9	9	180.63098	S11	1	1	P	245	2	245	P	10	1A	1	6	34
6	6	6	5.34459089	8	8	180.63098	S34	1	1	P	245	2	245	P	10	1A	1	6	14
7	7	7	5.51273149	7	7	176.14219	S4	1	1	P	245	2	245	P	10	1A	1	6	14
8	8	8	5.51273149	7	7	176.14219	S16	1	1	P	245	2	245	P	10	1A	1	6	14
9	9	9	7.8542688	6	6	176.14219	S5	1	1	P	245	2	245	P	10	1A	1	6	14
10	10	10	7.96519255	5	5	176.14219	S24	1	1	P	245	2	245	P	10	1A	1	6	14
11	11	11	11.0742751	4	4	176.14219	S27	1	1	P	245	2	245	P	10	1A	1	6	14
12	12	12	15.5649696	3	3	176.14219	S2	1	1	P	245	2	245	P	10	1A	1	6	14
13	13	13	18.7568637	2	2	176.14219	S14	1	1	P	245	2	245	P	10	1A	1	6	14
14	14	14	19.7141584	1	1	176.14219	S8	1	1	P	245	2	245	P	10	1A	1	6	14
15	15	15	28.5333365	1	1	176.14219	S13	1	1	P	245	2	245	P	10	1A	1	6	14
16	16	16	29.1751283	1	1	176.14219	S15	1	1	P	245	2	245	P	10	1A	1	6	14
14	INVT	INVT																	
15	CURNT	CURNT																	
45	PRIMAL	PRIMAL																	

OPTIMAL SOLUTION

Kelly AFB Iterations, N=16

06321 01 04/17/80										GENERATOR FUEL ALLOCATION PLAN										VERB= OUTPUT PAGE 17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						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Kelly AFB Slack Values, N=16

GENERATOR FUEL ALLOCATION PLAN

0032T 01 04/17/80

PHASE=OFF I I FUNC= 29.1751203 00J=TIME I I RMS=RMSV I I

COLUMNS

Generator # SHRFT.

COL	KJ	TYPE	COLUMN NAME	INDIC.	X-VALUE	DJ	COST*SCALE
10	10	PLUS	S2	*RASH	006.64331805	.	.00299000
19	19	PLUS	S3	*RASH	308.78912608	.	.00658000
20	20	PLUS	S4	*RASH	036.64381296	.	.00299000
21	21	PLUS	S5	*RASH	002.64011562	.	.00405000
22	22	PLUS	S6	*RASH	002.64010012	.	.00405000
23	23	PLUS	S7	*RASH	107.41670093	.	.00797000
24	24	PLUS	S8	*RASH	006.64379121	.	.00299000
25	25	PLUS	S9	*RASH	149.07290520	.	.01540000
26	26	PLUS	S10	*RASH	1475.15644813	.	.00144500
27	27	PLUS	S11	*RASH	139.45577787	.	.00516000
28	28	PLUS	S12	*RASH	58.01819428	.	.01043000
29	29	PLUS	S13	*RASH	157.41675623	.	.00797000
30	30	PLUS	S14	*RASH	157.41675429	.	.00797000
31	31	PLUS	S15	*RASH	006.64374925	.	.00299000
32	32	PLUS	S16	*RASH	1508.99150297	.	.00195000
33	33	PLUS	S17	*RASH	1512.03424000	.	.00215000
34	34	RMS	RMSV			29.17512042	.

FUEL ALLOCATIONS



Kelly AFB Fuel Allocations, N=16

APPENDIX P
EXAMPLE PROBLEM

The following is an example illustrating the validity of the analysis procedure for determining the maximum length of time that a system of generators can operate on a specified quantity of emergency fuel. For simplicity, only two generators are in the system. The example problem is outlined below.

