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Long-Term, Mid-Term, and Short-Term Fuel Scheduling

Volume 3: Economic Dispatch Fuel Price Strategies

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Research Project 1048-6

Final Report, January 1983

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ABSTRACT

This document is one of a set of three volumes constituting the final report for RP1048-6. The project objective has been to devise practical methods by which utilities might reduce operating costs through a coordinated approach to fuels management and generation scheduling and control.

Volume 3 of this report deals with methods of determining the value of fuel prices that should be used in an equal-incremental (equal-lambda) economic dispatch of generation in an electric power system. It is specifically concerned with the case in which a number of different fuel supplies having different prices and different constraints on procurement are available to each generating unit during the optimization period. Results of an industry survey, a mathematical analysis yielding the optimal value of dispatch fuel price for each unit, sensitivities of the system fuel cost to deviations from the optimal dispatch fuel prices, and a methodology for evaluating the values of dispatch fuel prices are presented.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

In the last few years fuel prices increased dramatically, and decreased generator availabilities became commonplace. These factors cause a need for better fuel use within the electric power industry. When a power system dispatcher decides which fuel type to use, real-time system conditions, daily fuel-use schedules, and special yearly fuel constraints must be taken into account. The overall objective of RP1048-6 was to develop digital computer programs in order to help utilities use their fuel resources effectively.

To accomplish this objective the project was divided into several phases. During the first phase of the work, functional specifications were written for the digital computer programs that were to be developed in the remaining phases of the project. Subsequent phases of the work developed the computer programs for use by the following groups:

- Fuels purchasing departments (long-term planning: weeks to years)
- System operations planners (mid-term planning: hours to weeks)
- System dispatchers (real-time operations: seconds to hours)

To assure the coordination of the results of the computer programs, much of the data needed by the programs are to be kept in common data files to facilitate the use of the interrelated software and to minimize duplication of data entry.

PROJECT OBJECTIVES

The objective of the first phase of this project was to develop a set of functional specifications for the computer programs needed for long-term, mid-term, and real-time fuel scheduling. The objective of the second phase was to develop the long-term fuel scheduling computer program. The objectives of the third phase were to develop the computer program for mid-term fuel scheduling and to develop the techniques for incorporating the long-term and mid-term results into real-time system operations.

PROJECT RESULTS

There were two key accomplishments in this project:

1. The development of an integrated long-term, mid-term, and real-time fuel scheduling technique

2. The development of a method for determining the incremental fuel price to use for generators with multiple fuel sources

During the work on Phases II and III, three digital computer programs were developed. One computer program that has been developed in Phase II, Unit Commitment, enables the user to forecast generating unit commitment and production costs for operation planning. The Long-Term Fuel Scheduling program and the Mid-Term Fuel and Generation Scheduling program are described in Volumes 1 and 2 of this final report. Volume 3 describes a method for determining the incremental fuel price to use in the mid-term scheduling program for those generators with multiple fuel sources.

The computer programs were developed in this project with the assistance of Public Service of Colorado (PSCo), the host utility for this project. PSCo is using the Long-Term Fuel Scheduling program on its corporate computer, and the Unit Commitment and the Mid-Term Fuel and Generation Scheduling programs are currently being integrated into the PSCo dispatch control center for daily use by its system operators. This integration is expected to be completed in the second quarter of 1984. All three computer programs are available from the Electric Power Software Center.

The specifications developed in the first phase of this project are reported in EPRI Interim Report EL-1319 (January 1980). The unit commitment program is described in EPRI Interim Report EL-2455, Volumes 1 and 2 (June 1982).

Charles J. Frank, Project Manager
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SUMMARY

This three-volume document is the final report for EPRI Research Project 1048-6. The aim of the project has been to develop tools and methods by which electric utilities might reduce operating costs through coordinated generation scheduling and fuel management. The motivation for the project lies in the enormously increased volatility of the fossil fuels market since 1973 and in the accompanying price increases. Fuels now account for a substantial portion of most utilities' operating expenses, and the incentive for reducing fuel-related costs--purchase, delivery, and storage--is enormous.

The project has been conducted in three phases. Phase I was concerned with the definition and analysis of the fuel and generation scheduling problems encountered by electrical utilities. Emphasis was placed on yearly and weekly fuel scheduling, and on instantaneous fuel dispatching when fuels are in short supply. Fuel contract management was revealed to be a central issue, since contracts exert a number of constraining forces on the actual operation of the utilites. A hierarchical framework linking long-, mid-, and short-term fuel scheduling was developed, and straightforward methodological approaches were developed for each of the three nested problems. Top-level software and file designs were laid out, and a skeletal cost/benefit analysis was performed. The results of Phase I were published in EPRI Interim Report EL-1319 in January 1980. That report also contains the mathematical theory underlying the project.

Phase II was a software development effort in which two computer programs were developed. The first, a user-friendly, long-term fuel scheduling program, was developed with the participation of Public Service Company of Colorado (PSCo). It deals with the problem of determining minimum cost schemes for acquiring, transporting, and maintaining an inventory of fuels. The modeling of long-term fuel contracts is a key feature of the program. The program has been installed and tested at PSCo. The second program is a general-purpose unit commitment program, intended for use in EPRI research projects and for planning at electric utilities. It has been installed at several EPRI member utilities for initial testing and

evaluation. One utility has used it extensively for planning purposes. This program has been documented in the interim report EL-2455 and is available from the Electric Power Software Center.

Phase III had two primary activities. The first was the development of a unit commitment program for use in the scheduling of generation when some or all fuel supplies are scarce, and that is more adapted toward use in daily operations than the operations planning-oriented program developed in Phase II. The remarkably efficient Phase II program was taken as the starting point in this effort, and many modifications relating to fuels, file structure, and program operation were incorporated to make the package more closely suited to daily use by operators and schedulers. A complete man-machine interface dialogue structure was designed. The second activity was a survey and analysis of the methods by which utilities determine fuel prices for use in economic dispatch. This is a question of key importance and one that has received slight attention in the literature.

The primary functions of this three-volume report are to document the Long-Term Fuel Scheduling (LTFS) program and the enhanced unit commitment program (dubbed the Mid-Term Fuel and Generation Scheduling, or MTFGS, program to distinguish it from its Phase II predecessor) and to report on the dispatch fuel price analysis.

The LTFS program is intended for use in optimally planning the monthly purchases, transportation, storage, and in some cases, the consumption of fossil fuels by a utility over the space of 1 to 2 years. The program is largely centered about long-term fuel contracts and their complexities; spot purchases, inventory limits and holding costs, transportation costs, and transshipment opportunites are also represented. Mathematically, this is a fairly large-scale problem--several thousand variables and constraints are generally involved--but it has a special algebraic structure that allows it to be solved very efficiently with a small public-domain optimization program. This routine is embedded in a substantial body of software that enables the user to formulate problems and obtain solutions expressed in familiar utility terms and units; this removes the burden of laboriously expressing the utility's fuel planning problem as an enormous collection of individual costs, constraints, and variables. This program was developed with the assistance of the Public Service Company of Colorado (PSCo), and it has been implemented and tested there.

The Mid-Term Fuel and Generation Scheduling program (MTFGS), also developed with PSCo's cooperation, is a very efficient unit commitment program with several fuel-related features designed to make it useful in scheduling generation when fuels are scarce or when one is attempting to follow a previously determined fuel-consumption plan. (The yearly fuel scheduling program's solution may be taken as a target consumption plan.) This program is an extension of the general-purpose unit commitment program developed in Phase II of this project, which in turn was based on one developed at Southern Company Services (SCS) in Birmingham, Alabama, in the mid-1970's. Dr. Charles A. Gibson of the University of Alabama developed the original program at SCS during a 15-month sabbatical leave, and he was a consultant in the development of the new computer programs. This heritage has lent a very practical, utility-oriented flavor to both unit commitment programs produced in this project. The MTFGS program contains sophisticated fuel accounting logic by which the estimated fuel consumption for each fuel type, at each plant, is computed for the current unit commitment schedule. Significant departures from target fuel consumptions are noted, and the user is then free either to accept the schedule as it is or to make some changes to the input--say, base-loading certain units at 80% of capacity and tightening the operating limits on another unit--that are in his view likely to result in a more appropriate fuel allocation, and rerun the program. It is sufficiently fast that repeated runs cause no burden; 90-unit, 168-hour problems typically solve in 9 CPU seconds on an IBM 3033 computer. Modified operating limits may be stored in a file for later use in on-line economic dispatch if fuel consumption is critical, but only if explicitly authorized by the user. For the utility that may wish to implement the MTFGS program in an interactive setting, a complete man-machine interface dialogue structure is described. CRT display formats are given, together with descriptions detailing their use by an operator. This work was done at PSCo for their own use and reflects the concerns and requirements of applications-oriented utility engineers. There is currently no graphics-oriented computer language with sufficient commonality to allow widespread EPRI distribution, so no man-machine interface code was developed. The utility with some sophistication in the area should be able to adapt and implement the scheme on its own system with relatively little effort.

Volume 1 is a user's guide to the yearly fuel scheduling program and the Mid-Term Fuel and Generation Scheduling program. It also contains a brief overview of the entire project. Volume 2 is a programmer's guide to the same two programs. Volume 3 is devoted to the analysis of dispatch fuel price strategies. It deals with the problem of determining most efficient economic dispatch prices at an electric utility. In the classical economic dispatch development, which yields the equal-incremental-cost criterion for economic loading of the generating units, no consideration is given to the most common case in which a number of fuels with different prices and constraints on use are available to the different generating plants. In the classical analysis it is tacitly assumed that there is sufficient available fuel, at a given single price, to supply all possible needs of a given generating unit. This is clearly an oversimplification in light of today's complex fuel market.

A utility survey, conducted as a part of this research project, shows that there is no universally accepted scheme for setting economic dispatch fuel prices. Eight of the twelve utilities surveyed were using weighted-average fuel prices for their dispatch fuel prices. Three other companies were using incremental prices. One company did not use economic dispatch in its daily operation.

In this volume, a mathematical argument is presented which shows that an equal-incremental dispatch which minimizes the instantaneous cost rate also minimizes the fuel cost over a period of time. Additionally, it is shown that the incremental fuel price should be used in the economic dispatch.

Simulations of the economic dispatch and evaluation of the production cost verify the mathematical results. The simulations were used to evaluate the sensitivity of the system fuel cost to errors in the economic dispatch. Fuel cost increases of .5% to 1% over the minimum cost due the use of the weighted-average fuel prices for dispatch are typical for nominal system fuel conditions. Sensitivities of the fuel cost due to random errors in the dispatch fuel prices were also evaluated.
A coordinated fuel management process and an evaluation of the incremental fuel prices are presented. Additional expenditures for fuel due to the lack of such a coordinated fuel procurement and management process can significantly exceed the .5% to 1% additional cost due to the dispatch fuel price errors alone.

This research project has produced the very satisfying results of obtaining the theoretical dispatch fuel prices and then linking these prices to the overall fuel management problem, with a very practical means of obtaining the incremental fuel prices as a part of the solution of the fuel procurement process.

Section 1

INTRODUCTION

This volume is concerned with the problem of selecting the fuel prices by which generating units are dispatched at an electric utility. The familiar equal-incremental-cost (or equal-lambda) dispatching technique assumes that there is a known functional relationship between generating unit output level and the incremental hourly operating cost of the unit. Such a relationship is generally assumed to be made up of an incremental heat rate curve multiplied by a constant corresponding to a fixed price of fuel.

Determining an appropriate fuel price to use is not a straightforward exercise. Many fossil steam-generating units use more than one fuel (say, coal and oil) with decidedly different costs per MBtu. Fuels may be supplied from different long-term contracts with different prices. The price of fuel from a single contract may vary with the monthly or yearly delivery quantity, and the base price is likely to be renegotiated yearly in any event. A given month's spot purchases can vary wildly in price. The fuel inventory that a utility carries is typically made up of fuels purchased at different times, at different prices, from different vendors; even determining an average price of fuel on hand is difficult. So-called "take-or-pay" contracts, in which the buyer is obligated to pay for a minimum quantity of fuel whether he uses it or not, further complicate the picture. The point is clear: It is often difficult to determine the price of fuel.

This report represents an attempt to analyze and understand this problem, and to provide practical suggestions by which utilities might lower their operating costs through better dispatch fuel price strategies. The research was slanted toward practical operations rather than toward mathematics or economics, as a sketch of the effort will show. An industry survey was done, in order to determine the methods that utilities are using today. A quantitative analysis of the dispatch fuel price problem viewed as an optimization problem was carried out, extending the conventional equal-incremental-cost rule to cover the instance of a multi-tiered fuel price structure with quantity limits on each tier of fuel. Computer simulations were done to verify the correctness of the analytical results, and also to estimate the sensitivity of overall production cost to errors in dispatch prices. Finally, a method for estimating dispatch fuel prices through the use of a linear programming model for optimizing monthly fuel acquisitions was investigated, and was found to be quite promising.

GUIDE TO THIS REPORT

Section 2 describes the methods and results of the industry survey. Section 3 gives the details of the mathematical analysis of the dispatch fuel price problem. Section 4 describes a simulation study of a fictitious two-unit, two-fuel system, and demonstrates the validity of the results of Section 3 in an idealized and simplified utility. Section 5 covers an analogous simulation study of a larger system. Section 6 discusses the linear programming-related method for determining dispatch prices through the optimization of monthly fuel acquisitions. Section 7 summarizes the results and conclusions of this portion of the project. Appendices A through I provide supporting data and information. Appendix J is a glossary of terms used in this three-volume report.

Section 2

INDUSTRY SURVEY

BACKGROUND

The first activity in this research task was to survey a number of utilities to determine the dispatch fuel price strategies that are actually in use today. Another aim of the survey was to gather users' views on the relative strengths and shortcomings of different dispatch price methodologies, so that this research task would be done with full benefit of several users' practical experience.

Because of the complexity of most utilities' fuel supply arrangements and the subtlety of the question of dispatch fuel prices, the survey was restricted to a small number of in-depth interviews rather than a large-sample mailed questionnaire. Twelve utilities were interviewed, and while they must remain anonymous we can assure that they represented a broad spectrum in terms of both geography and methodology.

KEY TERMS AND CONCEPTS

There are several words, phrases, and concepts associated with fuel dispatch pricing that should be explained before discussing the survey results.

When discussing dispatch fuel pricing with utility representatives, several terms frequently arise that should be defined at the outset. The incremental fuel price of fuel at a given time is the cost (¢/MBtu) that would be incurred in purchasing one more unit of fuel. This is consistent with the use of the term in economics, but in practice there is something of a departure from classical economic theory; fuel is generally not obtainable in infinitely divisible quantities, and hence one cannot determine the incremental price through differentiating a total cost curve. Fuel comes in discrete packets—rail car loads, unit trains, barges, specific spot opportunities, etc.—and one's estimate of the cost of the next unit of fuel depends on the size of the basic delivery packet. Weekly, daily, or hourly delivery constraints and the discrete nature of many long-term contracts' price vs. quantity relationship can complicate even natural gas, which, in principle, can be drawn in arbitrarily small units. (At some utilities the phrase "incremental fuel price" is used synonymously with "dispatch fuel price," irrespective of the method by which the dispatch price is found.)

There is a subtle point that makes it difficult to determine the true incremental cost of fuel. It is typically assumed that the incremental price of fuel at a generating unit is the price of the next MBtu that the given unit might require. There are secondary effects, though, in utilities with fuel transshipment capability or with long-term contracts whose allowable delivery points enjoy considerable overlap: if one unit requires an increase in fuel supply that draws previously allocated fuel from a contract whose deliveries are split among two or more locations, then the adjustments in the system's supply scheme to restore the other locations' fuel supplies must be taken into account in determining the cost to the utility of supplying the additional increment of fuel. This is a rather complex notion and is dealt with at length in Section 6.

A notion related to incremental fuel price is the replacement price, i.e., the cost of replacing fuels consumed in the current production period. This often involves price forecasting, since spot-market prices are volatile and contract prices may change in unforeseeable ways. Some utilities attempt to calculate replacement prices by selecting a time period in the future (say, the next 90 days) during which the current period's consumed fuel will be replaced and estimating the market prices that will prevail.

Some utilities use a weighted average price for dispatching purposes. The prices and quantities of all fuels purchased for each individual unit in some given time period are tabulated, and a weighted average fuel price for each unit is calculated.

One very direct approach favored by some utilities is that of a burn price. With this scheme, the dispatch price for an upcoming time period is taken to be the cost of the actual fuel that is anticipated to be burned. If the fuel to be burned has already been purchased and is in inventory, then invoice prices can be used. If a last-in, first-out fuel inventory policy is followed, then the prices of fuels to be delivered during the upcoming period can be used.

In general, the period over which dispatch prices are established and used seems to be one month. In practice, this means that at some time in the latter half of each month the dispatch prices for the upcoming month are determined.

The notions of weighted-average prices, replacement costs, burn costs, etc., are not mutually exclusive. For example, one company (identified as Company B in the next subsection) estimates each unit's fuel replacement price to be a weighted average of the prices of the fuels anticipated to be burned in the upcoming month. It uses a dispatch fuel price found by averaging this estimated replacement price with the most recent month's actual cost and then applying an escalation factor to this averaged value.

The terms delivered fuel and purchased fuel must be used carefully when discussing fuels acquired during a given period of time, since the purchase date may precede the delivery date by as much as one month. Invoice date and date of payment may also be used to specify fuel acquisitions in a period.

Regardless of the time frame in which the fuel is priced, the various time frames may be coupled with the pricing concepts based on quantity, such as weighted-average price or incremental cost.

SUMMARY OF THE SURVEY

Table 2-1, entitled "SUMMARY OF RESPONSES TO THE SURVEY ON DISPATCH FUEL PRICING," summarizes the survey of the 12 electric utilities. Company G does not appear in the table since this company does not utilize economic dispatch. For each company six entries appear in the table: major fuel type and its approximate percentage of the total fuel; other fuels used; approximate percentage of the major fuel which is secured by means of long-term contracts; nominal period of time between updates of the dispatch fuel price; type of dispatch price determination (incremental vs. weighted average); and the price estimation scheme (replacement vs. burn price).

COMMENTS ON SURVEY RESPONSES

It is the entries under items 5 and 6 that specify the basic concept under which the dispatch fuel price is evaluated. The actual mechanics used in evaluating the values differ among the companies that name the same concept for determining the dispatch fuel price.

Eight of the eleven companies stated that they use the weighted-average replacement price concept. In obtaining the values of replacement price, the mechanics employed by the different companies include using historical data, projected historical data, latest quoted price, etc., as is seen from the discussion for the individual companies. Using weighted-average pricing instead of incremen-

Table 2-1

SUMMARY OF RESPONSES TO THE SURVEY ON DISPATCH FUEL PRICING

TABLE ENTRY NUMBER						
COMPANY	MAJOR FUEL, %	OTHER FUELS	% MAJOR FUEL FROM CONTRACT	UPDATE PERIOD	DISPATCH PRICE TYPE	PRICE ESTIMATION SCHEME
A	COAL 70%	NUCLEAR	85%	ONE MONTH	INCREMENTAL	REPLACEMENT
B	COAL 80%	OIL NUCLEAR	80%	ONE MONTH	WEIGHTED AVERAGE	REPLACEMENT
C	OIL 60%	NUCLEAR NAT GAS	85%	ONE WEEK TO ONE MO	INCREMENTAL	REPLACEMENT
D	COAL 80%	NUCLEAR	90%	ONE MONTH	INCREMENTAL	REPLACEMENT
E	COAL 75%	NUCLEAR OIL NAT GAS	70%	ONE MONTH	WEIGHTED AVERAGE	THE GREATER OF THE PREVIOUS MONTH'S BURN PRICE OR PURCHASE PRICE
F	NAT GAS AND OIL 85%	NUCLEAR	65%	ONE MONTH	WEIGHTED AVERAGE	LAST PURCHASE
H	OIL 67%	COAL	NEAR 100%	ONE TO THREE MONTHS	WEIGHTED AVERAGE	REPLACEMENT
I	OIL 60%	NUCLEAR COAL NAT GAS	95%	TWO WEEKS	WEIGHTED AVERAGE	REPLACEMENT
J	COAL 75%	NUCLEAR OIL	90%	ONE MONTH	WEIGHTED AVERAGE	REPLACEMENT
K	OIL 45%	NUCLEAR COAL	80%	TWO WKS TO TWO MO	WEIGHTED AVERAGE	BURN
L	COAL OIL NAT GAS	NUCLEAR	80%	ONE MONTH	WEIGHTED AVERAGE	REPLACEMENT

tal pricing complicates the calculation of the replacement price because the price becomes dependent on the anticipated consumption of fuel by a given unit. In turn, the consumption by a given unit is dependent on the dispatch fuel price of that unit relative to the dispatch fuel price of the other units. Since the incremental price of fuel tends to change only with very large variations in the quantity consumed, the coupling of a unit's dispatch price and its consumption is not nearly so direct.

A few companies that use a weighted-average price stated that their unconstrained choice would be to use the incremental price, but that since the dispatch fuel price is also used for other functions such as pricing interchange sales with pool members and others, they are forced into using a weighted-average cost.

Most companies which use a weighted-average replacement price base the next period's prices on the weighted-average prices experienced during past periods and projections made from this operating history.

Although the table may show a specific nominal update period for the dispatch fuel price, a number of the companies reported that additional updates may be made if significant changes in the fuels condition were to occur.

THE SURVEY

A survey of 12 electric power utilities was conducted in order to determine the current practice in setting the dispatch fuel prices by a representative group of utilities. The utilities are designated as Company A through Company L, and each company is discussed in a separate subheading.

Company A

This company has predominantly coal-fired generation, with nuclear units making up approximately 30% of capacity. Both coal and nuclear units are run under economic dispatch. For the coal units, the fuel department of this company evaluates the dispatch fuel price and supplies the dispatch price for each unit to the operating department on a monthly basis. The price of the fuel that will replace the fuel to be consumed by a unit which is to pick up the next MW of system load is considered to be the incremental replacement price, which is used for the dispatch price. In order to evaluate the incremental replacement price, the fuel department looks at the projected fuel use at each unit for the coming month and matches long-term contract fuel and spot-market fuel requirements to the anticipated consumption. Then, based on bids obtained from fuel suppliers, they determine the price of spot-market fuel purchased. If it is decided that spot-market fuel is to be consumed by a unit during the coming month, then the dispatch fuel price used for that unit is the spot-market fuel price regardless of whether the price is higher or lower than the long-term contract fuel prices. If no spot-market fuel is required for the unit, then the dispatch fuel price would be the actual contract price.

The dispatch fuel prices used for nuclear units are also a replacement price and are the current market price of fuel. The nuclear dispatch fuel prices are evaluated on a monthly burn basis and are updated monthly for use in the economic dispatch.

Company B

The budgeting and planning department of this company evaluates the dispatch fuel price based on information provided by the fuel department.

The dispatch fuel price supplied to the operating department is a fuel replacement price. The fuel replacement price is an estimated weighted-average price of the fuel to be consumed during the upcoming month. The method used to evaluate the dispatch fuel price consists of taking a unit's most recent 1-month actual cost and the unit's 1-month projected cost, averaging the two values, and applying an escalation factor to the averaged value to hopefully approach the actual weighted-average cost of the fuel to be consumed in the month in which the dispatch fuel price is to be used. Additional details of this method are presented for the different fuels.

Approximately 80% of this company's fuel is coal. The fuel department provides to the budgeting and planning department the following information by plant on all coal received from each vendor for the prior nominal 30-day period:

a. Vendor name
b. Tons of coal delivered by vendor
c. Delivered cost of coal ($/ton)
d. Total delivered dollars
e. Btu/lb for delivered coal
f. Total millions of Btu
g. Total of (d) for all vendors
h. Total of (f) for all vendors

The above data are based on "actual" values. Also, the fuel department provides to the budgeting and planning department the "projected" distribution of coal in tons by plant for the current nominal 30-day period with the projected distribution to include the vendor name. Based on information provided by the fuel department, the budgeting and planning department calculates a value of delivered-coal-purchases cost (in cents per million Btu) for each plant for the prior nominal 30-day period involved. Also, based on the projected tonnage information for the current nominal 30-day period and the actual delivered coal cost for each vendor for the prior nominal 30-day period, a value for the delivered-coal-purchases cost is calculated for the current nominal 30-day period for each plant. For each vendor, the current month's Btu/lb is assumed to be the same as that for the prior nominal 30-day period. For vendors not in the prior period, a reasonable value is to be used. The cents per million Btu delivered coal cost value for each plant, calculated for both the prior and current nominal 30-day periods, is weighted by the respective tonnages to give a 2-month weighted-average value for each plant.

The resulting 2-month weighted-average price for each plant is then escalated by an appropriate percentage. This percentage is the "projected" 1-month compound rate of change in delivered coal cost on a company-wide basis, based on the next 6 months' projections. This projected information is obtained from the most recent fuel budget/forecast.

The projected quantity (in MBtu) of boiler lighter oil to be purchased for the current nominal 30-day period for each coal-fired plant is determined by the budgeting and planning department. This projection is based on the most recent official fuel budget/forecast. The escalated price of delivered oil is evaluated by using the procedure, to be presented later, for calculating the dispatch price for system oil-fired boiler and combustion turbine generating units.

The quantity of boiler lighter oil at its escalated cost is weighted with the quantity of coal per month based on the 2-month period as described earlier at its escalated cost. These values are then used to calculate a combined delivered coal and boiler lighter oil cost for each plant. No coal handling costs or variable supplies and maintenance costs are to be added to the escalated 2-month weighted-average value for each plant.

The dispatch fuel prices for coal-fired generating units are provided to the operating department on a monthly basis. The methodology for calculating the dispatch fuel price for oil-fired boiler units and combustion turbine generating units is given in the following discussion.

For any plant using oil in boilers or combustion turbines, the contract Btu/gallon data from the fuel procurement records are used to convert the latest posted contract invoice cents per gallon price, from all sources based on the same records, to a cents per million Btu value. All prices include delivery and any applicable taxes. For plants having multiple sources of supply, only the latest contract invoice price for the highest priced source, as posted by fuel procurement, is used.

The resulting value of cents per million Btu delivered oil purchases cost value for boiler oil or combustion turbine oil at each applicable plant is escalated by an appropriate percentage. This percentage is the projected 1-month compound rate of change in delivered cents per gallon oil cost on a company basis. It is based on the next 6 months' projections and is obtained from the most recent fuel budget/forecast. No variable supplies and maintenance costs are added to the escalated oil cost value for each plant.

The fuel dispatch prices used in the economic dispatch of oil-fired system generating units are provided to the operating department at the same time the economic dispatch prices for coal-fired units are provided. Accordingly, the economic dispatch prices for oil are updated on a monthly basis.

This company's fuel requirements are met by approximately 80% long-term contract fuel purchases and approximately 20% spot-market fuel purchases. The fuel prices are formula priced for long-term contracts and fixed priced for spot-market purchases. The procedure employed by this utility for forecasting future fuel procurement requirements relies upon a production costing program which is used to project fuel consumption for up to 15 years into the future. The computer forecasts are updated on an annual basis.