EXAMPLE PROBLEM INFORMATION

Emergency Generators		
<u>Generator #</u>	<u>Fuel Consumption (Gal/Hr)</u>	<u>Fuel Tank Capacity (Gal)</u>
1	3.5	1000
2	7.5	1500

Emergency Fuel Stocks: Total = 10000 gallons

The set of 3 linear equations required for this example problem can be solved by a standard analytical technique for solving simultaneous linear equations, and also by the LP600 computer program. Consistent results using the two techniques indicate the validity of the procedures used to derive the linear programming objective function and constraint set, and the validity of the procedure used to obtain the maximum length of time the ALCs can operate from the maximized objective function.

The linear equations for the analytical solution procedure are obtained as follows:

The length of time that generator #1 can operate is T_1 .

$$\begin{aligned}T_1 &= S_1/R_1 + F_1/R_1 \\T_1 &= S_1/3.5 + 100/3.5 \\&= .2857S_1 + 285.714\end{aligned}$$

The length of time that generator #2 can operate is T_2 .

$$\begin{aligned}T_2 &= S_2/R_2 + F_2/R_2 \\&= S_2/7.5 + 1500/7.5 \\&= .1333S_2 + 200\end{aligned}$$

Both generators are required to operate the same length of time, $T_{\max}$, so $T_1 = T_2 = T_{\max}$. The linear equations for the length of time each generator can operate now become:

$$T_{\max} = .2857S_1 + 285.714$$

for generator #1, and

$$T_{\max} = .1333S_2 + 200$$

for generator #2.

The supply constraint is:

$$S_1 + S_2 = 10000$$

The three equations can now be rearranged and solved simultaneously.

$$\begin{aligned}
T_{\max} - .2857S_1 &= 285.714 \\
T_{\max} &- .1333S_2 = 200 \\
S_1 &+ S_2 = 10000
\end{aligned}$$

Multiply row one by -1 and add to row two.

$$\begin{aligned}
.2857S_1 - .1333S_2 &= -85.714 \\
S_1 &+ S_2 = 10000
\end{aligned}$$

Multiple row two by .1333 and add to row one.

$$.419S_1 = 1247.286$$

Or: $S_1 = 2976.816 \text{ Gallons}$

Now solve for S_2 .

$$\begin{aligned}
S_1 + S_2 &= 10000 \\
2976.816 + S_2 &= 10000 \\
S_2 &= 7023.184 \text{ Gallons}
\end{aligned}$$

Solve for $T_{\max}$:

$$\begin{aligned}
T_{\max} - .2857S_1 &= 285.714 \\
T_{\max} - (.2857)(2975.816) &= 285.714 \\
T_{\max} &= 1134.1066 \text{ Hours} \\
T_{\max} &= 68046.3936 \text{ Minutes}
\end{aligned}$$

The information regarding the two generators is now used to develop the objective function and constraint set for the LP600 program. Note that in this example

problem the coefficients and constants are based on a consumption rate expressed in gallons per minute. The objective function is obtained as follows:

$$Z = S_1/NR_1 + S_2/NR_2$$

Since N is 2: $Z = 8.57S_1 + 4S_2$

The supply constraint is:

$$S_1 + S_2 \leq 10000$$

The time equality constraint is:

$$S_1/R_1 - S_2/R_2 = F_2/R_2 - F_1/R_1$$

or: $17.14S_1 - 8.00S_2 = -5142.86$

The constant K, expressed in minutes is:

$$K = F_1/R_1N + F_2/R_2N$$

$$K = 8571.428 + 6000$$

$$K = 14571.428 \text{ Minutes}$$

The set of equations, then, to be solved using the LP600 program is:

$$Z = 8.57S + 4S_2$$

$$S_1 + S_2 \leq 10000$$

$$17.14S_1 - 8.00S_2 = -5142.86$$

The LP600 program used to solve the problem and selected computer output products are shown on the following four pages. Though the input format for the LP600 program is not entirely obvious, the input program is included for those who may be familiar with this specific linear program package. The relevant items of information from the output of the program are identified on the three output pages. These are the optimal value for the objective function, and the fuel quantities, S_1 and S_2 , allocated to the generators.

From the LP600 output:

$$S_1 = 2977.6 \text{ Gallons}$$

$$S_2 = 7022.39 \text{ Gallons}$$

$$Z = 53607.682 \text{ Minutes}$$

The constant K must be added to the optimal value of the objective function to obtain the actual maximum time that the generators can operate.

$$\begin{aligned} T_{\max} &= Z + K \\ &= 53,607.68 + 14,571.43 \\ &= 68,179.11 \text{ Minutes} \end{aligned}$$

$$T_{\max} = 1136.32 \text{ Hours}$$

The slight differences between these results and those obtained from the analytical procedure can be attributed to decimal round-off error. For most practical

purposes, the maximum values obtained by the two procedures can be considered identical. Thus the procedures for developing the objective function and constraint set for the LP600 linear program, and the method for obtaining the maximum time from the optimal value for the objective function and the constant K appear to be valid.

Example Problem Input Program

```
10NNS,R(J) : ,8,16;;,16
20%:IDENT:WP1186, AFIT LSG S.D. NELSON
30%:USERID:80A053%KR79
40%:PROGRAM:RLHS
50%:LIMITS:10,39K,,5K
60%:PRNFL:H*,R,R,AF.LIB/LP.PAC
70%:REMOTE:SO,SL
80%:DISC:AA,A1,10R
90%:DISC:AB,A2,10R
100%:DISC:AC,A3,10R
110%:DISC:AD,A4,10R
120%:DISC:AE,A5,10R
130%:DATA:IN
140FILE:ELEC
150**** MATRIX ****
160MATRIX:ONE(Z),S1(P)=17.14
170:,S2(P)=-8.00
180MATRIX:TWO(P),S1=1
190:,S2=1
200**** OBJECTIVE FUNCTION ****
210MATRIX:OBJROW(FREE),S1=-8.57
220:,S2=-4
230**** RHS ****
240RHS:ONE,RHSONE=-5142.86
250:TWO=10000
260END***
270%:DATA:I*
280:PREPRO
290:TITLE:GENERATORFUELPLAN
300:CONVERT:SOURCE=ELEC/IN,IDENT=GFP
310:SETUP:SOURCE=GFP
320:SET:OBJ=OBJROW,RHS=RHSONE
330:PICTURE
340:PRIMAL
350:OUTPUT
360:ENDLP
370%:ENDJOB
380***EOF
```

```

PIAST 01 05/02/80 OPERATORFUELPLAN VERB= PRIMAL PAGE 15
PRAM=00P 1 1 FUNCT= 2571.43002+ 00J=0RJR00H1 1 RMS=RHS00F1 1
ITER ETA MIN FUNCTIONAL MINFS MBJS VALUE2 INCOMING VECTOR NAME IN KJ OUT KJ CCT VPC ACT MCT FCT 4.11M
1 1 1 2571.43002+ 1 0.00000000- S2 1 1 P 55 Z 1L 1 2 1A 2 2 42
2 2 2 53697.6021+ 1 17.1400001- S1 1 1 P 45 P 2L 1 2 2A 3 3 70
OPTIMAL SOLUTION 17.1400001- S1 1 1 P 45 P 2L 3 3 47
46 OUTPUT 30202 0

```

OPTIMAL SOLUTION

Example Problem Iterations, N=2--Optimal Solution

GENERATORFUELPLAN

01/ST 01 05/02/80

PHANZEP 1 1

FUNCIN 53607.6821

OBJ=ONJPOW

RMS=RHSONE1

NO-S

ROW NAME
1 7ERO ONF
2 PLUS IMU
3 FHE DBJROH

LOGICAL

INDIC.