This company possesses some ability to divert fuel shipments from one generating plant site to another, although the option is somewhat restricted due to environmental restrictions on air pollutants.

Company C

The operating department of this company has the responsibility for performing the economic dispatch and for calculating the dispatch fuel prices used in the dispatch. The dispatch fuel prices are based on information provided by the fuel department for each unit as follows:

a. Oil ($/barrel)
b. Coal ($/ton)
c. Gas ($/Mcf)

The above costs are converted to a cents per million Btu figure by the operating department.

The fuel prices provided by the fuel department are based on a replacement fuel cost. The replacement fuel price is taken to be the actual price of the last fuel purchased which is to be consumed during a predesignated time period usually consisting of one week. If spot-market fuel purchases are required to meet the fuel consumption for the next 1-week period then this is the fuel price provided by the fuel department for that unit regardless of whether the spot-market price was higher or lower than the long-term contract price of fuel consumed by that unit.

Oil is the major fuel consumed by this company and accounts for approximately 58% of the total fuel consumption. If no oil shipments have arrived during the previous 30-day period, the current New York market price is used as the replacement price. Typically, oil shipments arrive approximately every 10 days, with a 10- to 30-day lag in actual burn time from arrival time.

Natural gas and nuclear are the other fuels utilized by this company. The fuel price used for natural gas is also the replacement price and is evaluated as for oil. The dispatch price for nuclear units is evaluated using a monthly calculated burn and is based on the unit refueling cycle. The nuclear dispatch fuel price is updated monthly.

Approximately 85% of the fuel consumed by this company is procured by long-term, formula-priced fuel contracts with the remaining 15% requirement being met by spot-market, fixed-priced purchases. This company utilizes a system production cost program to provide annual fuel requirement forecasts for several years into the future. The forecasts are updated continuously as fuel prices change.

Company D

The fuel department of this company is responsible for evaluating the dispatch fuel prices for use by the operating department. The dispatch fuel price provided by the fuel department is the best market estimate price of the replacement fuel. The replacement fuel is that fuel which will be consumed by a unit to meet the last increment of load for the next month. The dispatch fuel price is the estimated market price of the fuel which would have to be purchased in order to meet the last increment of load. The price is based on judgment after reviewing various periodical trade publications which print current market fuel prices and after reviewing the most recent fuel contracts which have been signed.

Major fuels of this company are coal and nuclear, with coal accounting for 80% of the generation. If spot-market coal purchases were required to meet the expected coal consumption for a unit in the 30-day period, then the price of this fuel is used for the dispatch fuel price. The dispatch fuel prices are updated on a monthly basis.

At present this company purchases spot-market fuel for one plant only. The remaining fuel requirements are provided totally by long-term contract fuel purchases. The spot-market purchases can vary from 0 to 20% for the total fuel purchases on this system. Long-term fuel procurement is maintained primarily by long-term fuel contracts of two time durations, approximately 5 years and approximately 20 years. Contracts of both durations are based on formulas which consider escalation indices and labor factors. This company also maintains some short-term, 6-month fuel contracts which are fixed price. Future fuel purchases are based on a production costing computer program which is used to project the fuel requirements several years into the future.

Due to environmental restrictions, this company has almost no freedom to divert fuel shipments from one generating plant to another.

Company E

The fuel department of this compnay has the responsibility for evaluating the dispatch fuel price. Coal is the major fuel for this company, and for coal the dispatch fuel price for a generating unit is the higher of the two following prices:

a. The weighted-average cost of actual fuel burned by the unit during the previous month

b. The weighted-average cost of all fuel purchased for that unit during the previous month

The dispatch fuel prices are updated monthly about the middle of the month and are then used for a nominal 30-day period. Therefore, there is a 15-day lag between the time the dispatch fuel prices are determined and the time they are put into use.

The fuel consumed by this company is coal, nuclear, and small amounts of oil and natural gas, with coal accounting for approximately 75% of the total fuel consumption. This company maintains approximately 70% of the fuel purchases through long-term fuel contracts which are formula-priced, with the remaining fuel requirement being met by fixed-price, spot-market fuel purchases. Future fuel requirements are forecasted using a production cost computer model to project consumption several years into the future.

The fuel department has some limited ability to divert fuel shipments from one generating plant site to another.

Company F

The operating department of this company evaluates the dispatch fuel price to use for natural-gas-fired units based upon information provided by the fuel department. A subsidiary of this company has the responsibility for all oil procurement and evaluates the dispatch fuel price for the oil-fired generating units. This company utilizes natural gas and oil as the main fuels.

The dispatch fuel price for oil-fired units is a replacement price and is the price of the next barrel of oil which would have to be purchased in order to meet the next increment of load. The dispatch fuel price for oil is updated as often as there is a significant change in the market price. Oil procurement requirements are maintained by approximately 65% long-term contract with the remainder being spot-market purchases. The dispatch fuel price is updated when significant price changes occur. The dispatch price may be updated daily on some units due to the supply availability, while the prices for other units may be updated monthly. Approximately 60% of the total natural gas requirements are met by long-term contracts with the remainder being met by spot-market fuel purchases.

Company G

This company is a smaller utility and does not presently employ an economic dispatch routine for dispatching generation, and therefore does not need a dispatch fuel price.

Company H

The fuel department evaluates dispatch fuel price for this company. The dispatch fuel price used by this utility is a projected weighted-average replacement price based on the projected unit fuel consumption and the most recent fuel prices known.

The most recent fuel prices are evaluated by analyzing current long-term contract fuel prices and the most recent spot-market fuel purchase prices. The fuel consumption for a given unit is projected for the upcoming month and then the requirements are matched to the existing long-term contract fuels spot-market fuels purchases. Then weighted-average fuel prices are established for each unit based on the most recent fuel prices available and projected supply of fuel.

The fuel consumption of this company is approximately 67% oil and 33% coal, although nuclear units that are currently in the process of being brought on-line will alter the present mix of generation.

Oil is this company's dominant fuel and is procured entirely through long-term fuel contracts at present. The dispatch fuel price utilized for oil-fired plants is evaluated by the method presented previously and is updated monthly.

Roughly half of the coal is procured by means of long-term contracts, with the remainder procured through spot-market fuel purchases. Of the generating stations utilizing coal, approximately 80% of these burn only long-term contract coal and the remaining stations use predominantly spot-market coal. The dispatch fuel price of coal-fired units is also evaluated using the same method as that used for oil. For units burning long-term contract coal only, the dispatch fuel price is updated approximately once every 3 months. For units consuming spot-market coal fuel purchases, the dispatch price is revised as the market prices swing. Future fuel consumption requirements (based on judgment) are estimated by the fuel department using past experience and projections of future supply availabilities and generation construction.

This company has some ability to divert fuel shipments from plant to plant.

Company I

The fuel department of this company evaluates the dispatch fuel prices for units consuming oil, nuclear, and natural gas. The dispatch fuel price for this company's coal-fired units is obtained from a subsidiary, which has the responsibility for all coal procurement.

The dispatch fuel price for oil-fired units is the weighted-average replacement price for a unit. The price is based on the projected fuel consumption for the upcoming month and on the most recent market cost of oil. The prices used are the market prices available on the day the dispatch prices are delivered to the operating department for use in the economic dispatch. Fuel consumption for each unit is projected for the next 1-month period, and then existing long-term contract fuel and spot-market fuel purchases are matched to the projected fuel requirements. Then based on the most recent long-term contract fuel prices and spot-market fuel prices available, a weighted-average dispatch fuel price is evaluated for each unit.

Oil is the primary fuel consumed on this company's system, accounting for approximately 60% of overall fuel consumption. Oil tankers carrying an approximate 4- to 5-day supply arrive at the rate of about two a week. This company's oil supply is based on about 95% long-term contract fuel and the remainder is spot-market fuel purchases. The dispatch price for oil is updated approximately twice a month depending on oil shipment arrivals.

Coal, natural gas, and nuclear are utilized to meet the remaining system fuel requirements. The dispatch fuel prices used for nuclear units are based on the current fuel cycle cost and are updated only once a year. The dispatch fuel prices used for coal-fired units are a best market estimate replacement cost obtained from a subsidiary, and are updated once a month.

The subsidiary responsible for coal procurement provides the fuel department with dispatch prices to use for coal-fired units. The dispatch price supplied for the coal-fired units is a best market estimate replacement cost for the coal to be purchased for the next month. If a unit has more than one supplier of fuel or if spot-market purchases are required, then a weighted-average dispatch price is calculated in the same manner as was presented for oil.

Fuel procurement for stations consuming coal are based on 95% long-term contract fuel and 5% spot-market purchases. The long-term contracts for coal are in the 10- to 20-year range and are formula priced.

The fuel department uses a program to project requirements up to 20 years into the future. The fuel forecast is updated approximately once every 3 months in order to reflect the changes in fuel prices and projected requirements.

This company has a large amount of flexibility in diverting fuel shipments from plant to plant.

Company J

The systems operations department of this company evaluates the dispatch fuel prices based on information received from the fuels section of the purchasing department and from the civil and mechanical test sections. The values are updated monthly.

Coal is the major fuel accounting for approximately 75% of all fuel. Nuclear and oil account for approximately 20% and 5%, respectively. Roughly 90% of the coal is obtained by means of long-term contracts, with the remaining 10% being secured by spot-market purchases. All of the oil is purchased on the spot market.

This company uses a weighted-average replacement cost for the dispatch fuel price. Projected system MWh for the upcoming month are used to project MWh production and MBtu requirements for each plant section whose units share a common fuel supply. The total MBtu per plant section is divided into the quantity which the contract fuel will supply and quantities which must be supplied by means of spot-market purchases. The quantities are priced at the anticipated fuel prices for the upcoming month. A weighted-average price of the contract and spot-market fuels is then made and used as the dispatch fuel price for the plant section.

The long-term fuel contracts are formula-based, and the spot-market fuel purchases of this company are fixed-priced.

At half the plants, blending of different fuels is possible. Transshipments are possible, and the cost is calculated accordingly.

Company K

The dispatch fuel prices are evaluated by the fuels division of the electric production department of this company on a monthly basis.

Oil is the major fuel used by this company, accounting for nearly half of all fuel. Nuclear and coal share about equally in meeting the remaining fuel requirements. A small amount of electric energy is purchased from neighboring utilities. Nuclear fuel for this company, like the other companies, is obtained entirely by contract. Approximately 80% of the oil and coal is obtained by means of long-term contracts with the remainder being secured by fixed-price, spot-market purchases.

The long-term contracts are based on a formula which includes a fixed price plus escalation factors for inflation, labor, governmental requirements, etc.

The procedure for evaluating the dispatch fuel price approximates the weighted-average cost of fuel to be consumed during the upcoming month. A system energy forecast for the month is made. Estimates of the quantities of the different fuel types are made, based on cost and availability. These requirements are matched to contract and spot-market supplies. Economic loading studies are performed which more closely define the required quantities of the different fuels and give a better estimate of the weighted-average fuel prices. For coal the last purchase prices are used as the prices for the upcoming month's coal, based on the reasoning that shipments lag purchases such that the coal which will be burned during the upcoming month will have been purchased during the present month. This company uses the procedure for coal, known prices of nuclear fuel, and estimates of oil prices to approximate a replacement price of fuel for the generating units.

There exists a high degree of flexibility in reassigning fuel shipments among the plants for this company.

Company L

The operations department of this company evaluates the dispatch fuel prices using data supplied by the fuels department. The prices are updated monthly, or more frequently if there are large changes in the price of fuel.

The major fuel is coal, and other fuels include nuclear, oil, and natural gas. Usually long-term contracts account for about 80% of the requirements for coal. However, at the time of this survey the long-term contracts account for nearly all of the coal procurement. The long-term contracts are formula-type contracts.

By tracking a 2-month history, fuel requirements and prices are projected two months into the future. Prices are projected on the basis of quotes, contract specifications, and market conditions in order to get an estimate of the projected weighted-average replacement price of fuel for each unit.

In addition to its use for economic dispatch, the dispatch fuel price is also used for internal billing, intercompany billing, and interchange evaluation.

Coal which is shipped by rail may be diverted easily to balance the requirements of the various plants. Much higher transportation cost usually precludes the diversion of fuel from plants which are supplied by boat to plants which are supplied by rail.

Section 3

MATHEMATICAL ANALYSIS

INTRODUCTION

In the development of the equal-incremental cost (equal-lambda) economic dispatch, the evolution of which was reviewed by H. H. Happ (1), the analysis is carried out for the minimization of fuel cost rate in supplying an instantaneous system load. The equal-lambda criterion, which results in the minimization of the cost rate ($/h) in supplying the system load at the particular instant, is a direct function of the price of fuel at each generating unit. The price of fuel at each unit is tacitly assumed to be a known quantity; however, in the usual case the fuel that a generating unit will consume during a given time period (say the next 30 days) may possibly come from several different sources, each having different pricing schemes.

The problem considered in this section is that of minimizing the total system fuel cost ($) which will be incurred over a period of time, when there are a number of different prices of fuel at each generating unit and the quantity of fuel that is consumed by the unit is dependent on the dispatch fuel price which is used for the generating unit.

In this section, a mathematical analysis is presented that leads to a strategy for minimizing the total system fuel cost over a period of time for the situation in which each generating unit may have multiple sources of fuel. These different potential fuel supplies may have different prices and fuel consumption constraints. Thus, the analysis presented in this section differs from the classical analysis in two ways:

1. The minimization is taken over a period of time rather than a minimization at a given instant.
2. The effect of the different supplies of fuel with their different prices and constraints is considered.

MINIMIZATION OF THE SYSTEM FUEL COST

In power system operation one seeks to determine the loading on a given set of on-line generating units such that the total fuel cost over an operating period is minimized. At each instant the generating units must supply a given system load plus the attendant transmission system losses and must operate within their rated maximum and minimum power level limits.

Problem Formulation

Phrased mathematically, the problem is to minimize the sum of the fuel costs of each generating unit over the optimization period ($0 < t \leq T$).

$$COST = \sum_{i=1}^{N} C_i \qquad (3\text{-}1)$$

subject to the constraints

$$\sum_{i=1}^{N} P_i = P_D + P_L \qquad (3\text{-}2)$$

and

$$P_{min\ i} \leq P_i \leq P_{max\ i} \qquad (3\text{-}3)$$

where

- $COST$ = total system fuel cost for the optimization period in dollars
- C_i = cost of fuel for unit i over the optimization period in dollars
- P_i = power generation of unit i in MW
- P_D = load power demand in MW
- P_L = transmission loss in MW
- $P_{max\ i}$ = maximum power generation limit of unit i in MW
- $P_{min\ i}$ = minimum power generation limit of unit i in MW
- N = number of generating units

The Fuels

The fuel cost for unit i is made up of two components, the cost of its base fuel and the cost of its auxiliary fuel as follows:

$$C_i = Q_{Bi}F_{Bi} + Q_{Ai}F_{Ai} \tag{3-4}$$

where

Q_{Bi} = the quantity of base fuel for unit i in MBtu. The first fuel to be used would normally be long-term contract fuel. This base fuel can consist of any number of different fuels at different prices; however, this fuel must be consumed before the auxiliary fuel is used.

Q_{Ai} = the quantity of auxiliary fuel for unit i in MBtu. This is last block of fuel to be used in the optimization period. The term last indicates that the fuel consumed prior to the use of auxiliary fuel was used because of must-take constraints, a lower price than the auxiliary fuel, or some other reason.

F_{Bi} = the price of the base fuel for unit i in \$/MBtu.

F_{Ai} = the price of the auxiliary fuel for unit i in \$/MBtu.

In Eq. 3-4, in order to simplify the presentation only one price for one quantity of base fuel is given. Any number of increments of base fuel at their respective prices could be used with no change in the result.

Fuel Consumption and Cost

A generating unit's auxiliary fuel consumption is the difference between its total fuel consumption and the base fuel consumption, i.e.,

$$Q_{Ai} = \int_0^T h_i(P_i)dt - Q_{Bi} \tag{3-5}$$

where

$h_i(P_i)$ = the input-output (heat rate) relation for unit i in MBtu/h.
T = the optimization period.

Substituting Eq. 3-5 into Eq. 3-4 yields

$$C_i = Q_{Bi}F_{Bi} + \left(\int_0^T h_i(P_i)dt - Q_{Bi}\right)F_{Ai} \tag{3-6}$$

and rearranging and substituting Eq. 3-6 into Eq. 3-1 yields

$$\text{COST} = \sum_{i=1}^{N} (F_{Bi} - F_{Ai})Q_{Bi} + \int_{0}^{T} \sum_{i=1}^{N} F_{Ai}\, h_i(P_i)dt \quad . \tag{3-7}$$

In practice, the actual cost function may be more complex than in this simplified situation. In particular, when a generating system has access to a fuel source (typically gas) that is available to the system at a single price and that can be shifted from one unit (or plant) to another, the incremental fuel price at a given unit may depend on the allocations of all fuels across all units. This makes the overall system cost much more complicated to evaluate or optimize. Section 6 of this report discusses this effect in some detail. See also (3).

Minimizing the Cost Expression

Since the first term of Eq. 3-7 is a constant quantity, the total system fuel cost is minimized by minimizing the second term. The second term is minimized by minimizing the integrand at each instant of time as is shown in the following analysis. The h_i values are always positive. Even though the power demand is changing with time and, therefore, the generating unit powers are changing with time, the assumption that the generating units are operating essentially in steady state renders the values of P_i and h_i at any one time independent of other times. Therefore, since the value of the integrand at a given time depends only on the values of the generating unit powers at that time, the minimization of the integral over the optimization period by means of minimizing the integrand at each instant of time results in the minimum system fuel cost.

Therefore the problem becomes the ordinary optimization problem of minimizing

$$R = \sum_{i=1}^{N} F_{Ai} h_i(P_i) \tag{3-8}$$

subject to the constraint relations of Eqs. 3-2 and 3-3 where

R = the cost rate in \$/h .

Following the method of Lagrange, the constraint of Eq. 3-2 is adjoined to Eq. 3-8 by means of the Lagrange multiplier, λ. The inequality constraints of Eq. 3-3 may also be adjoined to Eq. 3-8 by means of the Kuhn-Tucker theorem with the result that the generator power levels which lie outside the power limits are to be set at the nearest power limit (2). Thus the augmented cost function becomes

$$R^{*} = \sum_{i=1}^{N} F_{Ai}h_i(P_i) + \lambda(-\sum_{i=1}^{N} P_i + P_D + P_L) \tag{3-9}$$

and the minimization is achieved by setting each partial derivative, shown in the following equation, to zero:

$$\frac{\partial R^{*}}{\partial P_i} = F_{Ai}\,\frac{\partial h_i(P_i)}{\partial P_i} + \lambda(-1 + \frac{\partial P_L}{\partial P_i}) \quad . \tag{3-10}$$

Setting Eq. 3-10 equal to zero yields

$$\lambda = \frac{F_{Ai}\,\dfrac{\lambda h_i(P_i)}{\partial P_i}}{1 - \dfrac{\partial P_L}{\partial P_i}} \quad , \tag{3-11}$$

which is recognized as the familiar equal-lambda criterion, but with the price of the last increment of fuel being used for the dispatch fuel price. This price is usually called the incremental fuel price. Thus, the use of incremental fuel prices in an equal-lambda dispatch is shown to minimize the total system fuel cost over the optimization period.

SUMMARY

In this section it has been proven mathematically that the minimum total system fuel cost incurred during an operating period is achieved when the price of the last increment of fuel to be consumed in the period by each generating unit is used as the dispatch fuel price for that unit. This is commonly called the incremental fuel price. In Sections 4 and 5 this result is verified and the sensitivity of the production cost to deviations from the optimal dispatch price is evaluated.

Since one is dealing with minimizing the fuel cost over a future time period, even though he knows that the incremental price should be used, he may have difficulty in evaluating the incremental fuel price values for each generating unit. The problem of obtaining these incremental fuel price values is dealt with in Section 6.

REFERENCES

1. H. H. Happ. "Optimal Power Dispatch - A Comprehensive Survey." IEEE Transactions on Power Apparatus and Systems, Vol. PAS-96, No. 3, May/June 1977, pp. 841-854.

2. M. E. El-Hawary and G. S. Christensen. "Optimal Economic Operation of Electric Power Systems." Academic Press, N.Y., 1979, pp. 77-79.

3. F. J. Trefny and K. Y. Lee. "Economic Fuel Dispatch." IEEE Transactions on Power Apparatus and Systems, Vol. PAS-100, No. 7, July 1981, pp. 3468-3477.

Section 4

THE TWO-UNIT SYSTEM

The purposes of the dispatch simulations are to verify the results of the mathematical analysis and to calculate the sensitivities of the fuel consumption and fuel cost to variations of the economic dispatch prices from the optimum values. This section describes the simulation of an idealized two-unit system. Section 5 discusses the simulation of a larger and more realistic system.

When only two units are involved, the relation between the economic dispatch prices of the two units is clearly seen and the sensitivity of the system economics to the deviations in the dispatch prices may be clearly related. Findings from the two-unit system are used to guide the simulations of the large system.

SYSTEM LOAD

For many of the simulations a load-duration curve representing a 30-day period is used. This curve is shown in Figure 4-1. The maximum load is 530 MW and the minimum load is 220 MW. The shape of the curve is representative of the load on many actual power systems. The level of load and the ratings of the two generating units are chosen to be consistent.

GENERATING UNITS

The first round of simulations used generating units with identical heat rates modeled as

$$h_i = 192 + 7.75\, P_i + .00246\, P_i^2 \qquad (4\text{-}1)$$

where

h_i = the heat rate for unit i (i=1,2) in MBtu/h
P_i = the net generated power of unit i in MW

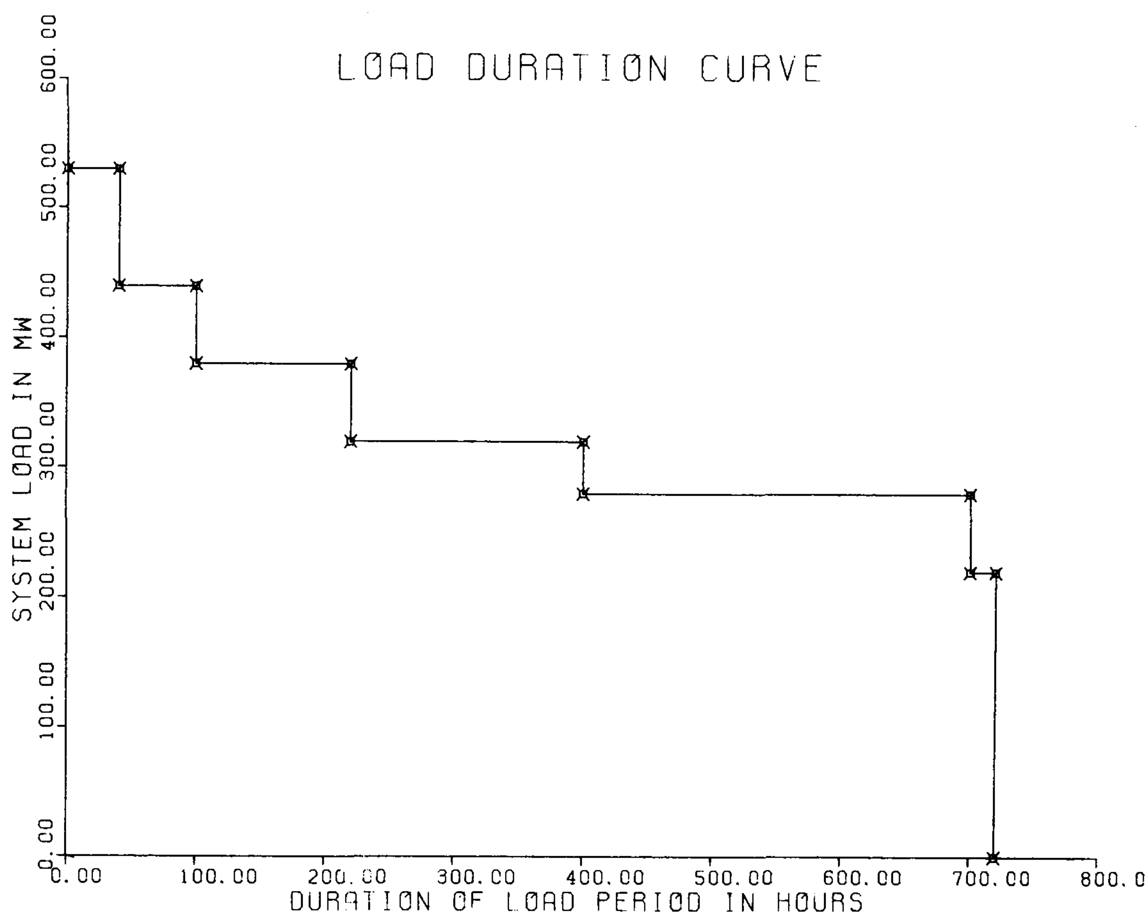


Figure 4-1. Load-Duration Curve for the 30-Day Period

The operating limits of the generating units are 270 MW maximum power and 100 MW minimum power. In other simulations the heat rate equation of one of the units was changed in order to evaluate the effect of dissimilar units.

ECONOMIC DISPATCH

A program was written that sets the generating unit power in accordance with the equal-lambda criterion and observes the maximum and minimum power limits of the generating units. The program also evaluates the production cost and other measures needed for comparisons.

PRODUCTION COST

The fuel consumed by the units during the optimization period was of two classes as follows:

Q_{Bi} = the base fuel of unit i which is a limited quantity, minimum take (also known as pay-or-take) in MBtu. This corresponds to long-term contract fuel supplies.

Q_{Ai} = the auxiliary fuel for unit i. This is fuel needed in excess of Q_{Bi} in the present time period of 30 days. There are no restrictions on the amount of this fuel that may be used. This corresponds to spot-market fuel.

The price of the fuel is represented as follows:

F_{Bi} = the price of the base fuel for unit i in \$/MBtu

F_{Ai} = the price of the auxiliary fuel for unit i in \$/MBtu

Using the heat rate equations of the units, Eq. 4-1, the total quantity of fuel consumed by each unit in meeting the system load shown in Figure 4-1 is evaluated. The costs of the base fuel and the auxiliary fuel are calculated using their respective consumption and fuel prices. The total system cost, average system cost, and other cost measures are calculated.

RESULTS OF THE SIMULATIONS

The curves of Figure 4-2 illustrate the variation of the total cost of all fuel consumed during the nominal 30-day period with the dispatch fuel price of Unit 2. The dispatch fuel price for Unit 1 is set at \$1.00/MBtu, which is the only price of fuel associated with this unit. Thus, the dispatch fuel price of Unit 2 is also the ratio of dispatch fuel price of Unit 2 to that of Unit 1. The ratio of the dispatch fuel prices of the two units determines the division of generated power between the two units, as is seen from Eq. 3-11.

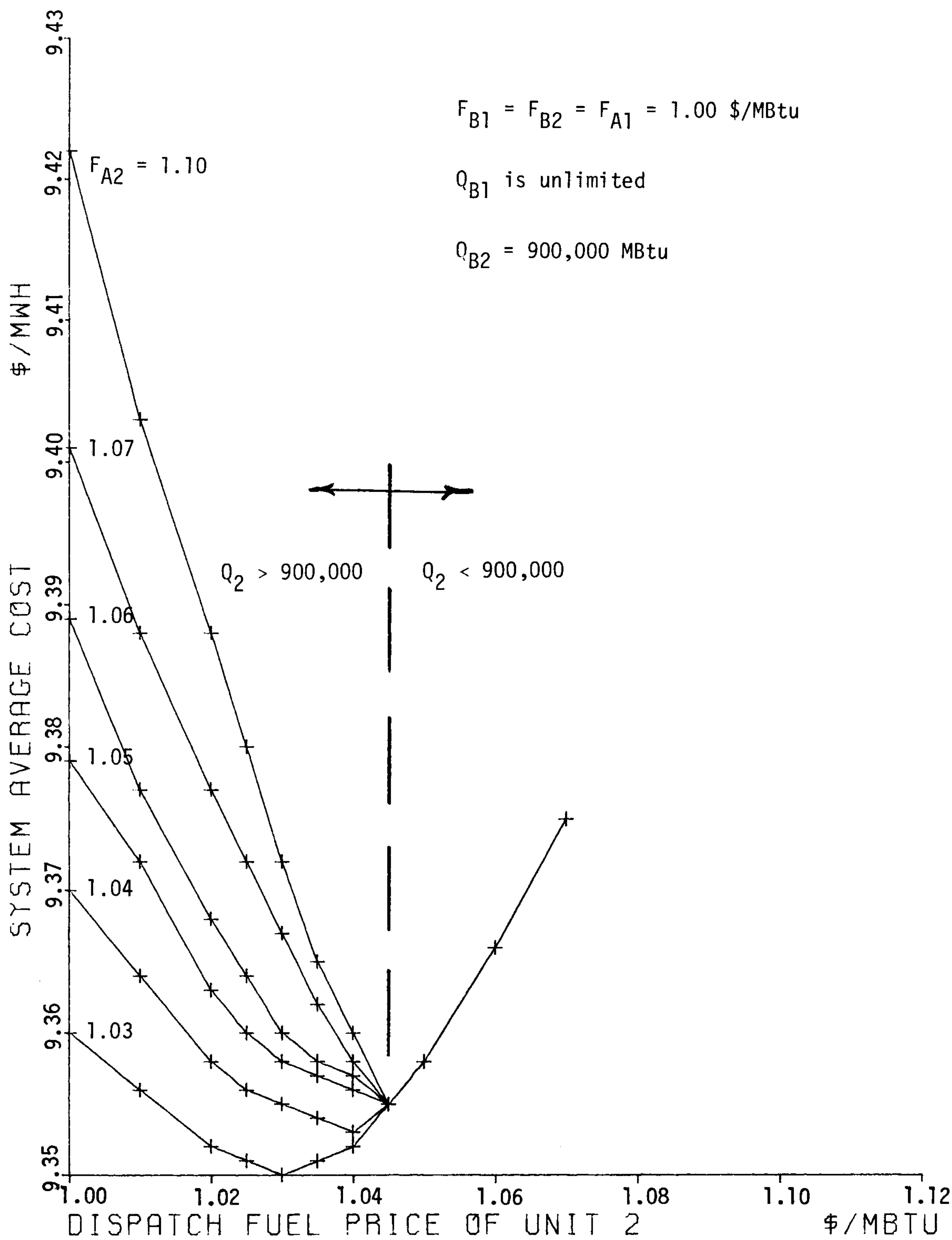


Figure 4-2. System Fuel Cost vs. Dispatch Price

For Unit 1 an unlimited supply of fuel at a price of 1.00 $/MBtu is specified. For Unit 2 the base fuel quantity is limited to 900,000 MBtu and has a price of 1.00 $/MBtu. A number of different prices for the auxiliary fuel price are assumed. A family of system average production cost curves corresponding to the auxiliary fuel price of 1.03, 1.04, 1.06, 1.07, and 1.10 $/MBtu are given in Figure 4-2.

The curves give the system average cost for fuel over the 30-day period when the system is dispatched the entire 30-day period using 1.00$/MBtu for the dispatch price for Unit 1 and repeating the dispatch using different values of dispatch price for Unit 2 varying from 1.00 to 1.15 $/MBtu.

At a dispatch fuel price for Unit 2 of 1.045 $/MBtu, the total fuel consumption of Unit 2 is the 900,000 MBtu. At dispatch fuel prices less than 1.045 $/MBtu, the fuel consumption is in excess of the 900,000 MBtu, and for dispatch fuel prices greater than 1.045, the consumption is less than 900,000 MBtu.

The results shown in Figure 4-2 verify the mathematical analysis of Section 3. Note that when the auxiliary fuel price of Unit 2 is 1.03 $/MBtu the system cost is minimized when Unit 2 is dispatched at a price of 1.03 $/MBtu. Likewise, when the auxiliary fuel price of Unit 2 is 1.04 the system cost is minimized when Unit 2 is dispatched at a price of 1.04. Thus, the system fuel cost is minimized when the fuel prices are set equal to their respective auxiliary fuel prices (i.e., their incremental fuel prices). However, when the dispatch price of Unit 2 exceeds 1.045 $/MBtu, the fuel consumption of Unit 2 falls below its base fuel quantity of 900,000 MBtu and no auxiliary fuel is consumed.

From the foregoing it is seen that using dispatch fuel prices corresponding to the auxiliary fuel prices of 1.05 $/MBtu and higher will result in no usage of auxiliary fuel, and the minimum system cost does not occur when these values are used as the dispatch fuel price. Also note that if Unit 2's base fuel price (1.00 $/MBtu) is used as the dispatch fuel price, Unit 2 consumes auxiliary fuel and the system cost is not minimized. The minimum system cost under this condition occurs when the dispatch fuel price is set to the limit such that all of the base fuel is consumed (1.045 $/MBtu, in this case). This is consistent with the mathematical analysis of Section 3.

Figure 4-3 illustrates the effect of using the previous month's weighted-average fuel cost of the units for the next month's dispatch fuel price. For the first

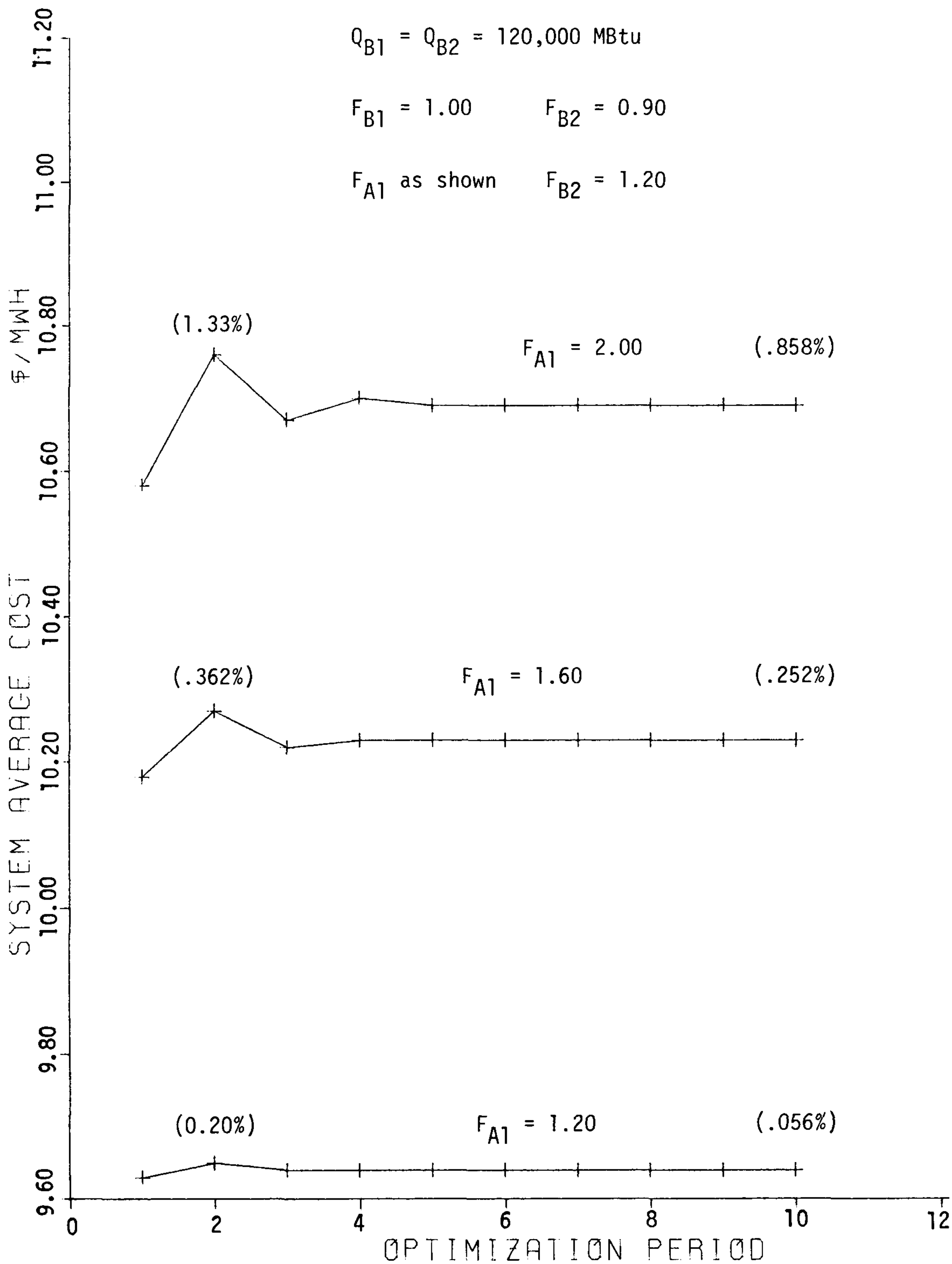


Figure 4-3. Use of the Weighted-Average Price of Fuel for the Dispatch Price

period the units' auxiliary fuel prices (incremental fuel prices) are used. For the next identical load period, the units' weighted-average fuel prices that resulted from the first period are used for the dispatch fuel prices. The system average cost and the units' weighted-average cost oscillate for several periods before settling down to a system average cost which is higher than that resulting from using the incremental fuel prices. The values in the parentheses give the percentages by which the system cost is increased over that resulting from the dispatch using the incremental fuel prices.

Curves for three different values of auxiliary fuel price for Unit 1 (1.20,1.60, and 2.00 $/MBtu) are shown in Figure 4-3. In all cases the quantity of base fuel for each of the two units is 120,000 MBtu; the base prices of fuel for Units 1 and 2 are 1.00 $/MBtu and 0.90 $/MBtu, respectively; and the auxiliary fuel price for Unit 2 is 1.20 $/MBtu.

SENSITIVITIES

The sensitivity of the overall system cost to deviations in the dispatch fuel prices from their optimal values depends on the relative quantities of base fuels and the auxiliary fuels, the difference in fuel prices between generating units, the relative prices of auxiliary fuel to base fuel for a given unit, and the presence of loading constraints that place units on their maximum limits or minimum limits a large portion of the time irrespective of the dispatch fuel price. In a case where the auxiliary fuel is approximately 25% of the total, fuel on one unit is 1.00 $/MBtu for all its fuel and fuel for the other unit is .90 $/MBtu for the base fuel and 2.20 $/MBtu for auxiliary fuel, the increase in system cost was 0.3% for a 10% deviation in dispatch fuel price, a 1.1% increase in system cost for a 20% deviation in dispatch fuel price and increasing sensitivities as the deviation in dispatch fuel prices increased even further. Sensitivities 10 times that given here were also encountered in other cases.

Section 5

THE LARGE SYSTEM

This section deals with the simulation of the economic dispatch of a large system and the evaluation of the resulting production cost and fuel accounting. The program used in the simulation is adapted from the Unit Commitment and Production Costing Program which was developed by the author and Boeing Computer Services Company in another phase of this project.

The sensitivity of the production cost due to the deviation of the dispatch fuel prices from their optimum values is affected by several other system parameters:

- The quantity of base fuel allocated for the optimization period relative to the auxiliary fuel on a total system basis
- The relative price of auxiliary fuel and base fuel as an average for the total system
- The relative price of auxiliary fuel and base fuel at each generating unit

For this analysis the production cost is always evaluated for an optimization period which is taken as 30 days. Other time periods could be used but the industry survey reveals that most electric power utilities use a 1-month period for updating their dispatch fuel prices. One should use the longest period for which reliable data are available. Customary forecasting uncertainties make it difficult to follow exactly a plan that carries far into the future, but looking farther into the future provides some insight in the execution of the plan.

SUMMARY

Simulations of the economic dispatch and evaluation of the production cost verify the mathematical results of Section 3, namely, that dispatching according to the price of the most costly fuel burned results in a minimum-cost allocation of generation. The simulations were used to evaluate the sensitivity of the system fuel cost to errors in the economic dispatch. Fuel cost increases of .5% to 1% over the minimum cost due to the use of the weighted-average fuel prices for dispatch are typical for nominal system fuel conditions. Sensitivities of the fuel cost due to random errors in the dispatch fuel prices were also evaluated with fuel cost increasing by up to 3% under nominal conditions.

SYSTEM LOAD

The system load is represented by the load duration curve shown in Figure 5-1. A 30-day period with seven different load levels ranging from a maximum of 15000 MW down to a minimum of 8500 MW is used.

GENERATING COMPLEMENT

The system has generating capacity of several different types, as shown in Table 5-1. Twenty-one tie lines provide for interchange capability.

Table 5-1

TOTAL GENERATING COMPLEMENT

TYPE OF UNITS	NUMBER OF UNITS	TOTAL CAPACITY OF EACH TYPE
Steam Units	79	15363 MW
Nuclear Units	1	760 MW
Hydro Units	17	1898 MW
Pumped Hydro Units	7	840 MW
Comb. Turbine Units	23	1410 MW
Total Generating Capacity		20271 MW

The steam units and the nuclear unit are considered as dispatchable units; the others are treated as nondispatchable units. These nondispatchable units are manually scheduled for a fixed load during a fixed period. Each unit has maximum and minimum power limits on generation.

The following schedules for generation are used in all of the simulations.

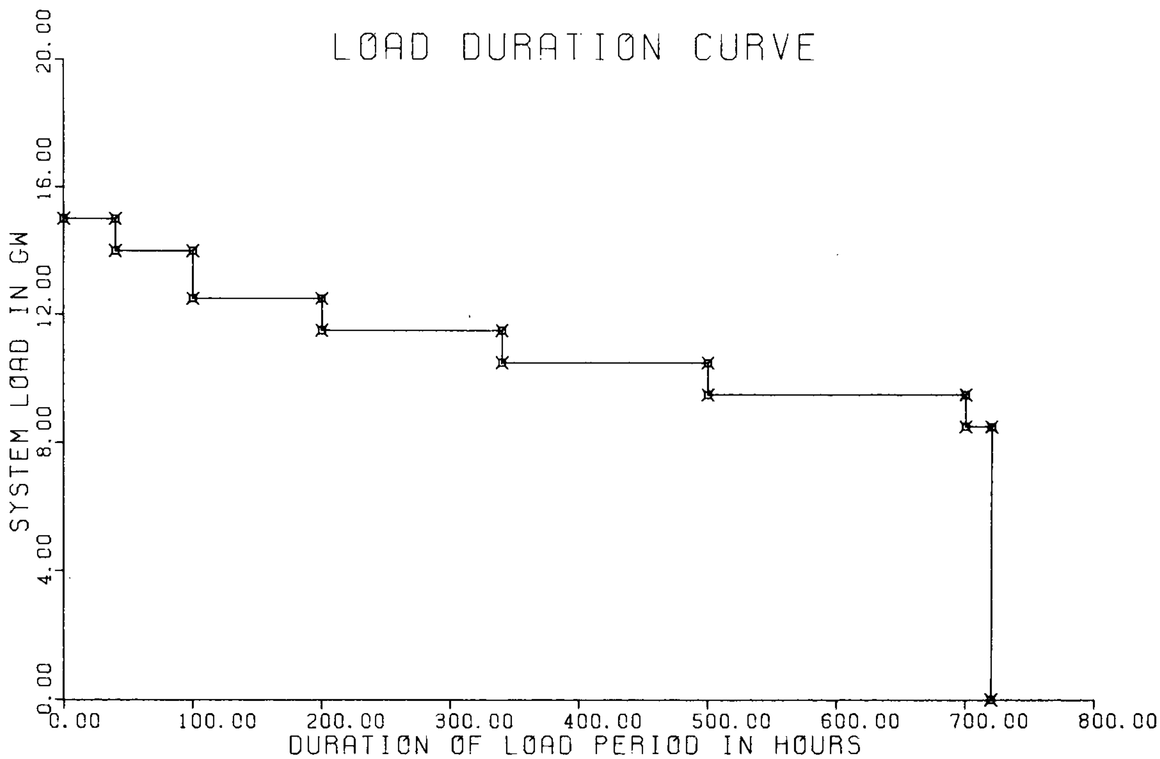


Figure 5-1. Load-Duration Curve for the 30-Day Period

- The steam units numbers 14, 24, and 27 are scheduled to be off-line in all periods, which means that these units produce zero generation.

- Steam units numbers 19 and 49 are scheduled to be on-line at fixed generation of 42 MW and 20 MW, respectively, for all levels of load.

- Hydro units numbers 104, 107, 108, and 109 are scheduled on-line with fixed generation levels of 80 MW, 600 MW, 250 MW, and 140 MW, respectively, during the highest load interval. During the next highest load interval, units 104, 107, and 109 are scheduled on-line at their previous generation levels. This scheduling simulates the use of hydro for peaking generation and is not scheduled after these intervals. Therefore, the total hydro generation is 1070 MW in the first interval, 820 MW in the second interval, and zero thereafter.

The total generating capacity scheduled on-line for each interval is given in Table 5-2.

Table 5-2

GENERATION CAPACITY FOR EACH LOAD INTERVAL

LOAD INTERVAL	GENERATING CAPACITY					TOTAL MAXIMUM CAPACITY
	THERMAL STEAM (MW)	NUCLEAR (MW)	HYDRO (MW)	PUMPED HYDRO (MW)	COMBUSTION TURBINE (MW)	
1	14941.50	760	1070	0	0	16771.50
2	14941.50	760	820	0	0	16521.50
3	14941.50	760	0	0	0	15701.50
4	14941.50	760	0	0	0	15701.50
5	14941.50	760	0	0	0	15701.50
6	14941.50	760	0	0	0	15701.50
7	14941.50	760	0	0	0	15701.50

These schedules are used in each of the simulations.

DATA USED IN THE SIMULATIONS

The simulation program requires a number of data sets. These data sets are described in the discussion which follows, and complete listings of the data are given in the appendices.

Generating Unit Name Data

These data are given in Appendix A. They show the unique name for each unit of different types, the station number where the unit is located, the entry point number through which the unit injects power into the transmission system, the type of fuel used by each unit, and the maximum and minimum generation limits of each unit. In addition, priority numbers for each unit and tie line are listed.

Generating Unit Performance Data

These data are given in Appendix B. They provide generating unit performance characteristics data, which are the constant, linear, and quadratic coefficients of the heat rate expression of each unit, given by

$$h_i = HA + HB*P_i + HC*P_i^2 \tag{5-1}$$

where

h_i = the heat rate of unit i, in MBtu/h.

P_i = the net power generated by unit i, in MW.

Other values shown in this type of data are not used in this program.

Generating Unit Fuel Data

These data are shown in Appendix C. The values of fuel prices of each unit (base price, auxiliary fuel price, and the dispatch fuel price) are included in this data set. Also the quantity of base fuel allotted to each unit is entered.

Tie Line Data

These data are shown in Appendix D. They are required when the user desires to schedule any interchange or if the program finds it necessary to schedule interchange to meet a peak load. Data concerning interchange tie lines are provided in this data. In the present analysis, interchange is not scheduled.

Manual Schedule Data

These data are shown in Appendix E. They are provided for each unit and each period for which one wishes to schedule that unit. These data show the unit identification number, the first and last interval of manual scheduling, the status of the unit to be scheduled, and the scheduled power level of the unit.

B-Constant Data

These data are given in Appendices F and G, respectively. These data provide B-coefficients for calculating the transmission losses and the incremental transmission losses. The equation for line losses is given by

$$PLOSS = XKLO + \sum_{N=1}^{NEP} B_{NO} P_N + \sum_{N=1}^{NEP} \sum_{J=1}^{NEP} P_N (B_{NJ}/100) P_J \quad (5\text{-}2)$$

where

PLOSS = total transmission loss in MW

XKLO = transmission loss equation constant in MW

P_N, P_J = total power injected at entry points N and J in MW

NEP = number of entry points in the system

B_{NO} and B_{NJ} = coefficients (in per unit on a 100 MVA base)

PRODUCTION COST AND FUEL ACCOUNTING

The program evaluates the production (fuel) costs, fuel usage, and other economic values needed for comparisons and for further use by the program, etc. The fuel consumed by each unit during the 30-day period is of two kinds:

Q_{Bi} = the base fuel of unit i, which is a limited or fixed quantity of fuel allotted for the nominal 30-day period. This corresponds to long-term contract fuel. This fuel is considered to be consumed before any auxiliary fuel would be used.

Q_{Ai} = the quantity of auxiliary fuel of unit i. This fuel is used only after all of the base fuel is consumed by the particular unit. There is no restriciton on the quantity of this fuel which would be used in the optimization period.

To meet the system load in each interval of the 30-day period, the unit power is set by the economic dispatch algorithm in accordance with the equal-lambda criterion while observing the minimum and maximum power limits of the generating units. Using the heat rate equation of the units, Eq. 5-1, the total fuel used by each unit in meeting the system load in each interval is evaluated for the 30-day period. The amount of auxiliary fuel used by a unit is then found by subtracting the base fuel allotment (given in the fuel data for the particular unit) from the unit's total fuel consumption. The costs of base fuel and the auxiliary fuel are calculated using their respective consumptions and fuel prices. The following two subsections explain the two alternate methods of assessing the resulting production costs.

Production Cost 1 (PC1)

This production cost is based on each unit's actual consumption of fuel during the 30-day period. Each unit in the system is allocated a certain base quantity of fuel for the 30-day period. In the base case (or reference case for economic comparisons) the allocation of base fuel is such that each unit consumes an amount of fuel which exceeds the base fuel allocation. In fact, for a specification of 80% base fuel for the system, each unit is allocated a base fuel equal to 80% of its total consumption. However, when the effect of errors in the dispatch fuel prices is being evaluated, the deviations in the dispatch fuel prices may result in some units failing to use all of their base fuel allocation. When a unit consumes more than the base fuel allocation, then auxiliary fuel is used as necessary in order to supply the total demand for fuel. Under this condition, the production cost for that unit is the sum of the cost of the base fuel and the cost of the auxiliary fuel. This is the normal case.

In the case in which a unit consumes less than its base fuel allocation, the assessment method of this section uses only the fuel which is consumed and the base fuel price.

This is summarized in the following equation for a unit's fuel cost:

$$P_{1i} = \begin{cases} Q_{Bi}F_{Bi} + (Q_i - Q_{Bi})F_{Ai} & \text{for } Q_i > Q_{Bi} \\ Q_iF_{Bi} & \text{for } Q_i \leq Q_{Bi} \end{cases} \qquad (5\text{-}3)$$

where

P_{1i} = the production cost for unit i for the month in \$
Q_i = total fuel usage for unit i during the month in MBtu
F_{Bi} = base fuel price in \$/MBtu
F_{Ai} = auxiliary fuel price in \$/MBtu

The total system production cost using this assessment of this cost (PC1) is the sum of the production costs for each unit.

Production Cost 2 (PC2)

This production cost is evaluated using the quantity of fuel purchased for each unit during the month. It is this concept of assessing the fuel cost that is used in the mathematical analysis of Section 3. As indicated earlier, the contract or base fuel is provided by the supplier on a long-term basis, and a fixed quantity per time period (e.g., per month and per year) is specified.

Normally PC2 and PC1 are the same since fuel in excess of the base fuel allocation is consumed. In practice this should always be the case provided good fuel management practices are used. However, in the simulations, where errors in the dispatch price are purposely introduced, there are cases in which a few units consume less than their base fuel allocation.

In the case in which the unit's consumption is less than the base fuel allocation, production cost 2 is calculated using the unit's total base fuel allocation even though not all of this fuel is consumed. The equation for calculating a unit's production cost using this assessment of the cost is

$$P_{2i} = \begin{cases} Q_{Bi}F_{Bi} + (Q_i - Q_{Bi})F_{Ai} & \text{for } Q_i > Q_{Bi} \\ Q_{Bi}F_{Bi} & \text{for } Q_i \leq Q_{Bi} \end{cases} \qquad (5\text{-}4)$$

where

P_{2i} = the production cost for unit i for the month in dollars.

The total system production cost is the sum of the production costs for each unit.

Total Load MWh Energy

The program evaluates the MWh load for each interval by multiplying the total power by the duration in hours for the interval. The total load energy for the month is calculated by adding the energy for all intervals.

System Average Cost

The system average cost is evaluated by dividing the production cost by the total load energy. There are two system average costs (one using production cost 1 and the other one using production cost 2).

Weighted-Average Fuel Costs

The program also evaluates the weighted-average of the base fuel cost and the auxiliary fuel cost for each unit in the system. This weighted-average price for each unit is used as the dispatch price during next month in a particular category of simulations discussed later.

Calculation of Auxiliary Fuel Consumed

The total auxiliary fuel consumed during the month is calculated as a percentage of the total system fuel consumption.

BASE CASES

The base cases are obtained using the auxiliary fuel price of each unit as the dispatch fuel price for that unit. The production cost of the base case is then used for comparing the production costs which are obtained when errors in the dispatch fuel prices are introduced.

Error in the dispatch fuel prices are introduced in two ways: through random variations and through the use of a weighted-average fuel price. This is explained more fully in a later portion of Section 5.

As stated earlier, the effect of the dispatch errors is dependent upon system parameters. Therefore, the relative system quantities and prices of base and auxiliary fuel are set at different values, and then the dispatch fuel prices are varied. The correlation of base and auxiliary fuel price values at each unit is also set at different values.

Correlation of the Generating Unit's Auxiliary and Base Fuel Prices

The relative values of the base and auxiliary fuel prices are in practice subject to a great deal of statistical variation when viewed across many units or utilities; there is no fixed ratio that relates the two. To account for this, the statistical relationship between base and auxiliary fuel prices is represented in the simulation model by having the auxiliary prices randomly generated in a way that obeys different observed or hypothesized linear correlations with the base price.

Figure 5-2 is a scatter diagram showing the auxiliary and base prices for several different units; these values are drawn from representative electric utility system data and exhibit a linear correlation of .24, which was the correlation used in the base-case simulations. Other simulations were done using correlations of .75 and .95.