ORASIS

L-VALUE

53607.68239145

SLACK VALUES

PI
.18178282
9.45425619
1.00000000

ORIGINAL RIGHT-
HAND SIDE
VALUES

RMS
5142.86884638
10000.00000000

Example Problem Slack Values

GENERATION FUEL PLAN

DATE 31 05/02/80

RHS=RHSONE

ORJ=0BJR0N

FUNCT= 53607.6021

FUEL ALLOCATIONS



Generator

COLUMNS

COL	RJ	TYPE	COLUMN NAME	STRUCT.	INRIC.	X-VALUE	DJ	COST-SCALE
4	PLUS	SJ	•BASIS	•BASIS	2977.61899249	•	•	8.57800005-
5	PLUS	SJ	•BASIS	•BASIS	7022.38000791	•	•	4.00000000-
6	RHS	RHSONE				•	53607.60239105	•

Example Problem Fuel Allocations

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Air Force Logistics Command. "Backup Power for Critical AFLC Facilities." Unpublished study, Task order No. 78-15, HQ AFLC/DEP, Wright-Patterson AFB OH, 1 May 1979.
2. _____. FY82 Military Construction Program. Wright-Patterson AFB OH, 26 October 1979.
3. Bierman, Sergeant Ronald E., USAF. Superintendent, Electrical Power Production Section, 2852 Civil Engineering Squadron (AFLC), McClellan AFB CA. Telephone interviews conducted intermittently from 25 March 1980 through 9 April 1980.
4. Boas, Richard J., and others. "Army Energy Plan." Unpublished technical report, unnumbered, Army Energy Office, Washington, 24 February 1978.
5. Carlson, A., and others. "USAF Terrestrial Energy Study--Vol. II, Part 2, Energy Conversion Systems Handbook." Unpublished technical report No. AFAPL-TR-78-19-Vol-3-Pt-2, Air Force Aeropropulsion Laboratory, Wright-Patterson AFB OH, May 1978. AD A057252.
6. Dolan, W. H., and E. M. Honig, Jr. "Analysis of Central Total Energy Systems at Military Facilities." Unpublished research report No. E-115, Construction Engineering Research Laboratory, Champaign IL, August 1977. AD A044813.
7. Emergency Power Generators Used and Managed Inefficiently by Department of Defense." Unpublished report, unnumbered, United States General Accounting Office, Washington, 20 May 1977.
8. Frankosky, James O., Frank Milner, and Charles Ravitsky. "A Summary of the DARPA Energy and Materials Shortages Program, Fiscal Years 1972-1976." Unpublished research report No. A-3825, Defense Advanced Research Projects Agency, Arlington VA, December 1976.

9. Gonzalez, Antonio M. Electrical Work General Foreman, Electrical Section (EEMKE), SARMPA Kelly Field Engineer, Kelly AFB TX. Telephone interviews conducted intermittently from 25 March 1980 through 16 April 1980.
10. Information Handling Services. "Visual Search Micro Film (VSMF) Data Control Services, Plant Engineer Series." Issue 11-1, Englewood CO, January 1980.
11. Norton, Master Sergeant Sidney E., USAF. Supervisor, Electrical Power Production Section, 2853 Civil Engineering Squadron (AFLC), Robins AFB GA. Telephone interviews conducted intermittently from 22 February 1980 through 3 April 1980.
12. Operations Plan. 2849 Air Base Group/DEM. Base Civil Engineer Base Recovery Plan. OPLAN 93-2. Hill AFB UT, 31 August 1979.
13. _____. 2851 Air Base Group/DEM. Disaster Preparedness and Base Recovery Support Plan. OPLAN 93-2. Kelly AFB TX, 1 May 1978.
14. _____. 2852 Air Base Group/DEM. Base Civil Engineer Base Recovery Plan. McClellan AFB CA, July 1979.
15. _____. 2853 Air Base Group/DEM. Base Civil Engineer Base Recovery Plan. Robins AFB GA, 1 March 1979.
16. Oppelt, Staff Sergeant David P., USAF. Assistant NCOIC, Electrical Power Production Section, 2849 Civil Engineering Squadron (AFLC), Hill AFB UT. Telephone interviews conducted intermittently from 28 February 1980 through 14 April 1980.
17. Pelham, Colonel Wendall, USA, and others. "Where Will the Energy Come From in 1987?" Unpublished research report, unnumbered, U.S. Army War College, Carlisle Barracks PA, February 1978. AD B024825.
18. Ragland, Staff Sergeant Craig K., USAF. Foreman, Electrical Power Production Section, 2845 Civil Engineering Squadron (AFLC), Tinker AFB OK. Telephone interviews conducted intermittently from 20 March 1980 through 11 April 1980.