Correlation of the Generating Unit's Auxiliary and Base Fuel Prices Used With the Random Variations in the Dispatch Prices

Several simulations were run with a fixed correlation factor of 0.24 between the generating unit's auxiliary and base fuel prices. Details of the setting of the other system parameters are discussed in following subsections. Table 5-3 summarizes the setting of parameters for the case of simulating random variations in the dispatch fuel prices. The first line of the table yields an example: Set the allocation of base fuel at 80% of the total consumption, set the system auxiliary

Table 5-3

SYSTEM PARAMETER VALUES

Base Case Values		
Percentage Allocation of Base Fuel/Auxiliary Fuel Quantity (System and each Unit)	Total System Auxiliary Fuel Price as X% Higher or Lower than the Total System Base Fuel Price	% rms Error (% Standard Deviation) of Dispatch Fuel Price
80/20	- 7	0 (Base case)
70/30	± 10	5
60/40	± 20	10
		15
50/50	± 30	20
	± 40	30
		40
		50

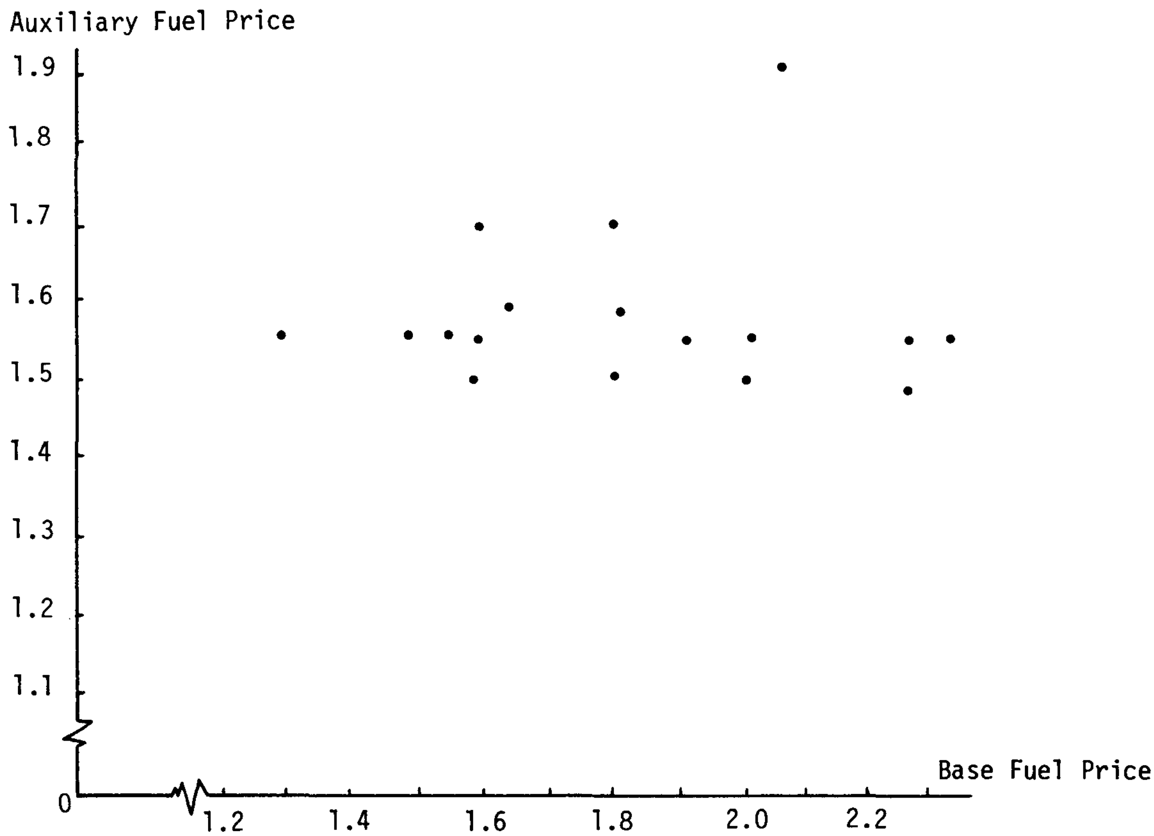


Figure 5-2. Scatter Diagram Relating the Units' Auxiliary and Base Fuel Prices

fuel price 7% lower than the base fuel price, and then dispatch the system using the auxiliary fuel price (zero error in the dispatch fuel price). This is the base case. Using these same parameter values the dispatch is repeated for rms errors of 5, 10, 15, 20, 30, 40, and 50 percent in the dispatch fuel price. Thus, there are 36 (4 allocations x 9 auxiliary fuel prices) different base cases in Table 5-3. A number of these same base cases are then repeated for the correlation factors of 0.75 and 0.95.

Correlation of the Generating Unit's Auxiliary and Base Fuel Prices When Using the Unit's Weighted-Average Price as the Dispatch Price

For the cases where a generating unit's weighted-average fuel price is used as its dispatch price, the correlation factor of 0.24 between the generating unit's auxiliary and base fuel prices was first used. Systemwide parameters of base fuel allocation and the relative prices of the system base fuel and the system auxiliary fuel were varied in a manner similar to that for the random variations in the dispatch fuel price. Later, a correlation factor of 0.95 between the unit's auxiliary and base fuel prices was also used.

LEVELS OF BASE FUEL ALLOCATION

Simulations were first performed using the auxiliary fuel price as the dispatch fuel price for all units. This simulation establishes the total fuel usage of each unit during the 30-day period. From this amount of total generating unit consumption the base fuel allocation of each unit is set at 80%, 70%, 60%, and 50% of the total fuel usage of that unit. Thus, the system total base fuel allocation is also the same percentage of the total system fuel consumption as was established for the individual units. Each of these simulations, at the different levels of base fuel but using the auxiliary fuel price for the dispatch fuel price, establishes a base case for economic comparison with the cases where the dispatch prices vary from the optimum values.

RELATION OF SYSTEMWIDE AUXILIARY AND BASE FUEL PRICES

As stated earlier, the relation between the auxiliary and base fuel prices <u>at the units</u> was established from representative data from an electric utility and then adjusted for other values of correlation.

By means of calculating the <u>system</u> weighted-average auxiliary fuel cost and the <u>system</u> weighted-average base fuel cost, the auxiliary fuel prices are all adjusted until a desired system auxiliary fuel price relative to the base price (e.g., a system auxiliary fuel price 10% greater than the system base fuel price) is achieved.

The original fuel data sets, for a 70% allocation of base fuel, resulted in a system auxiliary fuel price 7% lower than the base fuel price.

Additional fuel data sets are generated to represent cases in which the system auxiliary fuel price differs from the base fuel price by varying percentages. The eight cases considered had auxiliary prices equal to the base price plus (and minus) 10%, 20%, 30%, and 40%.

VARIATION IN THE DISPATCH FUEL PRICE

The main purpose of the simulation study is to assess the sensitivity of the production cost to variations of the dispatch fuel prices from their optimum values. These simulations used a statistical method to vary the dispatch prices of the units, and since some electric utilities are using the weighted-average fuel prices as dispatch fuel prices, the weighted-average fuel prices were also used. Both the above cases are considered separately in the next subsections.

Random Variation From the Optimum

It has been noted that if the dispatch prices are all varied by the same percentage from their optimum values, no change in the dispatch occurs. The optimum set of dispatch prices may be multiplied by any constant with no change in the resultant loading of the generating units. This is evident from an examination of Eq. 3-11.

In the simulations there are 80 dispatchable units each requiring a dispatch price. A random variation of the dispatch prices from their optimum values is modeled as follows. The method used specifies that the units' dispatch prices (F_{Di}) are to vary from their known optimal values (F_{Di}^{o}) such that the variable F_{Di}/F_{Di}^{o} has a normal distribution with the expected value of F_{Di} being F_{Di}^{o} and a specified standard deviation or rms error.

A standard random number generator was used to produce the 80 normally distributed random numbers (F_{Di}/F_{Di}^{o}) having a specified mean of 1.0 and a specified percentage of rms error.

Once the value of F_{Di}/F^{o}_{Di} is known, the dispatch prices for each unit can be calculated by multiplying the known optimum dispatch price by the normally distributed random number (F_{Di}/F^{o}_{Di}).

Another program was written which calculates the dispatch prices of the 80 units and creates a file of dispatch fuel prices for use in the simulation program. Simulations were performed making use of the dispatch fuel price data sets having rms errors of 5, 10, 15, 20, 30, 40, and 50 percent.

Use of the Weighted-Average Price

The weighted-average fuel price of each unit can be expressed by Eq. 5-5.

$$F_{WAVi} = \begin{cases} \dfrac{Q_{Bi}F_{Bi} + (Q_i - Q_{Bi})F_{Ai}}{Q_i} & , \quad Q_i > Q_{Bi} \\ F_{Bi} & , \quad Q_i \leq Q_{Bi} \end{cases} \tag{5-5}$$

where

F_{WAVi} = weighted-average fuel price for unit i in \$/MBtu
F_{Bi} = base fuel price of unit i in \$/MBtu
F_{Ai} = auxiliary fuel price of unit i in \$/MBtu
Q_i = total fuel usage by unit i for the month
Q_{Bi} = base fuel allotment for unit i in MBtu

The weighted-average fuel cost calculated using Eq. 5-5 is based on the fuel consumed, as in the case for production cost 1, rather than on the base fuel allocation.

In order to specify a unit's weighted-average fuel price as its dispatch fuel price an iterative technqiue is required. Since the relative dispatch prices of the units determine the consumption of the units and the unit's consumption determines its weighted-average fuel price, a procedure to simulate the use of weighted-average fuel prices for dispatch proceeds as follows:

- A succession of identical 30-day load periods are used.
- The optimum dispatch prices are used in the first load period. The resulting weighted-average fuel cost for each unit is calculated.

- The weighted-average fuel prices previously calculated are used as the dispatch price during the next load period. The new weighted-average fuel cost for each unit is calculated.
- The dispatches are repeated, using the previous month's weighted-average fuel prices as the dispatch prices, for 10 to 12 load periods (months).

As in the case for random variations in the dispatch price, the parameters specifying the relative quantities and prices of the base and auxiliary fuels are set at different values. The simulation of the use of weighted-average fuel prices is repeated for each of the combinations of quantities (50, 60, 70, and 80% base fuel) and prices (auxiliary prices of ±10 and ±30% higher/lower than base prices) of base and auxiliary fuels.

RESULTS OF THE SIMULATION

The results of the different simulations are presented in tabular form and in graphs; they are placed in Appendix H and Appendix I, respectively, because their bulk would divide the text in an awkward way.

Tables

Tables H-1 through H-36 and Tables H-53 through H-60 show the results of the simulations which are made for random errors in dispatch prices. For a list of the contents of these tables, see page H-1. Tables H-1 through H-36 present results generated using the correlation factor of 0.24 between the units' auxiliary and base fuel prices. In Tables H-53 through H-60, correlation factors of 0.75 and 0.95 are used. Tables H-37 through H-52 and Tables H-61 through H-64 correspond to the cases in which the generating units' weighted-average fuel prices are used as the dispatch prices. The entries in these tables are explained as follows:

- Auxiliary fuel price: This is a total system quantity only and does not apply to the relative auxiliary and base fuel prices for the individual generating units. The weighted-average auxiliary fuel price for the system is X% more (or less) than the weighted-average base fuel price for the system in the base case.
- Base fuel: The base fuel is given as a percentage of the total fuel consumed in one month in the base case. For the base case this same percentage of base fuel is allocated for each unit.
- Correlation factor: This is the value of the linear correlation factor between the generating unit's auxiliary and base fuel prices.

- % rms error in dispatch price (for random error cases): The simulations are made varying the dispatch price from the optimum price by 5%, 10%, 15%, 20%, 30%, 40%, and 50% rms errors. The mean value of the error is zero.

- Optimization period number: The weighted-average price strategy simulations model the evolution of dispatch prices through 12 consecutive time periods (months). The period number is simply the time index denoting the month.

- Auxiliary fuel used: As the dispatch is altered due to the errors in the dispatch price, the relative consumption of auxiliary and base fuel for the total system for the 1-month period will change. This entry gives the consumption of auxiliary fuel as a percentage of total consumption.

- Fuel cost 1: This cost is calculated using only the fuel consumed and is fully described earlier in this section as PC1.

- Fuel cost 2: This cost is calculated using total base fuel allocation and is described earlier in this section as PC2.

- % increase in cost over base case: The production cost for the base case is shown in each table. The increase in production cost is calculated using both fuel cost 1 and fuel cost 2.

Figures

The results of the simulations are also given in graphical form in Appendix I. Page I-1 gives a list of these figures. A correlation factor between the units' auxiliary and base fuel prices of 0.24 is used in Figures I-1 through I-60. Correlation factors with values of 0.24, 0.75, and 0.95 are used to illustrate its effect in Figures I-61 through I-66.

The first set of figures depicts the percentage increase in the total system fuel cost as calculated using both production cost 1 and production cost 2 versus the percentage standard deviation (rms error) in the dispatch price. Thus two curves are shown in each plot of Figures I-1 through I-36.

The next set of figures gives the previously described set of curves collected on four figures so that all 16 curves for the 50% base fuel allocation are shown on one graph. Likewise all the 16 curves for the 60%, 70%, and 80% base fuel allocation are shown on their respective graph sheets. These curves are depicted in Figures I-37 through I-40.

Figures I-41 through I-44 use the same information as the previous curves but present the effect of differing relative amounts of base and auxiliary fuels. Curves for 50%, 60%, 70%, and 80% base fuel are all plotted on the same curve sheet.

Four different curve sheets present auxiliary fuel prices and the two methods of evaluating the production cost.

Figures I-45 through I-60 depict the use of the weighted-average price of the auxiliary and base fuels consumed by a given unit for the unit's dispatch price. The iterations are carried out as previously described and the resulting increase in the system fuel cost is plotted against the number of 30-day optimization periods.

The effect of the correlation between the generating units' auxiliary and base fuel prices is illustrated in Figures I-62 through I-66. Figures I-61 and I-62 are for random variations in dispatch price and Figures I-63 through I-66 illustrate the correlation effect when the unit's weighted-average fuel price is used for the dispatch price.

ANALYSIS OF THE SIMULATION RESULTS

There are two general classes of variations in the dispatch prices from their optimum values. These two classes are:

1. A random variation in the dispatch prices among the units is produced such that the mean value of a unit's dispatch price is its optimum dispatch price. Sets of dispatch fuel data are produced which have standard deviations (rms error) of 0, 5, 10, 15, 20, 30, 40, and 50 percent. Figures I-1 through I-44 in Appendix I show the results of this variation for the unit's fuel data having a correlation factor of 0.24. Figures I-61 and I-62 allow comparison of results of using correlation factors of 0.24, 0.75, and 0.95.

2. The use of a unit's weighted-average fuel price for its dispatch fuel price is depicted in Figure I-45 through I-60 for the correlation factor of 0.24. Figures I-63 through I-66 depict the results of using the correlation factors of 0.24 and 0.95 between the units' auxiliary and base fuel prices.

Assessment of Production Cost

The mathematical analysis of Section 3 gives a strategy for minimizing the financial outlay for fuel for the optimization period. In the base cases all of the fuel purchased was consumed in the study period, but when the dispatch prices are varied from their optimum values there were cases in which one or more (usually less than five) units did not consume all of their base fuel. This condition causes the inventory of fuel at the affected units to increase because the base fuel is secured by must-take type contracts. Consequently, other units consume greater amounts of fuel than in the base cases. The production cost designated as production cost 2 (PC2) assesses the cost based on the funds which must be expended for fuel even though some of this fuel may not be consumed in the period.

The production cost which was designated as production cost 1 (PC1) assesses the fuel cost based on the fuel consumed. This cost, plus a penalty for increasing the inventory of some units and decreasing the inventory at other units, would seem to be the most reasonable evaluation of the fuel cost for the period. If the condition were to persist for some period of time, then transshipments of fuel among the plants would have to be made. The penalty for the under-consumption and over-consumption of fuel at the plants is difficult to evaluate in a generally applicable manner. We can, however, establish upper and lower bounds on this penalty, since the production costs PC1 and PC2 are the lower and upper bounds, repectively, on the production cost. The increase in production cost due to errors in the dispatch is calculated using PC1 and PC2, and curves depicting both assessments are plotted. In many cases all the base fuel at each unit is consumed, making PC1 and PC2 identical.

Random Errors in the Dispatch Price

The figures of Appendix I Figures I-1 through I-36 generally show that the percentage increase in production cost increases linearly with the rms error in the dispatch. This differs somewhat from the two-unit cases of Section 4, which showed a much greater sensitivity to the larger deviations in dispatch price and very small increases in production cost due to small errors in the dispatch price.

Figures I-37 through I-40 give the curves of Figures I-1 through I-36 grouped on only four curve sheets. The four sheets are for the four different percentages of base fuel, namely the base fuel accounting for 50, 60, 70, and 80 percent of the total fuel in the base case (zero rms error case).

The family of curves on each of these plots depicts the effect of the relative prices of auxiliary and base fuels. The percentage values shown on the curves are the percentage values by which the weighted-average auxiliary fuel price for the system differs from the weighted-average base fuel price for the system. Generally the percentage increase in total fuel cost is greater for the higher prices of auxiliary fuel relative to the base fuel price.

The fuel cost evaluated by means of PC2 is higher than that calculated by means of PC1 when the errors in the dispatch are large enough so that some units fail to use all of their base fuel allotment. For an rms error of 10% in the dispatch price, the increase in the fuel cost is as high as 3.3% using PC2 and 1.5% using PC1.

The information contained in Figures I-1 through I-40 is displayed in a different manner in the next four graphs. These graphs, Figures I-41 through I-44, illustrate the relative effect of different quantities of base fuel as a percentage of the total fuel of the base case. There are eight curves on each figure, representing 50, 60, 70, and 80 percent base fuel and two values of auxiliary fuel price. In the first two graphs the fuel cost is evaluated using PC1, and in the latter two PC2 is used.

From Figures I-41 and I-42 (PC1 curves) it is seen that the greatest increase in fuel cost occurs for the higher percentages of base fuel when the auxiliary fuel price is higher than the base fuel price. However, when the auxiliary fuel price is less than the base fuel price, the opposite is true in that the increase in fuel cost is less for the higher percentage of base fuel.

When the fuel cost is evaluated using PC2, illustrated by Figures I-43 and I-44, the increase in fuel cost is generally higher for the higher percentage of base fuel regardless of whether the auxiliary fuel price is higher or lower than the base fuel price.

Production costs evaluated by both PC1 and PC2 tend to increase with increasing levels of base fuel allotment when the auxiliary fuel is higher priced than the base fuel; however, when the auxiliary fuel price is less than that of the base fuel, production costs evaluated using PC1 decrease as the base fuel allotment increases from 50% to 80% of the total, while production costs evaluated using PC2 increase with the increasing level of base fuel allocation.

Figures I-61 and I-62 show that the correlation between the generating units' auxiliary and base fuel prices has very little effect on the increase in fuel cost over the optimum when random errors in the dispatch prices are present.

The increase in fuel cost due to random errors in the dispatch price is summarized in Table 5-4. The percentage increase in fuel cost is evaluated at the 10% rms error level in the dispatch price.

Use of the Weighted-Average Prices

Figures I-45 through I-60 show the percentage increase in the production cost when the unit's weighted-average fuel price is used for its dispatch price and a correlation factor of 0.24 exists between the generating unit's auxiliary and base

Table 5-4

SUMMARY OF THE RANDOM ERROR CASES

Base Fuel as a Percentage of Total Fuel	Total System Auxiliary Fuel Price as X% Higher or Lower Than the Total System Base Fuel Price	Percentage Increase in System Fuel Cost at the 10% rms Error Level in the Dispatch Price	
		PC1	PC2
50	-30	0.5	0.5
50	-10	0.5	0.5
50	10	0.6	0.6
50	30	0.6	0.6
60	-30	0.4	0.6
60	-10	0.5	0.7
60	10	0.6	0.8
60	30	0.7	0.8
70	-30	0.2	1.1
70	-10	0.4	1.3
70	10	0.7	1.5
70	30	0.9	1.7
80	-30	-0.2	1.9
80	-10	0.4	2.3
80	10	0.8	2.7
80	30	1.3	3.1

fuel prices. The effect of the correlation is depicted in Figures I-63 through I-66.

The utility survey showed that 8 of the 11 utilities were using the weighted-average price of fuel for the dispatch fuel price. Therefore, the effect of this variation in the dispatch price was investigated.

As explained earlier, the weighted-average fuel price of each unit which was calculated on the last iteration is used in the next iteration. The first dispatch is made using the optimum dispatch prices, and the curves show the amount of increase in production cost over the minimum fuel cost. Usually the dispatches converge to the same dispatch after several iterations, but in some cases the solutions seem to oscillate cyclically about the solution. In all cases, stable solutions are obtained.

Again the evaluation of the production cost by means of PC1 and PC2 are both plotted. Differences in the evaluation by the two means occur when the greater percentages of base fuel are allocated and when the auxiliary fuel price differs increasingly from the base fuel price.

When the base fuel allocation is 50% of the total (Figures I-45 through I-48), both PC1 and PC2 show an approximate 0.6% increase in system fuel cost when the auxiliary fuel price is 10% less than the base fuel price. The increase in system fuel cost is approximately 0.3% and 0.2% when the auxiliary fuel prices are 10% and 30% higher than the base fuel price, respectively.

When the base fuel allocation is 80% of the total (Figures I-57 through I-60), the increases in production cost calculated by means of PC1 and PC2 may differ widely. For example:

<u>80% base fuel allocation</u>
Auxiliary fuel price is 30% less than the base fuel price.
Production cost using PC1 is 1.4% less than the optimum.
Production cost using PC2 is 4.7% higher than the optimum.

Another example follows:

80% base fuel allocation

Auxiliary fuel price is 30% higher than the base fuel price.

Production cost using PC1 is 0.6% higher than the optimum.

Production cost using PC2 is 1.8% higher than the optimum.

The production cost values are average values since this case oscillates rather than converges.

The correlation between the generating units' auxiliary and base fuel prices has a very significant effect on the increase in fuel cost over the optimum, as is illustrated in Figures I-63 through I-66. In Figure I-63, the correlation factor of 0.24 yields an increase in fuel cost of 1.1 and 0.5 percent using PC2 and PC1, respectively. The correlation factor of 0.95 yields an increase in fuel cost of 0.2 percent using either PC1 or PC2.

Table 5-5 shows a summary of the increases in system fuel cost which result from using the weighted-average fuel prices of the generating units as the dispatch prices.

Table 5-5

SUMMARY OF THE WEIGHTED-AVERAGE CASES

Correlation Between the Generating Units' Auxiliary and Base Fuel Prices	Base Fuel as a Percentage of the Total Fuel	Total System Auxiliary Fuel Price as X% Higher or Lower Than the Total System Base Fuel Price	Percentage Increase in the System Fuel Cost	
			PC1	PC2
0.24	50	-30	0.78	1.43
0.24	50	-10	0.62	0.76
0.24	50	10	0.33	0.33
0.24	50	30	0.20	0.20
0.24	60	10	0.45	0.45
0.24	60	30	0.27	0.27
0.24	60	-30	0.62	1.92
0.24	60	-10	0.63	1.28
0.24	70	-30	-0.32	3.21
0.24	70	-10	0.39	2.43
0.24	70	10	0.49	1.11
0.24	70	30	0.4	0.5
0.24	80	-30	-1.42	4.70
0.24	80	-10	-0.22	4.45
0.24	80	30	0.6	1.8
0.24	80	10	0.46	3.18
0.95	70	-30	0.27	1.24
0.95	70	-10	0.26	0.48
0.95	70	10	0.2	0.2
0.95	70	30	0.18	0.18

Section 6

METHODOLOGY FOR DEVELOPING DISPATCH FUEL PRICES

Based on the mathematical analysis and the analysis by means of simulations of the two-unit system and of the large system, the correct values of dispatch fuel price for use in the equal-incremental-cost dispatch have been derived and verified. In this section we develop guidelines for a methodology for obtaining these values for a more realistic and complex fuel supply system.

Carolina Power and Light Company (CP&L) was of considerable assistance in this portion of the analysis. CP&L has developed an innovative computer-based system for fuel management, and it has been in use since approximately 1980. (The fuel scheduling software developed independently for EPRI under this project, RP 1048-6, is quite similar to CP&L's.) Representatives of CP&L generously shared their experiences and insights, and the methodology presented in this section was largely inspired by their observations.

CP&L's fuel management system is quite comprehensive; it contains analytical methods for determining fuel acquisition strategies, and it also includes considerable data acquisition and data management activity regarding fuel deliveries, inventories, etc. Our interest centers on the optimization scheme used for scheduling monthly fuel acquisitions. CP&L has formulated the fuel scheduling problem as a linear program and uses a standard linear programming (LP) code to solve it. This code, like any other LP, produces a set of dual variables (also known as simplex multipliers, shadow prices, marginal values, etc.) that give considerable information on the sensitivity of the optimal objective function value to perturbations in certain constraints. CP&L analysts observed that some of these dual variables were, in principle, equivalent to marginal prices of fuel. They further observed that when these dual variables are used as dispatch prices, they produce dispatch solutions that are quite satisfactory. The analysis in this section examines this general approach in a more rigorous way.

The CP&L fuel scheduling analysis has been duplicated at the University of Alabama using programs available at the University of Alabama Computing Center, and numerous computation experiments have been performed. Variations on their work have been investigated.

THE METHODOLOGY

The methodology proceeds in a two-step iterative fashion as follows:

1. By means of a production costing program, establish the fuel requirements at each plant based on the electrical load and estimated incremental fuel prices.

2. By means of a linear programming (LP)-based Fuel Management Program (FMP), determine the minimum-cost set of fuel offers from vendors. Incremental fuel prices are produced in this process; they are the dual variables corresponding to the plant fuel demand constraints.

If the incremental fuel price values produced in step 2 do not agree with the estimated values, repeat the steps until agreement is reached.

THE SYSTEM

The system that was simulated for fuel scheduling consisted of 14 units at 8 plants, 11 suppliers of "take-or-pay" contract fuels, and 7 spot-market fuel suppliers.

Generating Units and Plants

Particulars of the generating units and the location of the plant where they are located are given in Table 6-1. The incremental fuel price values are estimated values at this point in the analysis. (In this fortuitous instance these values are good estimates, since it turns out that they agree with the values produced by the LP analysis.)

CONCLUSIONS

The conclusions reached on the methodology for determining the incremental fuel prices can be summarized as follows:

- A linear programming-based fuel management program is an excellent tool for selecting the set of offers to supply the given fuel demands at each plant.

- As a bonus the linear programming algorithm produces the values of incremental fuel prices which may be used in an equal-lambda economic dispatch (for real-time and study purposes).

- A production costing program (which uses the incremental fuel price values from the LP) is used in conjunction with the linear programming algorithm in order to establish the demand for fuel at each plant. Iterations between the two programs may be required.

Table 6-1

GENERATING UNIT DATA

Unit No.	Plant	Heat Rate Coefficients a	b	c	Rating (MW)	Incremental Fuel Price ($/MBtu)
1	PLANT 1	139.809	7.399	.0049	200	1.52
2	PLANT 1	139.809	7.399	.0049	200	1.52
3	PLANT 2	99.807	7.924	.00748	140	1.64
4	PLANT 2	100.0	7.96	.005	170	1.64
5	PLANT 3	210.387	5.529	.00277	250	1.66
6	PLANT 4	100.0	7.96	.0065	175	1.66
7	PLANT 5	269.179	7.548	.00389	385	1.51
8	PLANT 5	550.613	7.772	.00126	670	1.51
9	PLANT 5	550.613	7.772	.00126	650	1.51
10	PLANT 6	550.613	7.8	.00146	670	1.51
11	PLANT 7	128.552	7.068	.02277	97	1.67
12	PLANT 7	128.552	7.068	.02277	106	1.67
13	PLANT 7	269.179	7.189	.00371	385	1.67
14	PLANT 8	100.0	7.96	.005	185	1.67

Load

This series of simulations deals with the annual fuel scheduling for the system, and hence an annual load-duration curve is used. Table 6-2 gives the load data for the thermal units including the effect of sales.

Table 6-2

LOAD-DURATION INTERVALS FOR THE ANNUAL SYSTEM LOAD

Load (MW)	Duration (hours)	Electrical Energy (MWh)
4000	440	1 760 000
3250	680	2 210 000
2500	1100	2 750 000
2400	1700	4 080 000
2200	1950	4 290 000
1900	2430	4 617 000
1700	460	782 000
TOTALS	8760	20 489 000

FUEL REQUIREMENTS

Using the system and load as previously described, the Production Cost Program produced the fuel requirements at each plant as shown in Table 6-3.

Table 6-3

FUEL REQUIREMENTS AT THE PLANTS

Plant	Fuel Requirement (MBtu)
PLANT 1	23 198 346
PLANT 2	9 624 901
PLANT 3	15 468 075
PLANT 4	5 135 299
PLANT 5	89 895 307
PLANT 6	32 856 999
PLANT 7	18 380 252
PLANT 8	5 286 248
TOTAL	199 845 427

FUEL SUPPLIERS

There are 11 suppliers of contract fuel. The take-or-pay fuel quantities are given in Table 6-4. In addition, each plant except PLANT 6, which is required to burn compliance fuel, has a spot-market supplier. Table 6-5 gives the prices of fuel from the vendors. Prices are FOB at the plant. It is assumed that there are sufficient quantities of spot-market fuel to meet all the requirements. Therefore, the model puts no limit on the quantity of the spot-market fuels.

Table 6-4

FUEL CONTRACTS WITH VENDORS

Plant	Fuel Quantity (GBtu)
VEND 1	14 400
VEND 2	1 380
VEND 3	34 776
VEND 4	2 280
VEND 5	16 395
VEND 6	7 296
VEND 7	22 800
VEND 8	5 664
VEND 9	17 591
VEND 10	2 304
VEND 11	28 750
TOTAL	153 636

Table 6-5

DELIVERED FUEL PRICE AT THE PLANTS

Vendor	Plant	Cost($/MBtu)	Vendor	Plant	Cost($/MBtu)
VEND 1	PLANT 1	1.53	VEND 3	PLANT 5	1.40
" 6	"	1.51	" 4	"	1.57
" 8	"	1.60	" 5	"	1.83
" 10	"	1.62	" 7	"	1.87
SPOT 1	"	1.53	" 9	"	1.81
VEND 4	PLANT 2	1.71	" 11	"	1.52
" 6	"	1.63	SPOT 5	"	1.51
" 7	"	2.06	VEND 9	PLANT 6	1.81
" 8	"	1.71	" 7	"	1.87
" 9	"	2.00	" 5	"	1.83
" 10	"	1.74	" 4	PLANT 7	1.74
" 11	"	1.71	" 6	"	1.66
SPOT 2	"	1.64	" 7	"	2.09
VEND 4	PLANT 3	1.73	" 8	"	1.74
" 6	"	1.67	" 9	"	2.03
" 7	"	2.08	" 10	"	1.77
" 8	"	1.75	" 11	"	1.74
" 9	"	2.02	SPOT 7	"	1.67
" 10	"	1.78	VEND 4	PLANT 8	1.74
" 11	"	1.73	" 6	"	1.66
SPOT 3	"	1.66	" 7	"	2.09
VEND 2	PLANT 4	1.68	" 8	"	1.74
" 4	"	1.72	" 9	"	2.03
" 6	"	1.65	" 10	"	1.77
" 7	"	2.08	" 11	"	1.74
" 8	"	1.73	SPOT 8	"	1.67
" 9	"	2.02			
" 10	"	1.76			
" 11	"	1.73			
SPOT 4	"	1.66			

OPTIMAL FUEL SCHEDULING

The FMP produced the optimal fuel purchases given in Table 6-6. Constraints on the quantity of fuel available from each vendor are satisfied, and the total fuel allocation matches the fuel requirements as evaluated by means of the Production Costing Program. Only the nonzero transactions are shown in Table 6-6. A number of fuel offers are not taken in the optimal solution, and these zero transactions are not shown.

Table 6-6

OPTIMAL FUEL PROCUREMENTS

Vendor	Plant	Fuel Quantity (MBtu)
VEND 1	PLANT 1	14 400 000
VEND 6	PLANT 1	7 296 000
VEND 10	PLANT 1	1 502 346
SPOT 2	PLANT 2	9 624 901
SPOT 3	PLANT 3	15 468 075
VEND 2	PLANT 4	1 380 000
SPOT 4	PLANT 4	3 755 298
VEND 3	PLANT 5	34 776 000
VEND 4	PLANT 5	2 280 000
VEND 5	PLANT 5	1 129 001
VEND 7	PLANT 5	22 800 000
VEND 11	PLANT 5	28 750 000
SPOT 5	PLANT 5	160 306
VEND 5	PLANT 6	15 265 999
VEND 9	PLANT 6	17 591 000
VEND 8	PLANT 7	377 752
VEND 10	PLANT 7	801 654
SPOT 7	PLANT 7	17 200 846
VEND 8	PLANT 8	5 286 248
TOTAL		199 845 426

INCREMENTAL FUEL PRICE

The values of the incremental fuel prices produced by the linear program are given in Table 6-1. From Table 6-5 it is seen that the incremental fuel prices for Plants 2, 3, 4, 5, 7, and 8 are the spot-market prices FOB the plant. However, this is not the case for PLANT 1 and PLANT 6.

Incremental Fuel Price at PLANT 1

Figure 6-1 illustrates the incremental fuel price at PLANT 1. The cost is calculated for an increase in demand of 1 MBtu at PLANT 1. The original optimal flows are shown in Figure 6-1(a), and the new optimal flows which result from the increased demand are shown in Figure 6-1(b). The prices for the paths are also shown. The flows in all the other paths do not change; therefore, they are not shown in the figure. The incremental cost is the result of the following:

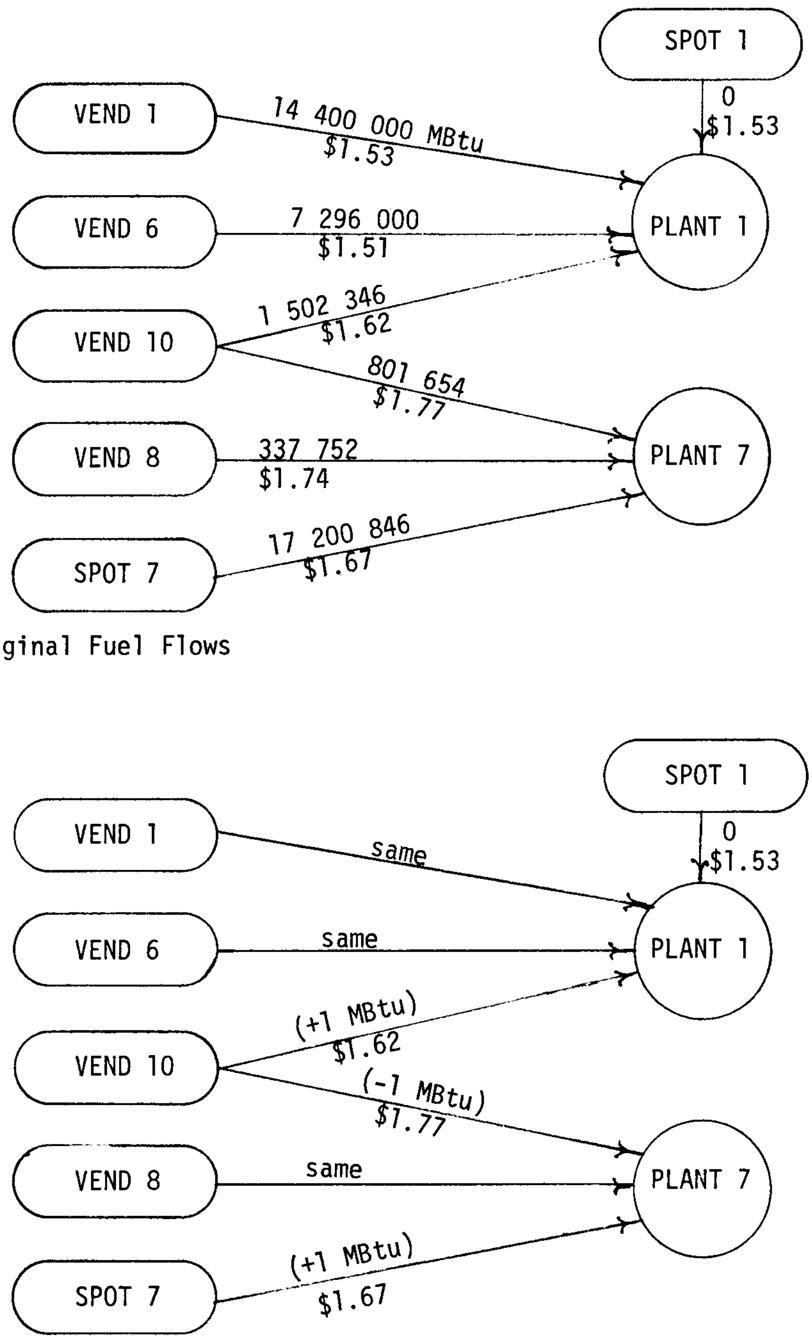
Increase of 1 MBtu from VEND 10 to PLANT 1 =	$ 1.62
Decrease of 1 MBtu from VEND 10 to PLANT 7 =	$-1.77
Increase of 1 MBtu from SPOT 7 to PLANT 7 =	$ 1.67
Net Cost = Incremental Cost =	$ 1.52

It is noted from Table 6-6 that no fuel from SPOT 1 (price of $1.53) is allocated by the optimal solution at this load level. The total fuel cost also shows an increase of $1.52 for the 1 MBtu increased demand at PLANT 1.

Incremental Fuel Price at PLANT 6

The incremental fuel price at PLANT 6 also comes about through a circuitous pattern. Figure 6-2 illustrates the circumstances. PLANT 6 is required to burn compliance fuel and does not have a spot-market supplier. Figure 6-2(a) gives the original optimal flows and part (b) of the figure gives the optimal flows which result from an increased demand of 1 MBtu at PLANT 6. The incremental cost is the result of the following changes:

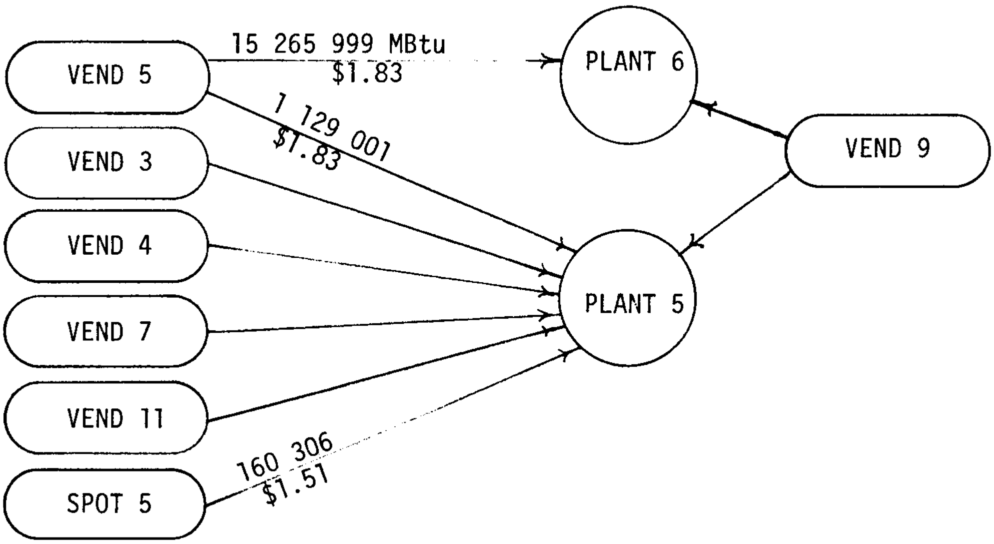
Increase 1 MBtu from VEND 5 to PLANT 6 =	$ 1.83
Decrease 1 MBtu from VEND 5 to PLANT 5 =	$-1.83
Increase 1 MBtu from SPOT 5 to PLANT 5 =	$ 1.51
Net Cost = Incremental Cost =	$ 1.51



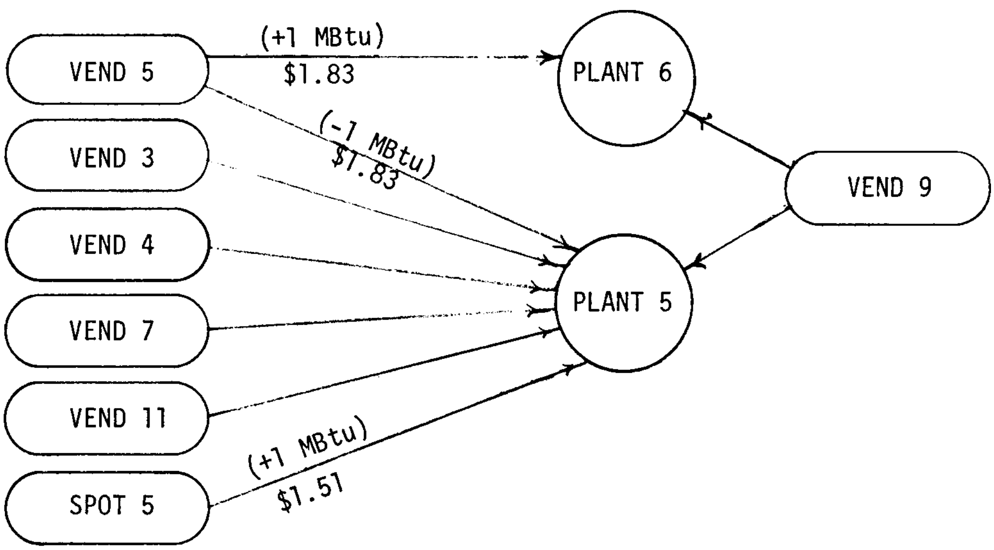
(a) Original Fuel Flows

(b) Fuel Flows with Increased Demand

Figure 6-1. Increased Demand at PLANT 1



(a) Original Fuel Flows



(b) Fuel Flows with Increased Demand

Figure 6-2. Increased Demand at PLANT 6

Thus the incremental fuel price at PLANT 6 is $1.51/MBtu, considerably less than the compliance fuel price of $1.83/MBtu, which may appear to be the incremental price if the LP analysis were not performed.

Verification of Optimality

A number of runs using the Production Costing program were made using dispatch fuel prices for the generating units which differed from the incremental prices produced by the FMP. The overall production costs in these cases were always higher than the base case. Dispatch fuel prices, which intuitively would appear to be likely candidates for incremental price values (e.g., spot-market price at PLANT 1), were tried.

FLEXIBILITY IN FUEL SCHEDULING

Since the fuel management procedures must look into the future, data on the amount of fuel required may be somewhat in error. The FMP can be used to evaluate the range of fuel requirements over which the incremental fuel prices do not change. Actually the fuel flows produced by the LP, while optimal, are not necessarily a unique solution since there are often a number of alternate solutions. So long as there exists marginal cost values which are equal to zero for shipments from any source (vendor) to any plant, then alternate optimal solutions will exist. Depending on the order in which the vendors and plants are processed, different solutions may be found by the linear programming code.

The analysis shown in this section is based on a single time period (1 year) within which fuel demands must be met. At CP&L, a single time period model (covering 1 month) is used to determine fuel purchases and shipments. Inventory plays a major role in neither of these approaches. Considerable flexibility is gained when one looks at the problem as a series of time periods, where inventory levels can be actively scheduled within allowable limits.

The case was analyzed wherein the total system fuel requirement was increased or decreased by certain percentages of the base case. The system change was accomplished by changing each plant requirement by the given percentage. For the case which was simulated in this analysis, the total system fuel requirement could be increased by approximately 3.5% without changing any of the incremental fuel prices at the plants. PLANT 1 was the critical plant with its incremental price increasing to $1.53/MBtu (the price of its spot-market fuel supply). When the total system fuel requirement was reduced by amounts greater than approximately 1.5%, the incremental fuel price at PLANT 5 changed to $1.45/MBtu.

No generalizations can be made regarding the percentage change that will cause the plant incremental prices to change from their base-case values. In other cases analyzed, increased requirements of nearly 35% were experienced before any plant incremental prices changed from their base-case values. However, the FMP can evaluate the range over which the incremental prices do not change.

Section 7

RESULTS AND CONCLUSIONS

This research has been directed toward developing economic dispatch fuel price strategies for the conditions where the fuel available to a given generating unit may have a number of different sources, each with different prices and constraints.

The main result of this research is the mathematical analysis establishing the optimality of the incremental fuel price for dispatch purposes in the multi-fuel supply case. Other results include the following:

- A survey of electric utilities revealed that there exist wide differences in the practice of setting economic dispatch fuel prices.
- A mathematical derivation of the optimal dispatch fuel prices has been obtained. This shows that the incremental fuel price yields minimum fuel cost for the optimization period.
- Simulations of a small system and of a large system were performed, and the simulations verify the mathematical results.
- Sensitivities of the system fuel cost to deviations from the optimal dispatch fuel prices were obtained by means of the simulations. Fuel cost increases of .5% to 1% over the minimum cost due to the dispatch fuel pricings practices of 75% of the electric utilities surveyed are typical.

The conclusions drawn from this work are:

- A linear programming-based fuel management program will not only select the optimal set of fuel offers from vendors but will also produce as a by-product the incremental fuel prices at each plant.
- A production costing program using the estimated load and estimated incremental fuel prices may be used to establish the demand for fuel for each plant for the optimization period.
- Iterations between the fuel management program and the production costing program may be necessary in order to reach agreement between the estimated incremental fuel prices and the values which result from the fuel management program.
- The estimated load should include the total thermal load including estimated sales.

- The optimization period should extend into the future as far as reasonable estimates can be made. For example, an optimization based on a 1-month period may produce an aberration in the incremental fuel price at a given plant.
- The inventorying of fuel should be included in the fuel management process.
- Additional expenditures for fuel due to the lack of an optimized procedure for fuel procurement and management can significantly exceed the 0.5% to 1% additional cost due to dispatch fuel price errors. Of course, the amount of additional expenditures will depend on how effective the present fuel management process is.

The dispatch fuel pricing strategies are intimately related to the fuel management process. Thus the minute-by-minute on-line economic dispatch and monthly, yearly, and even longer term fuel management processes are inseparable.

Appendix A

GENERATING UNIT NAME DATA

This appendix gives a complete set of Generating Unit Name Data. The data appear in the following format:

Column 1	Line number
Column 2	Data type
Column 3	Unit identification number
Column 4	Unit name
Column 5	Type of unit
Column 6	Entry point number
Column 7	Station number
Column 8	Priority of the unit
Column 9	Type of fuel used by unit
Column 10	Maximum generation (MW)
Column 11	Minimum generation (MW)

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1.	COL.	COL.	COL.	COL.	COL.	COL.	COL.	COL.	COL.	COL.
2.	2	3	4	5	6	7	8	9	10	11
3.	**********	******	**********	******	******	******	******	******	**********	**********
4.	2	1	STEAMA01	1	57	57	6	1	95.00	18.60
5.	2	2	STEAMB01	1	3	3	11	1	42.80	18.60
6.	2	3	STEAMB02	1	3	3	17	1	42.80	41.90
7.	2	4	STEAMB03	1	3	3	12	1	42.80	18.60
8.	2	5	STEAMB04	1	3	3	13	1	42.80	18.60
9.	2	6	STEAMC01	1	4	4	1	1	52.30	27.90
10.	2	7	STEAMC02	1	4	4	2	1	80.80	37.20
11.	2	8	STEAMD01	1	32	32	9	1	42.80	18.60
12.	2	9	STEAMD02	1	32	32	10	1	42.80	18.60
13.	2	10	STEAME01	1	5	5	63	1	156.80	69.80
14.	2	11	STEAME02	1	5	5	62	1	185.30	69.80
15.	2	12	STEAMF01	1	6	6	20	1	23.80	9.30
16.	2	13	STEAMF02	1	6	6	21	1	23.80	9.30
17.	2	14	STEAMF03	1	6	6	66	1	152.00	51.20
18.	2	15	STEAMG01	1	8	8	36	1	104.50	41.90
19.	2	16	STEAMG02	1	8	8	38	1	95.00	65.10
20.	2	17	STEAMG03	1	8	8	37	1	104.50	41.90
21.	2	18	STEAMH01	1	33	33	19	1	57.00	14.00
22.	2	19	STEAMH02	1	33	33	22	1	57.00	14.00
23.	2	20	STEAMH03	1	33	33	75	1	61.80	14.00
24.	2	21	STEAMH04	1	33	33	76	1	61.80	14.00
25.	2	22	STEAMJ01	1	9	9	54	1	247.00	102.30
26.	2	23	STEAMJ02	1	9	9	55	1	247.00	102.30
27.	2	24	STEAMG04	1	34	34	64	1	133.00	51.20
28.	2	25	STEAMG05	1	34	34	65	1	133.00	51.20
29.	2	26	STEAMK01	1	10	10	72	1	104.50	41.90
30.	2	27	STEAMK02	1	10	10	73	1	104.50	41.90
31.	2	28	STEAMK03	1	10	10	74	1	104.50	41.90
32.	2	29	STEAMK04	1	10	10	49	1	475.00	209.30
33.	2	30	STEAML01	1	11	11	7	1	66.50	23.30
34.	2	31	STEAML02	1	11	11	8	1	66.50	23.30
35.	2	32	STEAMM02	1	12	12	18	1	57.00	27.90
36.	2	33	STEAMM03	1	12	12	25	1	61.80	27.90
37.	2	34	STEAMM04	1	12	12	26	1	109.30	41.90

38.	2	35	STEAMM05	1	12	12	27	1	109.30	41.90
39.	2	36	STEAMM06	1	12	12	61	1	166.30	46.50
40.	2	37	STEAMM06	1	12	12	40	1	175.80	46.50
41.	2	38	STEAMN01	1	14	14	59	1	256.50	102.30
42.	2	39	STEAMN02	1	14	14	60	1	256.50	102.30
43.	2	40	STEAMP01	1	15	15	24	1	47.50	14.00
44.	2	41	STEAMQ01	1	45	45	3	1	23.80	4.70
45.	2	42	STEAMQ02	1	45	45	4	1	23.80	4.70
46.	2	43	STEAMQ03	1	45	45	5	1	23.80	4.70
47.	2	44	STEAMM08	1	16	16	42	1	684.00	325.50
48.	2	45	STEAMR02	1	26	26	67	1	133.00	37.20
49.	2	46	STEAMR01	1	26	26	68	1	133.00	37.20
50.	2	47	STEAMR03	1	26	26	56	1	247.00	83.70
51.	2	48	STEAMS01	1	49	49	14	1	42.80	18.60
52.	2	49	STEAMS02	1	49	49	15	1	38.00	18.60
53.	2	50	STEAMS03	1	49	49	16	1	38.00	18.60
54.	2	51	STEAMT01	1	19	19	78	1	23.80	4.70
55.	2	52	STEAMT02	1	19	19	79	1	23.80	4.70
56.	2	53	STEAMT03	1	19	19	77	1	33.30	14.00
57.	2	54	STEAMT04	1	19	19	34	1	85.50	37.20
58.	2	55	STEAMT05	1	19	19	35	1	85.50	37.20
59.	2	56	STEAMT06	1	19	19	39	1	332.50	93.00
60.	2	57	STEAMU01	1	20	20	70	1	80.80	27.90
61.	2	58	STEAMU02	1	20	20	71	1	80.80	27.90
62.	2	59	STEAMU03	1	20	20	69	1	109.30	27.90
63.	2	60	STEAMU04	1	20	20	57	1	247.00	74.40
64.	2	61	STEAMV01	1	23	23	44	1	684.00	325.50
65.	2	62	STEAMV02	1	23	23	45	1	684.00	325.50
66.	2	63	STEAMW01	1	25	25	29	1	256.50	69.80
67.	2	64	STEAMW02	1	25	25	30	1	256.50	69.80
68.	2	65	STEAMW03	1	25	25	31	1	256.50	69.80
69.	2	66	STEAMW04	1	25	25	32	1	256.50	69.80
70.	2	67	STEAMR04	1	26	26	50	1	361.00	130.20
71.	2	68	STEAMR02	1	26	26	43	1	684.00	325.50
72.	2	69	STEAMX01	1	29	29	58	1	256.50	93.00
73.	2	70	STEAMX02	1	29	29	53	1	308.80	111.60
74.	2	71	STEAMX03	1	29	29	48	1	475.00	139.50
75.	2	72	STEAMX04	1	29	29	47	1	494.00	111.60
76.	2	73	STEAMT07	1	19	19	33	1	475.00	186.00

77.	2	74	STEAMV05	1	20	20	46	1	475.00	186.00
78.	2	75	STEAMP02	1	15	15	23	1	47.50	14.00
79.	2	76	STEAMV03	1	23	23	41	1	874.00	279.00
80.	2	77	STEAMW05	1	25	25	28	1	874.00	279.00
81.	2	78	STEAMG06	1	34	34	51	1	332.50	139.50
82.	2	79	STEAMG07	1	34	34	52	1	332.50	139.50
83.	2	80	NUKEA01	1	6	6	80	4	760.00	204.60
84.	2	81	CTURB 1	2	26	26	1	2	60.00	.00
85.	2	82	CTURB 2	2	14	14	2	2	50.00	.00
86.	2	83	CTURB 3	2	3	3	3	2	30.00	.00
87.	2	84	CTURB 4	2	33	33	4	2	80.00	.00
88.	2	85	CTURB 5	2	23	23	5	2	40.00	.00
89.	2	86	CTURB 6	2	4	4	6	2	50.00	.00
90.	2	87	CTURB 7	2	4	4	7	2	50.00	.00
91.	2	88	CTURB 8	2	4	4	8	2	50.00	.00
92.	2	89	CTURB 9	2	6	6	9	2	80.00	.00
93.	2	90	CTURB 10	2	6	6	10	2	40.00	.00
94.	2	91	CTURB 11	2	15	15	11	2	40.00	10.00
95.	2	92	CTURB 12	2	20	20	12	2	40.00	10.00
96.	2	93	CTURB 13	2	25	25	13	3	20.00	10.00
97.	2	94	CTURB 14	2	5	5	14	3	40.00	10.00
98.	2	95	CTURB 15	2	9	9	15	3	80.00	10.00
99.	2	96	CTURB 16	2	4	4	16	3	100.00	10.00
100.	2	97	CTURB 17	2	4	4	17	3	100.00	10.00
101.	2	98	CTURB 18	2	4	4	18	3	50.00	10.00
102.	2	99	CTURB 19	2	4	4	19	3	50.00	10.00
103.	2	100	CTURB 20	2	58	58	20	3	120.00	10.00
104.	2	101	CTURB 21	2	58	58	21	3	120.00	10.00
105.	2	102	CTURB 22	2	58	58	22	3	60.00	10.00
106.	2	103	CTURB 23	2	58	58	23	3	60.00	10.00
107.	2	104	HYDRO001	4	37	37			81.00	
108.	2	105	HYDRO002	4	39	39			78.00	
109.	2	106	HYDRO001	4	54	54			144.00	
110.	2	107	HYDRO004	4	7	7			578.00	
111.	2	108	HYDRO005	4	55	55			249.00	
112.	2	109	HYDRO006	4	42	42			200.00	
113.	2	110	HYDRO007	4	41	41			92.00	
114.	2	111	HYDRO008	4	41	41			174.00	
115.	2	112	HYDRO009	4	56	56			191.00	

116.	2	113	HYDR0010	4	17	17		45.00	
117.	2	114	HYDR0011	4	3	3		6.00	
118.	2	115	HYDR0012	4	3	3		10.00	
119.	2	116	HYDR0013	4	33	33		10.00	
120.	2	117	HYDR0014	4	35	35		10.00	
121.	2	118	HYDR0015	4	2	2		10.00	
122.	2	119	HYDR0016	4	28	28		10.00	
123.	2	120	HYDR0017	4	27	27		10.00	
124.	2	121	TI0001	5	24				
125.	2	122	TIE002	5	21				
126.	2	123	TIE003	5	52				
127.	2	124	TIE004	5	51				
128.	2	125	TIE005	5	38				
129.	2	126	TIE006	5	44				
130.	2	127	TIE007	5	40				
131.	2	128	TIE008	5	43				
132.	2	129	TIE009	5	1				
133.	2	130	TIE010	5	27				
134.	2	131	TIE011	5	57				
135.	2	132	TIE012	5	2				
136.	2	133	TIE013	5	50				
137.	2	134	TIE014	5	48				
138.	2	135	TIE015	5	47				
139.	2	136	TIE016	5	46				
140.	2	137	TIE017	5	53				
141.	2	138	TIE018	5	22				
142.	2	139	TIE019	5	32				
143.	2	140	TIE020	5	5				
144.	2	141	TIE021	5	30				
145.	2	142	PSHYDR01	3	56	59	7	120.	50.
146.	2	143	PSHYDR02	3	56	59	6	120.	50.
147.	2	144	PSHYDR03	3	56	59	5	120.	50.
148.	2	145	PSHYDR04	3	56	59	4	120.	50.
149.	2	146	PSHYDR05	3	42	60	3	120.	50.
150.	2	147	PSHYDR06	3	42	60	2	120.	50.
151.	2	148	PSHYDR07	3	42	60	1	120.	50.