19. Shalar, Alexander. "Electrical Energy Allocations at Navy and Marine Corps Bases." Unpublished master's thesis, Naval Postgraduate School, Monterey CA, March 1975. AD A009821.
20. Shaw, Colonel William M., Jr. Assistant DCS/Engineering and Services, HQ AFLC/DEPR. Message, subject: Readiness Requirements--Review of Backup Electrical Power, to 2750 ABW/CV, 27 November 1978.
21. U.S. Department of the Air Force. Disaster Preparedness and Base Recovery Planning. AFR 93-2. Washington: Government Printing Office, 29 July 1974.
22. _____. Maintenance and Operation of Electrical Power Systems. AFR 91-4. Washington: Government Printing Office, 8 April 1974.
23. _____. Resources and Work Force Management. AFR 85-1. Washington: Government Printing Office, 22 September 1978.
24. _____. Utilities Services. AFR 91-5. Washington: Government Printing Office, 13 October 1976.
25. Wagner, Paul H. AFLC Command Fuels Officer, HQ AFLC/LORFF, Wright-Patterson AFB OH. Personal interviews conducted intermittently from 5 February 1980 to 14 April 1980.
26. Zweigle, Lieutenant Colonel Maurice L., USA. "Technological Feasibility of Alternative Energy Sources." Unpublished research report, unnumbered, U.S. Army War College, Carlisle Barracks PA, 28 October 1974. AD A005549.

B. RELATED SOURCES

Carlson, A., and others. "USAF Terrestrial Energy Study--Vol. III, Part I, Summary Data Display." Unpublished technical report No. AFAPL-TR-78-19-Vol-3-PT-1. Air Force Aero Propulsion Laboratory. Wright-Patterson AFB OH, May 1978.

DeWitte, Captain Michael D., USAF. "Alternative Energy Sources for United States Air Force Installations." Unpublished technical report No. AFWL-TR-75-193, Air Force Weapons Laboratory, Kirtland AFB NM, August 1975. AD A014858.

Hall, First Lieutenant David C., USAF. "USAF Terrestrial Energy Study--Vol. I, Executive Summary." Unpublished technical report No. AFAPL-TR-78-19-Vol-1, Air Force Aero Propulsion Laboratory, Wright-Patterson AFB OH, April 1978. AD A055213.

Manchester, Captain David L., USAF, and Captain Ronald L. Schuldt, USAF. "Development of an Air Force Facilities Energy Information System." Unpublished master's thesis. LSSR 8-78A, AFIT/LS, Wright-Patterson AFB OH, June 1978. AD A059409.

Tetra Tech, Inc. "Energy Fact Book--1977." Unpublished technical report, unnumbered, Office of Naval Research, Arlington VA, April 1977. AD A038802.

U.S. Department of the Air Force. Air Force Design Manual--Criteria and Standards of Air Force Construction. AFM 88-15. Washington: Government Printing Office, 8 January 1975.

_____. Policies, Procedures and Criteria for the Management and Conservation of Utilities. AFM 91-12. Washington: Government Printing Office, 19 August 1971.

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