END DATA. ERRORS: NONE. TIME: 1.887 SEC. IMAGE COUNT: 151

Appendix B

GENERATING UNIT PERFORMANCE DATA

This appendix gives a complete set of Generating Unit Performance Data. The data appear in the following format:

Column 1	Line number
Column 2	Data type
Column 3	Unit number
Column 4	Constant of heat rate equation
Column 5	Linear coefficient of heat rate equation
Column 6	Quadratic coefficient of heat rate equation
Column 7	Minimum up-time (h)
Column 8	Minimum down-time (h)

WDATA,L DATA3,
DATA 9R1 SL74T9 01/06/82 16:05:41 (1)

1.	COL.	COL.	COL.	COL.	COL.	COL.	COL.
2.	2	3	4	5	6	7	8
3.	********	********	********	********	********	********	********
4.	3	1	100.000	4.950	.06000	8	8
5.	3	2	104.289	5.650	.09476	8	8
6.	3	3	104.289	5.650	.09476	8	8
7.	3	4	82.097	6.972	.07192	8	8
8.	3	5	82.097	6.972	.07192	8	8
9.	3	6	46.012	8.389	.04096	8	8
10.	3	7	81.750	7.050	.01610	8	8
11.	3	8	32.242	9.307	.02433	8	8
12.	3	9	32.242	9.307	.02433	8	8
13.	3	10	110.625	7.603	.00767	8	8
14.	3	11	139.809	7.550	.00500	8	8
15.	3	12	40.345	8.618	.08979	8	8
16.	3	13	40.345	8.618	.08979	8	8
17.	3	14	185.107	6.781	.01029	8	8
18.	3	15	128.552	7.068	.02277	8	8
19.	3	16	128.552	7.068	.02277	8	8
20.	3	17	128.552	7.068	.02277	8	8
21.	3	18	147.772	9.069	.06211	8	8
22.	3	19	106.994	8.772	.06795	8	8
23.	3	20	104.900	7.957	.04234	8	8
24.	3	21	104.900	7.957	.04234	8	8
25.	3	22	155.333	7.572	.00395	24	24
26.	3	23	155.333	7.572	.00395	24	24
27.	3	24	99.807	7.924	.00748	8	8
28.	3	25	99.807	7.924	.00748	8	8
29.	3	26	114.769	7.304	.01409	8	8
30.	3	27	114.769	7.304	.01409	8	8
31.	3	28	114.769	7.304	.01409	8	8
32.	3	29	360.380	7.774	.00136	24	24
33.	3	30	57.790	9.039	.02364	8	8
34.	3	31	57.790	9.039	.02363	8	8
35.	3	32	102.761	9.439	.04400	8	8
36.	3	33	62.766	8.861	.02590	8	8
37.	3	34	67.609	9.422	.00875	8	8

38.	3	35	67.609	9.422	.00875	8	8
39.	3	36	100.000	7.960	.00500	8	8
40.	3	37	100.000	7.960	.00500	8	8
41.	3	38	202.124	7.661	.00253	24	24
42.	3	39	202.124	7.661	.00253	24	24
43.	3	40	33.252	10.581	.01717	8	8
44.	3	41	58.862	5.664	.20023	8	8
45.	3	42	58.862	5.664	.20023	8	8
46.	3	43	58.862	5.664	.20023	8	8
47.	3	44	550.613	7.402	.00120	24	24
48.	3	45	98.158	8.020	.00528	8	8
49.	3	46	98.158	8.020	.00528	8	8
50.	3	47	167.979	7.786	.00307	24	24
51.	3	48	36.900	10.020	.02400	8	8
52.	3	49	36.900	10.020	.02400	8	8
53.	3	50	48.600	9.000	.03200	8	8
54.	3	51	25.512	10.355	.06103	8	8
55.	3	52	25.512	10.355	.06103	8	8
56.	3	53	37.177	9.708	.04322	8	8
57.	3	54	129.750	5.608	.03065	8	8
58.	3	55	129.750	5.608	.03065	8	8
59.	3	56	269.179	7.189	.00371	24	24
60.	3	57	60.000	8.410	.01070	8	8
61.	3	58	60.000	8.410	.01070	8	8
62.	3	59	105.397	8.269	.00475	8	8
63.	3	60	210.387	7.373	.00369	24	24
64.	3	61	528.766	8.201	.00030	24	24
65.	3	62	628.476	7.761	.00071	24	24
66.	3	63	218.401	7.283	.00351	24	24
67.	3	64	218.401	7.283	.00351	24	24
68.	3	65	218.401	7.283	.00351	24	24
69.	3	66	218.401	7.283	.00351	24	24
70.	3	67	254.939	7.476	.00275	24	24
71.	3	68	550.613	7.402	.00120	24	24
72.	3	69	192.263	7.746	.00246	24	24
73.	3	70	216.621	7.341	.00301	24	24
74.	3	71	369.091	7.391	.00185	24	24
75.	3	72	329.425	7.322	.00212	24	24
76.	3	73	387.117	8.246	.00069	24	24

77.	3	74	398.457	7.487	.00190	24	24
78.	3	75	33.252	10.581	.01717	8	8
79.	3	76	849.850	7.473	.00080	24	24
80.	3	77	849.850	7.473	.00080	24	24
81.	3	78	332.764	6.601	.00500	24	24
82.	3	79	332.764	6.601	.00500	24	24
83.	3	80	995.963	8.925	.00049	24	24
84.	3	81	10.	10.		4	
85.	3	82	10.	10.		4	
86.	3	83	10.	10.		4	
87.	3	84	10.	10.		4	
88.	3	85	10.	10.		4	
89.	3	86	10.	10.		4	
90.	3	87	10.	10.		4	
91.	3	88	10.	10.		4	
92.	3	89	10.	10.		4	
93.	3	90	10.	10.		4	
94.	3	91	10.	10.		4	
95.	3	92	10.	10.		4	
96.	3	93	10.	10.		4	
97.	3	94	10.	10.		4	
98.	3	95	10.	10.		4	
99.	3	96	10.	10.		4	
100.	3	97	10.	10.		4	
101.	3	98	10.	10.		4	
102.	3	99	10.	10.		4	
103.	3	100	10.	10.		4	
104.	3	101	10.	10.		4	
105.	3	102	10.	10.		4	
106.	3	103	10.	10.		4	

END DATA, ERRORS: NONE. TIME: 1.574 SEC. IMAGE COUNT: 106

Appendix C

GENERATING UNIT FUEL DATA

This appendix gives a complete set of Generating Unit Fuel Data. The data appear in the following format:

Column 1	Line number
Column 2	Data type
Column 3	Unit number
Column 4	Base fuel price ($/MBtu)
Column 5	Dispatch price ($/MBtu)
Column 6	Cost of cold start ($)
Column 7	Auxiliary fuel price ($/MBtu)
Column 8	Base fuel allocation (MBtu)

WDATA•L DATA61.
DATA 9R1 SL74T9 01/06/82 16:05:52 (1)

COL. 2	COL. 3	COL. 4	COL. 5	COL. 6	COL. 7	COL. 8
******	******	******	******	******	******	******
4	1	2.2500	1.5000	237.0	1.5000	207556.
4	2	2.0000	1.5500	245.0	1.5500	129915.
4	3	2.0000	1.5500	245.0	1.5500	255723.
4	4	2.0000	1.5500	245.0	1.5500	126143.
4	5	2.0000	1.5500	245.0	1.5500	126143.
4	6	2.3000	1.5500	250.0	1.5500	169090.
4	7	2.3000	1.5500	292.0	1.5500	337482.
4	8	2.2500	1.5500	245.0	1.5500	109700.
4	9	2.2500	1.5500	245.0	1.5500	109699.
4	10	1.5000	1.5500	367.0	1.5500	419523.
4	11	1.5000	1.5500	393.0	1.5500	582301.
4	12	1.6000	1.5500	222.0	1.5500	65176.
4	13	1.6000	1.5500	222.0	1.5500	65176.
4	14	1.6000	1.5500	367.0	1.5500	0.
4	15	1.5500	1.5500	315.0	1.5500	265494.
4	16	1.5500	1.5500	315.0	1.5500	354698.
4	17	1.5500	1.5500	315.0	1.5500	265494.
4	18	1.3000	1.5500	267.0	1.5500	147624.
4	19	1.3000	1.5500	267.0	1.5500	300022.
4	20	1.3000	1.5500	267.0	1.5500	132126.
4	21	1.3000	1.5500	267.0	1.5500	132126.
4	22	2.0000	1.5500	452.0	1.5500	821465.
4	23	2.0000	1.5500	452.0	1.5500	821463.
4	24	1.5500	1.5500	346.0	1.5500	0.
4	25	1.5500	1.5500	346.0	1.5500	351027.
4	26	1.3000	1.5500	312.0	1.5500	300040.
4	27	1.3000	1.5500	312.0	1.5500	0.
4	28	1.3000	1.5500	312.0	1.5500	300040.
4	29	1.3000	1.5500	627.0	1.5500	1740517.
4	30	2.2500	1.5000	273.0	1.5000	149283.
4	31	2.2500	1.5000	273.0	1.5000	149290.
4	32	1.6000	1.5000	260.0	1.5000	201781.
4	33	1.6000	1.5000	267.0	1.5000	166395.
4	34	1.6000	1.5000	317.0	1.5000	240787.

38.	4	35	1.6000	1.5000	317.0	1.5000	240787.
39.	4	36	1.6000	1.5000	377.0	1.5000	368684.
40.	4	37	1.6000	1.5000	392.0	1.5000	371261.
41.	4	38	1.8000	1.5000	465.0	1.5000	1072345.
42.	4	39	1.8000	1.5000	468.0	1.5000	1072357.
43.	4	40	2.0000	1.5000	245.0	1.5000	93115.
44.	4	41	2.2500	1.5000	217.0	1.5000	61848.
45.	4	42	2.2500	1.5000	217.0	1.5000	61848.
46.	4	43	2.2500	1.5000	217.0	1.5000	61848.
47.	4	44	1.6000	1.5000	737.0	1.5000	2726491.
48.	4	45	1.8000	1.5000	344.0	1.5000	353304.
49.	4	46	1.8000	1.5000	344.0	1.5000	353277.
50.	4	47	1.8000	1.5000	444.0	1.5000	758891.
51.	4	48	2.0500	1.9000	242.0	1.9000	116714.
52.	4	49	2.0500	1.9000	242.0	1.9000	124438.
53.	4	50	2.0500	1.9000	247.0	1.9000	114444.
54.	4	51	1.6000	1.7000	217.0	1.7000	38067.
55.	4	52	1.6000	1.7000	217.0	1.7000	38067.
56.	4	53	1.6000	1.7000	232.0	1.7000	91506.
57.	4	54	1.8000	1.7000	287.0	1.7000	205373.
58.	4	55	1.8000	1.7000	287.0	1.7000	205370.
59.	4	56	1.8000	1.7000	506.0	1.7000	603401.
60.	4	57	1.6500	1.6000	285.0	1.6000	152696.
61.	4	58	1.6500	1.6000	285.0	1.6000	152696.
62.	4	59	1.6500	1.6000	322.0	1.6000	185241.
63.	4	60	1.8000	1.6000	447.0	1.6000	632071.
64.	4	61	1.5000	1.5500	736.0	1.5500	3003036.
65.	4	62	1.5000	1.5500	736.0	1.5500	2940215.
66.	4	63	1.9000	1.5500	453.0	1.5500	887835.
67.	4	64	1.9000	1.5500	453.0	1.5500	887834.
68.	4	65	1.9000	1.5500	453.0	1.5500	887832.
69.	4	66	1.9000	1.5500	453.0	1.5500	887832.
70.	4	67	1.6000	1.5000	533.0	1.5000	1098005.
71.	4	68	1.6000	1.5000	737.0	1.5000	2579973.
72.	4	69	1.5000	1.5500	467.0	1.5500	1013911.
73.	4	70	1.5000	1.5500	522.0	1.5500	1155055.
74.	4	71	1.5000	1.5500	625.0	1.5500	1819656.
75.	4	72	1.5000	1.5500	631.0	1.5500	1722273.
76.	4	73	2.0000	1.7000	627.0	1.7000	1026425.

77.	4	74	1.8000	1.6000	627.0	1.6000	1134288.
78.	4	75	1.6000	1.6000	245.0	1.6000	93115.
79.	4	76	1.5000	1.5500	600.0	1.5500	3629817.
80.	4	77	1.9000	1.5000	600.0	1.5000	3791548.
81.	4	78	1.5500	1.5500	600.0	1.5500	1079896.
82.	4	79	1.5500	1.5500	600.0	1.5500	1079897.
83.	4	80	1.0000	1.0000	6000.0	1.0000	4063241.
84.	4	81	2.70		100.		
85.	4	82	2.70		100.		
86.	4	83	2.70		100.		
87.	4	84	2.70		100.		
88.	4	85	2.70		100.		
89.	4	86	2.70		100.		
90.	4	87	2.70		100.		
91.	4	88	2.70		100.		
92.	4	89	2.70		100.		
93.	4	90	2.70		100.		
94.	4	91	2.70		100.		
95.	4	92	2.70		100.		
96.	4	93	2.70		100.		
97.	4	94	2.70		100.		
98.	4	95	2.70		100.		
99.	4	96	2.70		100.		
100.	4	97	2.70		100.		
101.	4	98	2.70		100.		
102.	4	99	2.70		100.		
103.	4	100	2.70		100.		
104.	4	101	2.70		100.		
105.	4	102	2.70		100.		
106.	4	103	2.70		100.		

END DATA, ERRORS: NONE, TIME: 1.543 SEC. IMAGE COUNT: 106

Appendix D

TIE LINE DATA

This appendix gives a complete set of Tie Line Data. The data appear in the following format:

Column 1	Line number
Column 2	Data type
Column 3	Identification number of company
Column 4	Name of company
Column 5	Prescheduled interchange fraction
Column 6	Flag indicating that distribution factors follow

(Tie Line Distribution Factors are entered following the head card above.)

```
@DATA,L DATA62.
DATA 9R1 SL74T9 01/06/82 16:06:04 (1)
    1.         COL. COL.   COL.         COL.      COL.
    2.           2    3      4            5         6
    3.          ************************************
    4.            5  501  WEST             .4        1.
    5.       .3         .05       .038     0.        .031      .019      .032      .04
    6.       .05        .056      .028     .01       .2        .1        .024      .022
    7.       0.         0.        0.       0.        0.
    8.            5  502  NORTH            .2        1.
    9.       .396       .069      .044     0.        .042      .027      .043      .041
   10.       .02        .077      .038     .015      .103      .044      .022      .019
   11.       0.         0.        0.       0.        0.
   12.            5  503  NE               .2        1.
   13.       .253       .039      .022     0.        .03       .03       .031      .031
   14.       .047       .23       .093     .041      .087      .035      .017      .014
   15.       0.         0.        0.       0.        0.
   16.            5  504  EAST             .1        1.
   17.       .185       .028      .015     0.        .026      .02       .028      .027
   18.       .062       .177      .218     .072      .081      .032      .016      .013
   19.       0.         0.        0.       0.        0.
   20.            5  505  SOUTH            .1        1.
   21.
   22.
   23.       .178       .707      .098     .017      0.
END DATA, ERRORS: NONE. TIME:  1.198 SEC. IMAGE COUNT: 23
```

Appendix E

MANUAL SCHEDULE DATA

This appendix gives a complete set of Manual Schedule Data. The data appear in the following format:

Column 1	Line number
Column 2	Data type
Column 3	Unit number
Column 4	First interval of the period of manual scheduling
Column 5	Last interval of the period of manual scheduling
Column 6	Status of unit
Column 7	Fixed power generation

```
WDATA,L DATA63.
DATA 9R1 SL74T9 01/06/82 16:06:16 (1)
     1.          COL. COL.        COL.       COL.       COL.      COL.
     2.            2    3           4          5          6         7
     3.            ***********************************************
     4.            7   27                                -1
     5.            7   14                                -1
     6.            7   24                                -1
     7.            7    1                                 1
     8.            7    3                                 1
     9.            7    6                                 1
    10.            7   19                                 2        42
    11.            7   31                                 1
    12.            7   43                                 1
    13.            7   49                                 2        20
    14.            7  104           1          2          1        80
    15.            7  109           1          2          1       140
    16.            7  108           1          1          1       250
    17.            7  107           1          2          1       600
END DATA, ERRORS: NONE. TIME:  1.161 SEC. IMAGE COUNT: 17
```

Appendix F

B_{NO} CONSTANT DATA

This appendix gives a complete set of B_{NO} Constant Data which is used in calculating transmission loss. The data appear in the following format:

Column	1	2	3	4	5	6	7	8	9
	Line number	BO_1	BO_2	BO_3	BO_4	BO_5	BO_6	BO_7	BO_8
		BO_9	BO_{10}	BO_{11}	-	-	-	-	-
		-	-	-	-	-	-	-	-
		BO_{57}	BO_{58}	-	-	-	-	-	BO_{64}

WDATA,L DATA10.
DATA 9R1 SL74T9 01/06/82 16:06:31 (1)

1.	COL.	COL.	COL.	COL.	COL.	COL.	COL.	COL.
2.	2	3	4	5	6	7	8	9
3.	**********	**********	**********	**********	**********	**********	**********	**********
4.	0.0112	0.0149	0.0294	0.0517	0.0279	0.0585	-.0410	0.0071
5.	0.0083	0.0071	-.0095	-.0253	-.0245	-.0315	-.0161	-.0251
6.	0.0490	-.0610	-.0195	-.0556	0.0088	0.0730	0.0073	0.0075
7.	-.0232	-.0524	0.0093	0.0265	0.0095	0.2435	0.0414	0.0411
8.	0.0123	0.0031	0.0187	0.0159	-.0056	-.0093	-.0200	-.0107
9.	-.0289	-.0240	0.0073	-.0174	-.0435	0.0122	-.0268	-.0440
10.	-.0665	-.0594	0.0116	0.0090	0.1074	-.0588	-.0196	-.0055
11.	0.0182	0.0084						

END DATA, ERRORS: NONE. TIME: 1.124 SEC. IMAGE COUNT: 11

Appendix G

B_{NJ} CONSTANT DATA

This appendix gives a complete set of B_{NJ} Constant Data which is used in calculating transmission loss. The data appear in the following format:

Column	1	2	3	4	5	6	7	8	9
	Line No.	$B_{1(1)}$	$B_{1(2)}$	$B_{1(3)}$	$B_{1(4)}$	$B_{1(5)}$	$B_{1(6)}$	$B_{1(7)}$	$B_{1(8)}$
		$B_{1(9)}$	$B_{1(10)}$	$B_{1(11)}$	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		$B_{1(57)}$	$B_{1(58)}$						
		$B_{2(1)}$	$B_{2(2)}$	$B_{2(3)}$	$B_{2(4)}$	$B_{2(5)}$	$B_{2(6)}$	$B_{2(7)}$	$B_{2(8)}$
		$B_{2(9)}$	$B_{2(10)}$	$B_{2(11)}$	-	-	-	-	-
		-	-	-	-	-	-	-	-
		$B_{2(57)}$	$B_{2(58)}$						
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		$B_{58(1)}$	$B_{58(2)}$	$B_{58(3)}$	$B_{58(4)}$	$B_{58(5)}$	$B_{58(6)}$	$B_{58(7)}$	$B_{58(8)}$
		$B_{58(9)}$	$B_{58(10)}$	$B_{58(11)}$	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		$B_{58(57)}$	$B_{58(58)}$						

WDATA,L DATA11.
DATA 9R1 SL74T9 01/06/82 16:04:32 (1)

1.	COL.	COL.	COL.	COL.	COL.	COL.	COL.	COL.
2.	2	3	4	5	6	7	8	9
3.	************	************	************	************	************	************	************	************
4.	0.0321	0.0022	0.0019	0.0000	-.0036	-.0008	-.0016	0.0017
5.	0.0022	0.0021	-.0007	-.0014	-.0021	-.0027	-.0037	-.0014
6.	0.0022	-.0032	-.0046	-.0045	0.0022	-.0002	0.0022	0.0022
7.	-.0010	-.0046	0.0074	-.0035	0.0022	-.0004	-.0040	-.0039
8.	0.0023	0.0018	0.0055	0.0020	0.0000	-.0009	-.0010	-.0019
9.	-.0016	-.0015	-.0018	-.0014	-.0044	-.0049	-.0049	-.0043
10.	-.0051	-.0046	0.0020	0.0021	-.0004	-.0013	-.0014	-.0004
11.	0.0018	0.0019						
12.	0.0022	0.0196	0.0025	0.0008	-.0032	-.0003	-.0016	0.0013
13.	0.0018	0.0017	-.0008	-.0014	-.0020	-.0026	-.0035	-.0013
14.	0.0063	-.0031	-.0043	-.0042	0.0016	0.0004	0.0018	0.0018
15.	-.0010	-.0043	0.0033	-.0032	0.0037	0.0005	-.0035	-.0035
16.	0.0018	0.0015	0.0019	0.0016	-.0001	-.0009	-.0010	-.0018
17.	-.0015	-.0014	-.0018	-.0013	-.0042	-.0046	-.0047	-.0041
18.	-.0048	-.0043	0.0015	0.0016	0.0001	-.0013	-.0014	-.0003
19.	0.0097	0.0069						
20.	0.0019	0.0025	0.0165	0.0013	-.0032	0.0001	-.0016	0.0014
21.	0.0020	0.0018	-.0007	-.0013	-.0020	-.0026	-.0036	-.0013
22.	0.0060	-.0031	-.0043	-.0043	0.0018	0.0009	0.0020	0.0020
23.	-.0009	-.0044	0.0020	-.0032	0.0029	0.0010	-.0035	-.0035
24.	0.0019	0.0016	0.0019	0.0017	0.0000	-.0009	-.0009	-.0018
25.	-.0015	-.0014	-.0018	-.0013	-.0043	-.0048	-.0048	-.0041
26.	-.0049	-.0044	0.0017	0.0017	0.0005	-.0012	-.0014	-.0002
27.	0.0024	0.0025						
28.	0.0000	0.0008	0.0013	0.0256	-.0012	0.0041	-.0020	-.0001
29.	0.0002	0.0002	-.0017	-.0019	-.0023	-.0028	-.0039	-.0018
30.	0.0011	-.0032	-.0036	-.0041	0.0001	0.0061	0.0003	0.0003
31.	-.0014	-.0040	0.0003	-.0023	0.0013	0.0168	-.0015	-.0019
32.	0.0002	0.0001	0.0001	-.0000	-.0012	-.0019	-.0017	-.0025
33.	-.0020	-.0020	-.0025	-.0019	-.0042	-.0050	-.0048	-.0041
34.	-.0046	-.0042	-.0000	0.0000	0.0074	-.0017	-.0018	-.0001
35.	0.0008	0.0010						
36.	-.0036	-.0032	-.0032	-.0012	0.0184	0.0022	-.0006	-.0032
37.	-.0033	-.0032	-.0024	-.0013	0.0005	0.0011	0.0016	-.0014
38.	-.0037	0.0024	0.0087	0.0050	-.0034	-.0001	-.0032	-.0032

39.	-.0013	0.0063	-.0033	0.0070	-.0030	-.0022	0.0202	0.0142
40.	-.0034	-.0030	-.0035	-.0036	-.0026	-.0026	-.0020	-.0021
41.	-.0014	-.0016	-.0020	-.0015	0.0040	0.0021	0.0036	0.0039
42.	0.0067	0.0050	-.0034	-.0033	-.0004	-.0011	-.0004	-.0016
43.	-.0034	-.0031						
44.	-.0008	-.0003	0.0001	0.0041	0.0022	0.0145	-.0012	-.0007
45.	-.0006	-.0006	-.0014	-.0013	-.0013	-.0016	-.0023	-.0013
46.	-.0004	-.0017	-.0010	-.0020	-.0007	0.0056	-.0005	-.0005
47.	-.0009	-.0017	-.0006	0.0000	0.0000	0.0041	0.0021	0.0013
48.	-.0006	-.0005	-.0007	-.0008	-.0012	-.0016	-.0013	-.0018
49.	-.0014	-.0014	-.0018	-.0013	-.0022	-.0031	-.0027	-.0021
50.	-.0020	-.0020	-.0008	-.0007	0.0047	-.0011	-.0010	0.0005
51.	-.0003	-.0001						
52.	-.0016	-.0016	-.0016	-.0020	-.0006	-.0012	0.0197	-.0008
53.	-.0013	-.0012	0.0018	0.0021	0.0055	0.0021	0.0016	0.0020
54.	-.0020	0.0041	-.0000	0.0004	-.0014	-.0016	-.0012	-.0012
55.	0.0022	0.0002	-.0014	0.0004	-.0014	-.0029	-.0007	-.0005
56.	-.0014	-.0008	-.0015	-.0015	0.0009	0.0019	0.0024	0.0019
57.	0.0019	0.0019	0.0020	0.0026	0.0006	0.0012	0.0008	0.0007
58.	-.0000	0.0004	-.0015	-.0014	-.0017	0.0068	0.0040	0.0010
59.	-.0017	-.0015						
60.	0.0017	0.0013	0.0014	-.0001	-.0032	-.0007	-.0008	0.0115
61.	0.0022	0.0021	-.0002	-.0008	-.0012	-.0021	-.0030	-.0007
62.	0.0009	-.0025	-.0040	-.0039	0.0020	-.0002	0.0022	0.0022
63.	-.0003	-.0040	0.0017	-.0029	0.0016	-.0005	-.0035	-.0034
64.	0.0021	0.0025	0.0019	0.0020	0.0004	-.0003	-.0004	-.0012
65.	-.0009	-.0008	-.0011	-.0007	-.0038	-.0041	-.0042	-.0036
66.	-.0045	-.0039	0.0018	0.0019	-.0004	-.0006	-.0001	0.0005
67.	0.0012	0.0014						
68.	0.0022	0.0018	0.0020	0.0002	-.0033	-.0006	-.0013	0.0022
69.	0.0035	0.0026	-.0003	-.0010	-.0017	-.0023	-.0033	-.0010
70.	0.0015	-.0029	-.0042	-.0041	0.0025	0.0000	0.0027	0.0027
71.	-.0006	-.0042	0.0022	-.0031	0.0021	-.0001	-.0036	-.0036
72.	0.0031	0.0023	0.0025	0.0026	0.0005	-.0004	-.0005	-.0014
73.	-.0012	-.0011	-.0014	-.0010	-.0040	-.0044	-.0045	-.0039
74.	-.0048	-.0042	0.0024	0.0024	-.0002	-.0009	-.0010	-.0000
75.	0.0017	0.0018						
76.	0.0021	0.0017	0.0018	0.0002	-.0032	-.0006	-.0012	0.0021
77.	0.0026	0.0047	0.0003	-.0010	-.0017	-.0023	-.0032	-.0010
78.	0.0013	-.0028	-.0041	-.0040	0.0043	-.0000	0.0028	0.0028

79.	-.0006	-.0041	0.0020	-.0031	0.0019	-.0001	-.0035	-.0035
80.	0.0026	0.0021	0.0024	0.0038	0.0016	0.0002	-.0002	-.0014
81.	-.0012	-.0011	-.0014	-.0010	-.0039	-.0043	-.0044	-.0038
82.	-.0046	-.0041	0.0040	0.0038	-.0003	-.0009	-.0010	-.0000
83.	0.0016	0.0017						
84.	-.0007	-.0008	-.0007	-.0017	-.0024	-.0014	0.0018	-.0002
85.	-.0003	0.0003	0.0303	0.0018	0.0006	0.0001	-.0008	0.0019
86.	-.0012	-.0007	-.0025	-.0021	-.0000	-.0015	-.0002	-.0002
87.	0.0023	-.0023	-.0006	-.0018	-.0005	-.0025	-.0027	-.0025
88.	-.0004	0.0000	-.0005	0.0000	0.0210	0.0298	0.0184	0.0018
89.	0.0017	0.0018	0.0019	0.0022	-.0019	-.0016	-.0019	-.0017
90.	-.0028	-.0022	-.0003	-.0002	-.0016	0.0023	0.0009	0.0008
91.	-.0009	-.0007						
92.	-.0014	-.0014	-.0013	-.0019	-.0013	-.0013	0.0021	-.0008
93.	-.0010	-.0010	0.0018	0.0122	0.0014	0.0022	0.0014	0.0050
94.	-.0018	0.0006	-.0010	-.0003	-.0012	-.0015	-.0010	-.0010
95.	0.0033	-.0007	-.0012	-.0007	-.0012	-.0027	-.0015	-.0013
96.	-.0011	-.0005	-.0013	-.0013	0.0010	0.0020	0.0024	0.0051
97.	0.0054	0.0047	0.0054	0.0072	0.0000	0.0009	0.0003	0.0002
98.	-.0010	-.0004	-.0012	-.0012	-.0017	0.0030	0.0011	0.0013
99.	-.0015	-.0013						
100.	-.0021	-.0020	-.0020	-.0023	0.0005	-.0013	0.0055	-.0012
101.	-.0017	-.0017	0.0006	0.0014	0.0134	0.0030	0.0026	0.0014
102.	-.0025	0.0051	0.0015	0.0016	-.0018	-.0019	-.0017	-.0017
103.	0.0015	0.0016	-.0019	0.0019	-.0018	-.0034	0.0004	0.0008
104.	-.0018	-.0013	-.0020	-.0020	-.0001	0.0006	0.0011	0.0012
105.	0.0013	0.0012	0.0012	0.0015	0.0018	0.0024	0.0021	0.0019
106.	0.0014	0.0016	-.0019	-.0019	-.0020	0.0028	0.0068	0.0006
107.	-.0022	-.0020						
108.	-.0027	-.0026	-.0026	-.0028	0.0011	-.0016	0.0021	-.0021
109.	-.0023	-.0023	0.0001	0.0022	0.0030	0.0093	0.0091	0.0019
110.	-.0031	0.0045	0.0029	0.0048	-.0024	-.0023	-.0023	-.0023
111.	0.0015	0.0038	-.0025	0.0016	-.0024	-.0040	0.0011	0.0013
112.	-.0025	-.0018	-.0026	-.0026	-.0006	0.0001	0.0006	0.0018
113.	0.0023	0.0017	0.0019	0.0017	0.0058	0.0093	0.0074	0.0061
114.	0.0037	0.0048	-.0025	-.0024	-.0024	0.0016	0.0015	-.0001
115.	-.0027	-.0025						
116.	-.0037	-.0035	-.0036	-.0039	0.0016	-.0023	0.0016	-.0030
117.	-.0033	-.0032	-.0008	0.0014	0.0026	0.0091	0.0417	0.0012
118.	-.0042	0.0050	0.0040	0.0071	-.0034	-.0032	-.0032	-.0032

119.	0.0007	0.0054	-.0034	0.0019	-.0033	-.0053	0.0016	0.0018
120.	-.0035	-.0028	-.0036	-.0036	-.0016	-.0008	-.0003	0.0008
121.	0.0015	0.0009	0.0010	0.0009	0.0087	0.0391	0.0197	0.0092
122.	0.0052	0.0071	-.0035	-.0034	-.0032	0.0009	0.0009	-.0009
123.	-.0037	-.0035						
124.	-.0014	-.0013	-.0013	-.0018	-.0014	-.0013	0.0020	-.0007
125.	-.0010	-.0010	0.0019	0.0050	0.0014	0.0019	0.0012	0.0070
126.	-.0018	0.0005	-.0011	-.0005	-.0011	-.0015	-.0010	-.0010
127.	0.0033	-.0009	-.0012	-.0008	-.0011	-.0027	-.0016	-.0014
128.	-.0011	-.0005	-.0013	-.0012	0.0010	0.0020	0.0024	0.0070
129.	0.0068	0.0063	0.0077	0.0043	-.0002	0.0006	0.0001	-.0000
130.	-.0012	-.0006	-.0012	-.0012	-.0016	0.0030	0.0010	0.0014
131.	-.0015	-.0013						
132.	0.0022	0.0063	0.0060	0.0011	-.0037	-.0004	-.0020	0.0009
133.	0.0015	0.0013	-.0012	-.0018	-.0025	-.0031	-.0042	-.0018
134.	0.0858	-.0036	-.0049	-.0049	0.0013	0.0005	0.0015	0.0015
135.	-.0014	-.0050	0.0028	-.0037	0.0027	0.0003	-.0040	-.0040
136.	0.0015	0.0011	0.0017	0.0012	-.0005	-.0014	-.0014	-.0024
137.	-.0020	-.0019	-.0024	-.0018	-.0048	-.0054	-.0054	-.0047
138.	-.0055	-.0050	0.0012	0.0013	0.0001	-.0017	-.0019	-.0007
139.	0.0051	0.0039						
140.	-.0032	-.0031	-.0031	-.0032	0.0024	-.0017	0.0041	-.0025
141.	-.0029	-.0028	-.0007	0.0006	0.0051	0.0045	0.0050	0.0005
142.	-.0036	0.0738	0.0050	0.0060	-.0030	-.0026	-.0028	-.0028
143.	0.0004	0.0067	-.0030	0.0025	-.0028	-.0047	0.0024	0.0025
144.	-.0030	-.0024	-.0031	-.0031	-.0013	-.0007	-.0002	0.0000
145.	0.0005	0.0003	0.0001	0.0004	0.0056	0.0054	0.0059	0.0056
146.	0.0070	0.0060	-.0030	-.0029	-.0027	0.0014	0.0023	-.0007
147.	-.0032	-.0030						
148.	-.0046	-.0043	-.0043	-.0036	0.0087	-.0010	-.0000	-.0040
149.	-.0042	-.0041	-.0025	-.0010	0.0015	0.0029	0.0040	-.0011
150.	-.0049	0.0050	0.0152	0.0093	-.0042	-.0027	-.0041	-.0041
151.	-.0012	0.0114	-.0042	0.0067	-.0040	-.0051	0.0092	0.0086
152.	-.0044	-.0037	-.0045	-.0045	-.0029	-.0027	-.0020	-.0017
153.	-.0010	-.0013	-.0016	-.0013	0.0080	0.0053	0.0075	0.0078
154.	0.0123	0.0095	-.0043	-.0042	-.0028	-.0008	0.0000	-.0021
155.	-.0044	-.0042						
156.	-.0045	-.0042	-.0043	-.0041	0.0050	-.0020	0.0004	-.0039
157.	-.0041	-.0040	-.0021	-.0003	0.0016	0.0048	0.0071	-.0005
158.	-.0049	0.0060	0.0093	0.0161	-.0041	-.0033	-.0040	-.0040

159.	-.0007	0.0123	-.0041	0.0043	-.0040	-.0057	0.0052	0.0051
160.	-.0043	-.0036	-.0044	-.0044	-.0026	-.0022	-.0016	-.0011
161.	-.0004	-.0007	-.0009	-.0007	0.0139	0.0098	0.0136	0.0138
162.	0.0124	0.0166	-.0042	-.0041	-.0034	-.0004	0.0001	-.0019
163.	-.0044	-.0042						
164.	0.0022	0.0016	0.0018	0.0001	-.0034	-.0007	-.0014	0.0020
165.	0.0025	0.0043	-.0000	-.0012	-.0018	-.0024	-.0034	-.0011
166.	0.0013	-.0030	-.0042	-.0041	0.0095	-.0001	0.0027	0.0027
167.	-.0007	-.0043	0.0021	-.0032	0.0019	-.0002	-.0037	-.0036
168.	0.0025	0.0020	0.0024	0.0039	0.0011	-.0002	-.0005	-.0016
169.	-.0013	-.0012	-.0016	-.0011	-.0041	-.0045	-.0046	-.0040
170.	-.0048	-.0042	0.0092	0.0073	-.0003	-.0011	-.0012	-.0001
171.	0.0015	0.0017						
172.	-.0002	0.0004	0.0009	0.0061	-.0001	0.0056	-.0016	-.0002
173.	0.0000	-.0000	-.0015	-.0015	-.0019	-.0023	-.0032	-.0015
174.	0.0005	-.0026	-.0027	-.0033	-.0001	0.0286	0.0001	0.0001
175.	-.0011	-.0032	-.0000	-.0014	0.0008	0.0071	-.0002	-.0007
176.	-.0000	-.0000	-.0001	-.0002	-.0011	-.0016	-.0015	-.0021
177.	-.0017	-.0016	-.0020	-.0015	-.0034	-.0042	-.0040	-.0033
178.	-.0036	-.0034	-.0002	-.0002	0.0165	-.0014	-.0014	0.0004
179.	0.0003	0.0005						
180.	0.0022	0.0018	0.0020	0.0003	-.0032	-.0005	-.0012	0.0022
181.	0.0027	0.0028	-.0002	-.0010	-.0017	-.0023	-.0032	-.0010
182.	0.0015	-.0028	-.0041	-.0040	0.0027	0.0001	0.0030	0.0030
183.	-.0006	-.0041	0.0022	-.0031	0.0021	-.0000	-.0035	-.0035
184.	0.0027	0.0023	0.0025	0.0027	0.0007	-.0003	-.0005	-.0014
185.	-.0011	-.0011	-.0014	-.0009	-.0039	-.0043	-.0044	-.0038
186.	-.0046	-.0041	0.0026	0.0026	-.0002	-.0009	-.0010	0.0000
187.	0.0017	0.0019						
188.	0.0022	0.0018	0.0020	0.0003	-.0032	-.0005	-.0012	0.0022
189.	0.0027	0.0028	-.0002	-.0010	-.0017	-.0023	-.0032	-.0010
190.	0.0015	-.0028	-.0041	-.0040	0.0027	0.0001	0.0030	0.0040
191.	-.0006	-.0042	0.0022	-.0031	0.0021	-.0000	-.0035	-.0035
192.	0.0027	0.0023	0.0025	0.0027	0.0007	-.0003	-.0005	-.0014
193.	-.0011	-.0011	-.0014	-.0009	-.0039	-.0043	-.0044	-.0038
194.	-.0047	-.0041	0.0026	0.0026	-.0002	-.0009	-.0010	0.0000
195.	0.0017	0.0019						
196.	-.0010	-.0010	-.0009	-.0014	-.0013	-.0009	0.0022	-.0003
197.	-.0006	-.0006	0.0023	0.0033	0.0015	0.0015	0.0007	0.0033
198.	-.0014	0.0004	-.0012	-.0007	-.0007	-.0011	-.0006	-.0006

199.	0.0037	-.0010	-.0008	-.0007	-.0008	-.0022	-.0015	-.0013
200.	-.0007	-.0001	-.0009	-.0008	0.0014	0.0025	0.0028	0.0036
201.	0.0032	0.0033	0.0036	0.0036	-.0004	0.0002	-.0003	-.0003
202.	-.0013	-.0007	-.0008	-.0008	-.0013	0.0030	0.0013	0.0018
203.	-.0011	-.0009						
204.	-.0046	-.0043	-.0044	-.0040	0.0063	-.0017	0.0002	-.0040
205.	-.0042	-.0041	-.0023	-.0007	0.0016	0.0038	0.0054	-.0009
206.	-.0050	0.0067	0.0114	0.0123	-.0043	-.0032	-.0041	-.0042
207.	-.0010	0.0147	-.0042	0.0054	-.0041	-.0056	0.0067	0.0065
208.	-.0044	-.0038	-.0045	-.0045	-.0028	-.0025	-.0018	-.0015
209.	-.0008	-.0011	-.0013	-.0010	0.0107	0.0073	0.0102	0.0104
210.	0.0154	0.0125	-.0043	-.0042	-.0032	-.0006	0.0001	-.0021
211.	-.0045	-.0043						
212.	0.0074	0.0033	0.0020	0.0003	-.0033	-.0006	-.0014	0.0017
213.	0.0022	0.0020	-.0006	-.0012	-.0019	-.0025	-.0034	-.0012
214.	0.0028	-.0030	-.0042	-.0041	0.0021	-.0000	0.0022	0.0022
215.	-.0008	-.0042	0.0166	-.0032	0.0024	-.0001	-.0036	-.0036
216.	0.0022	0.0018	0.0032	0.0020	0.0001	-.0007	-.0008	-.0017
217.	-.0014	-.0013	-.0016	-.0012	-.0041	-.0045	-.0046	-.0040
218.	-.0048	-.0042	0.0020	0.0020	-.0002	-.0011	-.0012	-.0002
219.	0.0024	0.0024						
220.	-.0035	-.0032	-.0032	-.0023	0.0070	0.0000	0.0004	-.0029
221.	-.0031	-.0031	-.0018	-.0007	0.0019	0.0016	0.0019	-.0008
222.	-.0037	0.0025	0.0067	0.0043	-.0032	-.0014	-.0031	-.0031
223.	-.0007	0.0054	-.0032	0.0583	-.0030	-.0034	0.0076	0.0121
224.	-.0033	-.0028	-.0034	-.0034	-.0022	-.0019	-.0014	-.0013
225.	-.0008	-.0010	-.0012	-.0009	0.0036	0.0023	0.0034	0.0036
226.	0.0056	0.0044	-.0033	-.0032	-.0016	-.0004	0.0015	-.0013
227.	-.0034	-.0032						
228.	0.0022	0.0037	0.0029	0.0013	-.0030	0.0000	-.0014	0.0016
229.	0.0021	0.0019	-.0005	-.0012	-.0018	-.0024	-.0033	-.0011
230.	0.0027	-.0028	-.0040	-.0040	0.0019	0.0008	0.0021	0.0021
231.	-.0008	-.0041	0.0024	-.0030	0.0038	0.0014	-.0033	-.0033
232.	0.0021	0.0017	0.0021	0.0019	0.0002	-.0007	-.0007	-.0016
233.	-.0013	-.0012	-.0016	-.0011	-.0039	-.0044	-.0044	-.0038
234.	-.0046	-.0041	0.0018	0.0019	0.0005	-.0010	-.0012	-.0000
235.	0.0037	0.0037						
236.	-.0004	0.0005	0.0010	0.0168	-.0022	0.0041	-.0029	-.0005
237.	-.0001	-.0001	-.0025	-.0027	-.0034	-.0040	-.0053	-.0027
238.	0.0003	-.0047	-.0051	-.0057	-.0002	0.0071	-.0000	-.0000

239.	-.0022	-.0056	-.0001	-.0034	0.0014	0.2797	-.0030	-.0030
240.	-.0002	-.0003	-.0002	-.0004	-.0019	-.0030	-.0026	-.0040
241.	-.0030	-.0029	-.0040	-.0028	-.0058	-.0074	-.0068	-.0057
242.	-.0063	-.0058	-.0004	-.0003	0.0071	-.0026	-.0027	-.0008
243.	0.0007	0.0010						
244.	-.0040	-.0035	-.0035	-.0015	0.0202	0.0021	-.0007	-.0035
245.	-.0036	-.0035	-.0027	-.0015	0.0004	0.0011	0.0016	-.0016
246.	-.0040	0.0024	0.0092	0.0052	-.0037	-.0002	-.0035	-.0035
247.	-.0015	0.0067	-.0036	0.0076	-.0033	-.0030	0.0733	0.0169
248.	-.0038	-.0033	-.0039	-.0039	-.0029	-.0029	-.0023	-.0025
249.	-.0016	-.0018	-.0024	-.0017	0.0042	0.0018	0.0036	0.0041
250.	0.0070	0.0052	-.0037	-.0037	-.0006	-.0013	-.0005	-.0018
251.	-.0037	-.0035						
252.	-.0039	-.0035	-.0035	-.0019	0.0142	0.0013	-.0005	-.0034
253.	-.0036	-.0035	-.0025	-.0013	0.0008	0.0013	0.0018	-.0014
254.	-.0040	0.0025	0.0086	0.0051	-.0036	-.0007	-.0035	-.0035
255.	-.0013	0.0065	-.0036	0.0121	-.0033	-.0030	0.0169	0.0425
256.	-.0037	-.0032	-.0038	-.0038	-.0028	-.0027	-.0021	-.0021
257.	-.0014	-.0016	-.0020	-.0015	0.0042	0.0023	0.0038	0.0041
258.	0.0068	0.0052	-.0037	-.0036	-.0010	-.0011	-.0002	-.0018
259.	-.0037	-.0035						
260.	0.0023	0.0018	0.0019	0.0002	-.0034	-.0006	-.0014	0.0021
261.	0.0031	0.0026	-.0004	-.0011	-.0018	-.0025	-.0035	-.0011
262.	0.0015	-.0030	-.0044	-.0043	0.0025	-.0000	0.0027	0.0027
263.	-.0007	-.0044	0.0022	-.0033	0.0021	-.0002	-.0038	-.0037
264.	0.0051	0.0022	0.0026	0.0028	0.0005	-.0005	-.0006	-.0016
265.	-.0013	-.0012	-.0015	-.0011	-.0042	-.0046	-.0046	-.0041
266.	-.0049	-.0043	0.0024	0.0024	-.0003	-.0010	-.0011	-.0001
267.	0.0017	0.0018						
268.	0.0018	0.0015	0.0016	0.0001	-.0030	-.0005	-.0008	0.0025
269.	0.0023	0.0021	0.0000	-.0005	-.0013	-.0018	-.0028	-.0005
270.	0.0011	-.0024	-.0037	-.0036	0.0020	-.0000	0.0023	0.0023
271.	-.0001	-.0038	0.0018	-.0028	0.0017	-.0003	-.0033	-.0032
272.	0.0022	0.0033	0.0020	0.0020	0.0006	-.0001	-.0001	-.0008
273.	-.0007	-.0006	-.0008	-.0004	-.0035	-.0038	-.0039	-.0034
274.	-.0042	-.0037	0.0019	0.0020	-.0003	-.0004	-.0006	0.0003
275.	0.0014	0.0015						
276.	0.0055	0.0019	0.0019	0.0001	-.0035	-.0007	-.0015	0.0019
277.	0.0025	0.0024	-.0005	-.0013	-.0020	-.0026	-.0036	-.0013
278.	0.0017	-.0031	-.0045	-.0044	0.0024	-.0001	0.0025	0.0025

279.	-.0009	-.0045	0.0032	-.0034	0.0021	-.0002	-.0039	-.0038
280.	0.0026	0.0020	0.0205	0.0023	0.0002	-.0007	-.0008	-.0017
281.	-.0014	-.0013	-.0017	-.0012	-.0043	-.0047	-.0048	-.0042
282.	-.0050	-.0045	0.0023	0.0024	-.0004	-.0012	-.0013	-.0002
283.	0.0017	0.0019						
284.	0.0020	0.0016	0.0017	-.0000	-.0036	-.0008	-.0015	0.0020
285.	0.0026	0.0038	0.0000	-.0013	-.0020	-.0026	-.0036	-.0012
286.	0.0012	-.0031	-.0045	-.0044	0.0039	-.0002	0.0027	0.0027
287.	-.0008	-.0045	0.0020	-.0034	0.0019	-.0004	-.0039	-.0038
288.	0.0028	0.0020	0.0023	0.0166	0.0013	-.0002	-.0005	-.0017
289.	-.0014	-.0013	-.0017	-.0012	-.0043	-.0047	-.0048	-.0042
290.	-.0050	-.0045	0.0037	0.0039	-.0005	-.0012	-.0013	-.0002
291.	0.0015	0.0016						
292.	0.0000	-.0001	0.0000	-.0012	-.0026	-.0012	0.0009	0.0004
293.	0.0005	0.0016	0.0210	0.0010	-.0001	-.0006	-.0016	0.0010
294.	-.0005	-.0013	-.0029	-.0026	0.0011	-.0011	0.0007	0.0007
295.	0.0014	-.0028	0.0001	-.0022	0.0002	-.0019	-.0029	-.0028
296.	0.0005	0.0006	0.0002	0.0013	0.0353	0.0207	0.0126	0.0008
297.	0.0008	0.0009	0.0008	0.0012	-.0025	-.0024	-.0026	-.0023
298.	-.0033	-.0027	0.0008	0.0009	-.0012	0.0013	0.0003	0.0005
299.	-.0002	-.0001						
300.	-.0009	-.0009	-.0009	-.0019	-.0026	-.0016	0.0019	-.0003
301.	-.0004	0.0002	0.0298	0.0020	0.0006	0.0001	-.0008	0.0020
302.	-.0014	-.0007	-.0027	-.0022	-.0002	-.0016	-.0003	-.0003
303.	0.0025	-.0025	-.0007	-.0019	-.0007	-.0030	-.0029	-.0027
304.	-.0005	-.0001	-.0007	-.0002	0.0207	0.0634	0.0224	0.0019
305.	0.0018	0.0019	0.0019	0.0023	-.0020	-.0018	-.0020	-.0018
306.	-.0029	-.0023	-.0004	-.0003	-.0018	0.0024	0.0010	0.0008
307.	-.0011	-.0009						
308.	-.0010	-.0010	-.0009	-.0017	-.0020	-.0013	0.0024	-.0004
309.	-.0005	-.0002	0.0184	0.0024	0.0011	0.0006	-.0003	0.0024
310.	-.0014	-.0002	-.0020	-.0016	-.0005	-.0015	-.0005	-.0005
311.	0.0028	-.0018	-.0008	-.0014	-.0007	-.0026	-.0023	-.0021
312.	-.0006	-.0001	-.0008	-.0005	0.0126	0.0224	0.0347	0.0025
313.	0.0022	0.0024	0.0025	0.0028	-.0013	-.0010	-.0013	-.0012
314.	-.0022	-.0016	-.0007	-.0006	-.0016	0.0029	0.0014	0.0010
315.	-.0011	-.0009						
316.	-.0019	-.0018	-.0018	-.0025	-.0021	-.0018	0.0019	-.0012
317.	-.0014	-.0014	0.0018	0.0051	0.0012	0.0018	0.0008	0.0070
318.	-.0024	0.0000	-.0017	-.0011	-.0016	-.0021	-.0014	-.0014

319.	0.0036	-.0015	-.0017	-.0013	-.0016	-.0040	-.0025	-.0021
320.	-.0016	-.0008	-.0017	-.0017	0.0008	0.0019	0.0025	0.1276
321.	0.0063	0.0273	0.0080	0.0045	-.0007	-.0002	-.0006	-.0005
322.	-.0019	-.0011	-.0017	-.0016	-.0023	0.0031	0.0008	0.0012
323.	-.0020	-.0018						
324.	-.0016	-.0015	-.0015	-.0020	-.0014	-.0014	0.0019	-.0009
325.	-.0012	-.0012	0.0017	0.0054	0.0013	0.0023	0.0015	0.0068
326.	-.0020	0.0005	-.0010	-.0004	-.0013	-.0017	-.0011	-.0011
327.	0.0032	-.0008	-.0014	-.0008	-.0013	-.0030	-.0016	-.0014
328.	-.0013	-.0007	-.0014	-.0014	0.0008	0.0018	0.0022	0.0063
329.	0.0138	0.0057	0.0070	0.0043	0.0000	0.0009	0.0003	0.0002
330.	-.0011	-.0004	-.0014	-.0013	-.0018	0.0028	0.0010	0.0012
331.	-.0016	-.0015						
332.	-.0015	-.0014	-.0014	-.0020	-.0016	-.0014	0.0019	-.0008
333.	-.0011	-.0011	0.0018	0.0047	0.0012	0.0017	0.0009	0.0063
334.	-.0019	0.0003	-.0013	-.0007	-.0012	-.0016	-.0011	-.0011
335.	0.0033	-.0011	-.0013	-.0010	-.0012	-.0029	-.0018	-.0016
336.	-.0012	-.0006	-.0013	-.0013	0.0009	0.0019	0.0024	0.0273
337.	0.0057	0.0242	0.0075	0.0041	-.0004	0.0004	-.0002	-.0003
338.	-.0014	-.0008	-.0013	-.0013	-.0018	0.0029	0.0009	0.0013
339.	-.0016	-.0014						
340.	-.0018	-.0018	-.0018	-.0025	-.0020	-.0018	0.0020	-.0011
341.	-.0014	-.0014	0.0019	0.0054	0.0012	0.0019	0.0010	0.0077
342.	-.0024	0.0001	-.0016	-.0009	-.0016	-.0020	-.0014	-.0014
343.	0.0036	-.0013	-.0016	-.0012	-.0016	-.0040	-.0024	-.0020
344.	-.0015	-.0008	-.0017	-.0017	0.0008	0.0019	0.0025	0.0080
345.	0.0070	0.0075	0.1304	0.0046	-.0005	0.0000	-.0004	-.0004
346.	-.0017	-.0010	-.0017	-.0016	-.0023	0.0031	0.0009	0.0013
347.	-.0019	-.0018						
348.	-.0014	-.0013	-.0013	-.0019	-.0015	-.0013	0.0026	-.0007
349.	-.0010	-.0010	0.0022	0.0072	0.0015	0.0017	0.0009	0.0043
350.	-.0018	0.0004	-.0013	-.0007	-.0011	-.0015	-.0009	-.0009
351.	0.0036	-.0010	-.0012	-.0009	-.0011	-.0028	-.0017	-.0015
352.	-.0011	-.0004	-.0012	-.0012	0.0012	0.0023	0.0028	0.0045
353.	0.0043	0.0041	0.0046	0.0225	-.0004	0.0003	-.0002	-.0002
354.	-.0014	-.0008	-.0012	-.0012	-.0017	0.0039	0.0012	0.0015
355.	-.0015	-.0013						
356.	-.0044	-.0042	-.0043	-.0042	0.0040	-.0022	0.0006	-.0038
357.	-.0040	-.0039	-.0019	0.0000	0.0018	0.0058	0.0087	-.0002
358.	-.0048	0.0056	0.0080	0.0139	-.0041	-.0034	-.0039	-.0039

359.	-.0004	0.0107	-.0041	0.0036	-.0039	-.0058	0.0042	0.0042
360.	-.0042	-.0035	-.0043	-.0043	-.0025	-.0020	-.0013	-.0007
361.	0.0000	-.0004	-.0005	-.0004	0.0272	0.0135	0.0205	0.0172
362.	0.0107	0.0139	-.0041	-.0040	-.0034	-.0002	0.0002	-.0018
363.	-.0043	-.0041						
364.	-.0049	-.0046	-.0048	-.0050	0.0021	-.0031	0.0012	-.0041
365.	-.0044	-.0043	-.0016	0.0009	0.0024	0.0093	0.0391	0.0006
366.	-.0054	0.0054	0.0053	0.0098	-.0045	-.0042	-.0043	-.0043
367.	0.0002	0.0073	-.0045	0.0023	-.0044	-.0074	0.0018	0.0023
368.	-.0046	-.0038	-.0047	-.0047	-.0024	-.0018	-.0010	-.0002
369.	0.0009	0.0004	0.0000	0.0003	0.0135	0.1730	0.0501	0.0128
370.	0.0071	0.0098	-.0045	-.0044	-.0043	0.0004	0.0004	-.0017
371.	-.0049	-.0046						
372.	-.0049	-.0047	-.0048	-.0048	0.0036	-.0027	0.0008	-.0042
373.	-.0045	-.0044	-.0019	0.0003	0.0021	0.0074	0.0197	0.0001
374.	-.0054	0.0059	0.0075	0.0136	-.0046	-.0040	-.0044	-.0044
375.	-.0003	0.0102	-.0046	0.0034	-.0044	-.0068	0.0036	0.0038
376.	-.0046	-.0039	-.0048	-.0048	-.0026	-.0020	-.0013	-.0006
377.	0.0003	-.0002	-.0004	-.0002	0.0205	0.0501	0.1050	0.0174
378.	0.0101	0.0136	-.0046	-.0045	-.0040	-.0000	0.0003	-.0019
379.	-.0049	-.0046						
380.	-.0043	-.0041	-.0041	-.0041	0.0039	-.0021	0.0007	-.0036
381.	-.0039	-.0038	-.0017	0.0002	0.0019	0.0061	0.0092	-.0000
382.	-.0047	0.0056	0.0078	0.0138	-.0040	-.0033	-.0038	-.0038
383.	-.0003	0.0104	-.0040	0.0036	-.0038	-.0057	0.0041	0.0041
384.	-.0041	-.0034	-.0042	-.0042	-.0023	-.0018	-.0012	-.0005
385.	0.0002	-.0003	-.0004	-.0002	0.0172	0.0128	0.0174	0.0269
386.	0.0103	0.0139	-.0040	-.0039	-.0034	-.0000	0.0003	-.0016
387.	-.0042	-.0040						
388.	-.0051	-.0048	-.0049	-.0046	0.0067	-.0020	-.0000	-.0045
389.	-.0048	-.0046	-.0028	-.0010	0.0014	0.0037	0.0052	-.0012
390.	-.0055	0.0070	0.0123	0.0124	-.0048	-.0036	-.0046	-.0047
391.	-.0013	0.0154	-.0048	0.0056	-.0046	-.0063	0.0070	0.0068
392.	-.0049	-.0042	-.0050	-.0050	-.0033	-.0029	-.0022	-.0019
393.	-.0011	-.0014	-.0017	-.0014	0.0107	0.0071	0.0101	0.0103
394.	0.0283	0.0126	-.0048	-.0047	-.0036	-.0010	-.0002	-.0025
395.	-.0050	-.0048						
396.	-.0046	-.0043	-.0044	-.0042	0.0050	-.0020	0.0004	-.0039
397.	-.0042	-.0041	-.0022	-.0004	0.0016	0.0048	0.0071	-.0006
398.	-.0050	0.0060	0.0095	0.0166	-.0042	-.0034	-.0041	-.0041

399.	-.0007	0.0125	-.0042	0.0044	-.0041	-.0058	0.0052	0.0052
400.	-.0043	-.0037	-.0045	-.0045	-.0027	-.0023	-.0016	-.0011
401.	-.0004	-.0008	-.0010	-.0008	0.0139	0.0098	0.0136	0.0139
402.	0.0126	0.0248	-.0043	-.0042	-.0034	-.0005	0.0001	-.0020
403.	-.0045	-.0043						
404.	0.0020	0.0015	0.0017	-.0000	-.0034	-.0008	-.0015	0.0018
405.	0.0024	0.0040	-.0003	-.0012	-.0019	-.0025	-.0035	-.0012
406.	0.0012	-.0030	-.0043	-.0042	0.0092	-.0002	0.0026	0.0026
407.	-.0008	-.0043	0.0020	-.0033	0.0018	-.0004	-.0037	-.0037
408.	0.0024	0.0019	0.0023	0.0037	0.0008	-.0004	-.0007	-.0017
409.	-.0014	-.0013	-.0017	-.0012	-.0041	-.0045	-.0046	-.0040
410.	-.0048	-.0043	0.0457	0.0078	-.0004	-.0012	-.0013	-.0002
411.	0.0014	0.0016						
412.	0.0021	0.0016	0.0017	0.0000	-.0033	-.0007	-.0014	0.0019
413.	0.0024	0.0038	-.0002	-.0012	-.0019	-.0024	-.0034	-.0012
414.	0.0013	-.0029	-.0042	-.0041	0.0073	-.0002	0.0026	0.0026
415.	-.0008	-.0042	0.0020	-.0032	0.0019	-.0003	-.0037	-.0036
416.	0.0024	0.0020	0.0024	0.0039	0.0009	-.0003	-.0006	-.0016
417.	-.0013	-.0013	-.0016	-.0012	-.0040	-.0044	-.0045	
418.	-.0047	-.0042	0.0078	0.0175	-.0003	-.0011	-.0012	-.0002
419.	0.0015	0.0016						
420.	-.0004	0.0001	0.0005	0.0074	-.0004	0.0047	-.0017	-.0004
421.	-.0002	-.0003	-.0016	-.0017	-.0020	-.0024	-.0032	-.0016
422.	0.0001	-.0027	-.0028	-.0034	-.0003	0.0165	-.0002	-.0002
423.	-.0013	-.0032	-.0002	-.0016	0.0005	0.0071	-.0006	-.0010
424.	-.0003	-.0003	-.0004	-.0005	-.0012	-.0018	-.0016	-.0023
425.	-.0018	-.0018	-.0023	-.0017	-.0034	-.0043	-.0040	-.0034
426.	-.0036	-.0034	-.0004	-.0003	0.1111	-.0015	-.0016	-.0000
427.	0.0000	0.0002						
428.	-.0013	-.0013	-.0012	-.0017	-.0011	-.0011	0.0068	-.0006
429.	-.0009	-.0009	0.0023	0.0030	0.0028	0.0016	0.0009	0.0030
430.	-.0017	0.0014	-.0008	-.0004	-.0011	-.0014	-.0009	-.0009
431.	0.0030	-.0006	-.0011	-.0004	-.0010	-.0026	-.0013	-.0011
432.	-.0010	-.0004	-.0012	-.0012	0.0013	0.0024	0.0029	0.0031
433.	0.0028	0.0029	0.0031	0.0039	-.0002	0.0004	-.0000	-.0000
434.	-.0010	-.0005	-.0012	-.0011	-.0015	0.0285	0.0028	0.0014
435.	-.0014	-.0012						
436.	-.0014	-.0014	-.0014	-.0018	-.0004	-.0010	0.0040	-.0001
437.	-.0010	-.0010	0.0009	0.0011	0.0068	0.0015	0.0009	0.0010
438.	-.0019	0.0023	0.0000	0.0001	-.0012	-.0014	-.0010	-.0010

439.	0.0013	0.0001	-.0012	0.0015	-.0012	-.0027	-.0005	-.0002
440.	-.0011	-.0006	-.0013	-.0013	0.0003	0.0010	0.0014	0.0008
441.	0.0010	0.0009	0.0009	0.0012	0.0002	0.0004	0.0003	0.0003
442.	-.0002	0.0001	-.0013	-.0012	-.0016	0.0028	0.0139	0.0014
443.	-.0015	-.0014						
444.	-.0004	-.0003	-.0002	-.0001	-.0016	0.0005	0.0010	0.0005
445.	-.0000	-.0000	0.0008	0.0013	0.0006	-.0001	-.0009	0.0014
446.	-.0007	-.0007	-.0021	-.0019	-.0001	0.0004	0.0000	0.0000
447.	0.0018	-.0021	-.0002	-.0013	-.0000	-.0008	-.0018	-.0018
448.	-.0001	0.0003	-.0002	-.0002	0.0005	0.0008	0.0010	0.0012
449.	0.0012	0.0013	0.0013	0.0015	-.0018	-.0017	-.0019	-.0016
450.	-.0025	-.0020	-.0002	-.0002	-.0000	0.0014	0.0014	0.0082
451.	-.0004	-.0002						
452.	0.0018	0.0097	0.0024	0.0008	-.0034	-.0003	-.0017	0.0012
453.	0.0017	0.0016	-.0009	-.0015	-.0022	-.0027	-.0037	-.0015
454.	0.0051	-.0032	-.0044	-.0044	0.0015	0.0003	0.0017	0.0017
455.	-.0011	-.0045	0.0024	-.0034	0.0037	0.0007	-.0037	-.0037
456.	0.0017	0.0014	0.0017	0.0015	-.0002	-.0011	-.0011	-.0020
457.	-.0016	-.0016	-.0019	-.0015	-.0043	-.0049	-.0049	-.0042
458.	-.0050	-.0045	0.0014	0.0015	0.0000	-.0014	-.0015	-.0004
459.	0.0220	0.0102						
460.	0.0019	0.0069	0.0025	0.0010	-.0031	-.0001	-.0015	0.0014
461.	0.0018	0.0017	-.0007	-.0013	-.0020	-.0025	-.0035	-.0013
462.	0.0039	-.0030	-.0042	-.0042	0.0017	0.0005	0.0019	0.0019
463.	-.0009	-.0043	0.0024	-.0032	0.0037	0.0010	-.0035	-.0035
464.	0.0018	0.0015	0.0019	0.0016	-.0001	-.0009	-.0009	-.0018
465.	-.0015	-.0014	-.0018	-.0013	-.0041	-.0046	-.0046	-.0040
466.	-.0048	-.0043	0.0016	0.0016	0.0002	-.0012	-.0014	-.0002
467.	0.0102	0.0151						

END DATA, ERRORS: NONE, TIME: 3.575 SEC. IMAGE COUNT: 467

Appendix H

TABULAR RESULTS OF SIMULATION STUDIES

This appendix contains tabular summaries of the results of a number of simulation studies modeling the relationship between total fuel costs and dispatch fuel price policies and errors. The interpretation and significance of the tables is explained in Section 5.

For the reader's convenience, an ordered list of the tables in this appendix is given below.

Table H-1

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.000056	100 744 297.	100 744 297.	-	-	.6000
5	-	50.125289	100 947 830.	100 947 830.	.20202930	.20202930	.6002
10	-	50.254563	101 173 554.	101 173 554.	.42608566	.42608566	.6007
15	1(#66)	50.422986	101 337 711.	101 415 096.	.58902986	.66584314	.6012
20	1(#66)	50.521778	101 538 862.	101 662 311.	.78869477	.91123173	.6031
30	1(#66)	50.538701	102 144 467.	102 268 464.	1.38982557	1.51290648	.6121
40	1(#66)	50.614200	102 462 825.	102 584 150.	1.70583154	1.82626018	.6152
50	1(#66)	51.044961	102 796 394.	103 173 989.	2.03693613	2.41174147	.6162

Table H-2

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	49.999962	107 039 210.	107 039 210.	-	-	.7000
5	-	50.125280	107 276 808.	107 276 808.	.22197287	.22197287	.7003
10	-	50.254573	107 540 086.	107 540 086.	.46793694	.46793694	.7008
15	1(#66)	50.423196	107 744 929.	107 822 309.	.65930887	.73160013	.7013
20	1(#66)	50.521748	107 986 913.	108 110 329.	.88537928	1.00067909	.7036
30	1(#66)	50.523684	108 967 744.	109 092 001.	1.80170798	1.91779348	.7188
40	1(#66)	50.614202	109 064 416.	109 185 805.	1.89202255	2.00542867	.7177
50	1(#66)	50.698715	109 376 829.	109 495 768.	2.18389037	2.29500759	.7200

Table H-3

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.000007	113 336 501.	113 336 501.	-	-	.8000
5	-	50.125227	113 607 829.	113 607 829.	.23940037	.23940037	.8003
10	-	50.254562	113 908 853.	113 908 853.	.50500235	.50500235	.8009
15	1(#66)	50.423545	114 154 675.	114 232 061.	.72189806	.79017791	.8015
20	1(#66)	50.521872	114 437 077.	114 560 468.	.97106932	1.07994069	.8041
30	1(#66)	50.518645	115 548 163.	115 672 161.	1.95141192	2.06081888	.8215
40	1(#66)	50.615272	115 670 418.	115 791 867.	2.05928096	2.16643885	.8202
50	1(#66)	51.039532	116 186 454.	116 564 294.	2.51459414	2.84797305	.8215

Table H-4

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL (CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.000048	119 634 210.	119 634 210.	-	-	.9000
5	-	50.125251	119 939 451.	119 939 451.	.25514524	.25514524	.9004
10	-	50.254599	120 278 117.	120 278 117.	.53822982	.53822982	.9010
15	1(#66)	50.423057	120 563 307.	120 640 643.	.77661481	.84125852	.9018
20	1(#66)	50.519413	120 882 036.	121 005 501.	1.04303442	1.14623649	.9046
30	1(#66)	50.513147	122 145 268.	122 269 228.	2.09894642	2.20256227	.9246
40	1(#66)	50.613176	122 270 284.	122 391 636.	2.20344496	2.30488083	.9227
50	1(#66)	51.040848	122 892 003.	123 269 360.	2.72312823	3.03855389	.9242

Table H-5

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 7% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.000026	121 628 778.	121 628 778.	-	-	.9317
5	-	50.125301	121 944 953.	121 944 953.	.25995081	.25995081	.9320
10	-	50.254564	122 295 351.	122 295 351.	.54803888	.54803888	.9327
15	1 (#66)	50.423182	122 593 598.	122 670 984.	.79324976	.85687451	.9334
20	1 (#66)	50.519295	122 924 541.	123 048 010.	1.06534244	1.11685542	.9364
30	1 (#66)	50.521965	124 233 227.	124 357 111.	2.14130983	2.24316403	.9567
40	1 (#66)	50.613986	124 363 923.	124 485 262.	2.24876466	2.34852645	.9551
50	1 (#66)	51.040182	125 006 880.	125 386 606.	2.77738708	3.08958790	.9568

Table H-6

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	49.999162	132 224 001.	132 224 001.	-	-	1.1000
5	-	50.125231	132 599 505.	132 599 505.	.2839908	.2839908	1.1004
10	-	50.253397	133 010 063.	133 010 063.	.59449267	.59449267	1.1012
15	1(#66)	50.423036	133 379 023.	133 456 412.	.87353430	.93206301	1.1021
20	1(#66)	50.521078	133 783 451.	133 906 938.	1.17940009	1.27279237	1.1056
30	1(#66)	50.539893	134 899 478.	135 023 726.	2.02344352	2.11741135	1.1222
40	1(#66)	50.613693	135 476 466.	135 597 926.	2.45981514	2.55167440	1.1278
50	1(#66)	51.040804	136 292 728.	136 669 942.	3.07714784	3.36243188	1.1296

Table H-7

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	49.999581	138 519 124.	138 519 124.	-	-	1.2000
5	-	50.125246	138 927 558.	138 927 558.	.29485748	.29485748	1.2004
10	-	50.253714	139 376 298.	139 376 298.	.61881275	.61881275	1.2013
15	1(#66)	50.42430	139 789 758.	139 866 752.	.91729861	.97288227	1.2023
20	1(#66)	50.519743	140 227 270.	140 350 502.	1.23314814	1.32211202	1.2061
30	1(#66)	50.524953	141 919 240.	142 043 188.	2.45461845	2.54409924	1.2323
40	1(#66)	50.614054	142 078 496.	142 199 774.	2.56958887	2.65714213	1.2303
50	1(#66)	51.042712	142 993 812.	143 371 736.	3.23037559	3.50320724	1.2323

Table H-8

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	49.998392	144 812 318.	144 812 318.	-	-	1.3000
5	-	50.125018	145 258 064.	145 258 064.	.30780945	.30780945	1.3005
10	-	50.254299	145 747 050.	145 747 050.	.64547823	.64547823	1.3014
15	1(#66)	50.423573	146 196 632.	146 273 770.	.95593663	1.00920419	1.3025
20	1(#66)	50.513751	146 635 500.	146 758 894.	1.25899649	1.34420608	1.3063
30	1(#66)	50.521375	148 498 622.	148 622 424.	2.5455735	2.631064383	1.3350
40	1(#66)	50.616147	148 689 654.	148 810 998.	2.67749044	2.76128444	1.3328
50	1(#66)	50.698537	149 260 978.	149 379 900.	3.07201767	3.1541391	1.3372

Table H-9

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.000073	151 115 390.	151 115 390.	-	-	1.4000
5	-	50.124004	151 585 414.	151 585 414.	.31103649	.31103649	1.4005
10	-	50.254687	152 117 146.	152 117 146.	.66290799	.66290799	1.4016
15	1(#66)	50.422855	152 603 084.	152 680 304.	.9844755	1.03557551	1.4027
20	1(#66)	50.512946	153 078 864.	153 202 334.	1.2993210	1.38102677	1.4068
30	1(#66)	50.513904	155 060 028.	155 184 294.	2.61034825	2.69258079	1.4377
40	1(#66)	50.614334	155 287 118.	155 408 568.	2.76062417	2.84099323	1.4353
50	1(#66)	50.696978	155 903 086.	156 022 252.	3.16823849	3.24709609	1.4400

Table H-10

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.000033	105 781 225.	105 781 225.	-	-	.6000
5	1(#66)	40.154656	105 981 701.	105 988 147.	.18951945	.19561316	.6003
10	1(#66)	40.447560	106 110 041.	106 321 663.	.31084533	.51090162	.6012
15	2(#62,66)	40.726456	106 233 526.	106 631 810	.42758154	.80409826	.6017
20	2(#62,66)	40.880028	106.418 303.	106 911 602.	.60225999	1.06859888	.6041
30	2(#62,66)	40.954760	107 002 357.	107 560 630.	1.15439388	1.68215579	.6152
40	2(#62,66)	41.333864	107 235 622.	108 032 788.	1.37491034	2.12850907	.6165
50	2(#62,66)	42.292874	107 423 210.	108 888 565.	1.55224614	2.93751559	.6138

Table H-11

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.999921	110 817 141.	110 817 141.	-	-	.7000
5	1(#66)	40.154501	111 052 328.	111 058 565.	.212298	.21785799	.7003
10	1(#66)	40.447513	111 236 129.	111 447 664.	.37808952	.56897605	.7013
15	2(#62,66)	40.726637	111 411 719.	111 809 914.	.53653973	.89586591	.7020
20	2(#62,66)	40.880017	111 642 273.	112 136 022.	.74500207	1.19014169	.7047
30	2(#62,66)	41.436166	112 511 411.	113 463 061.	1.52888802	2.38764504	.7181
40	2(#62,66)	41.334353	112 646 698.	113 444 418.	1.65096931	2.37082183	.7193
50	2(#62,66)	41.835152	112 878 753.	114 000 244.	1.86037283	2.87239227	.7180

Table H-12

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.999975	115 854 980.	115 854 980.	-	-	.8000
5	1(#66)	40.154602	116 124 371.	116 130 848.	.23252432	.23811492	.8004
10	1(#66)	40.447500	116 363 974.	116 575 509.	.43933718	.62192319	.8015
15	2(#62,66)	40.727064	116 591 976.	116 990 190.	.63613666	.97985429	.8023
20	2(#62,66)	40.880191	116 868 846.	117 362 138.	.87511645	1.30090047	.8054
30	2(#62,66)	41.429589	117 917 196.	118 867 827.	1.77999772	2.60053298	.8207
40	2(#62,66)	41.335157	118 061 971.	118 859 412.	1.90495998	2.59326962	.8221
50	2(#62,66)	42.286706	118 520 615.	119 986 546.	2.30083764	3.56615311	.8184

Table H-13

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.000025	120 893 150.	120 893 150.	-	-	.9000
5	1(#66)	40.154634	121 197 015.	121 203 499.	.25135005	.25671346	.9005
10	1(#66)	40.447534	121 492 223.	121 703 744.	.49553924	.67050449	.9018
15	2(#62,66)	40.726485	121 771 025.	122 169 186.	.72615776	1.05550727	.9026
20	2(#62,66)	40.877230	122 089 669.	122 583 020.	.98973267	1.39782113	.9061
30	2(#62,66)	41.417473	123 339 596.	124 285 749.	2.02364317	2.80627891	.9238
40	2(#62,66)	41.332909	123 470 941.	124 268 384.	2.13228869	2.79191497	.9248
50	2(#62,66)	42.288228	124 079 649	125 544 936	2.63579780	3.84784907	.9207

Table H-14

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 7% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.999999	122 488 793.	122 488 793.	-	-	.9317
5	1 (#66)	40.154719	122 803 765.	122 810 285.	.25714352	.26246646	.9321
10	1 (#66)	40.447436	123 116 415.	123 327 852.	.51239136	.68500879	.9334
15	1 (#66)	40.726666	123 411 881.	123 810 139.	.75361016	1.07874848	.9343
20	2 (#62,66)	40.877083	123 744 459.	124 237 808.	1.02512725	1.42789797	.9379
30	2 (#62,66)	41.433140	125 055 278.	126 005 331.	2.09528148	2.87090591	.9557
40	2 (#62,66)	41.333844	125 187 401.	125 984 827.	2.20314685	2.85416642	.9573
50	2 (#62,66)	42.287758	125 831 415.	127 300 041.	2.72892067	3.92790872	.9531

Table H-15

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.998961	130 964 484.	130 964 484.	-	-	1.1000
5	1 (#66)	40.15460	131 339 752.	131 346 222.	.28654181	.29148208	1.1005
10	1 (#66)	44.446270	131 742 748.	131 954 528.	.59425577	.75596374	1.1021
15	2(#62,66)	40.726664	132 128 251.	132 526 715.	.88861267	1.19286615	1.1032
20	2(#62,66)	40.879313	132 543 443.	133 036 930.	1.20563908	1.58244887	1.1074
30	2(#62,66)	40.956861	133 673 795.	134 233 156.	2.06873721	2.49584612	1.1279
40	2(#62,66)	41.33344	134 295 968.	135 093 592.	2.54380724	3.15284559	1.1303
50	2(#62,66)	42.289301	135 188 068.	136 654 462.	3.22498426	4.34467256	1.1253

Table H-16

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.999465	136 000 784.	136 000 784.	-	-	1.2000
5	1(#66)	40.154642	136 409 546.	136 416 050.	.30055856	.30534088	1.2005
10	1(#66)	40.446621	136 868 688.	137 080 428.	.63816102	.79385129	1.2023
15	2(#66,68)	40.727018	137 309 660.	137 706 302.	.96240326	1.25405011	1.2034
20	2(#66,68)	40.877039	137 763 550.	138 255 942.	1.29614398	1.65819483	1.2081
30	2(#66,68)	41.436862	139 589 996.	140 540 340.	2.63911122	3.33788952	1.2310
40	2(#66,68)	41.333905	139 707 720.	140 504 926.	2.72567248	3.31184998	1.2330
50	2(#66,68)	42.290340	140 743 044.	142 208 952.	3.48693573	4.56480306	1.2276

Table H-17

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	39.998037	141 034 490.	141 034 490.	-	-	1.3000
5	1(#66)	40.154659	141 481 196.	141 488 134.	.31673529	.32165465	1.3006
10	1(#66)	40.44724	141 998 484.	142 210 100.	.68351649	.83356206	1.3025
15	2(#62,66)	40.726423	142 487 032.	142 884 166.	1.02991970	1.31150614	1.3037
20	2(#62,66)	40.870416	142 947 906.	143 441 118.	1.35670075	1.70641096	1.3084
30	2(#62,66)	41.432246	144 994 296.	145 944 020.	2.80768624	3.48108464	1.3336
40	2(#62,66)	41.336422	145 128 094.	145 925 514.	2.90255523	3.46796301	1.3358
50	2(#62,66)	41.835673	145 830 138.	146 952 168.	3.40033704	4.19590831	1.3335

Table H-18

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.000054	146 078 108.	146 078 108.	-	-	1.4000
5	1(#66)	40.153738	146 549 800.	146 557 176.	.32290396	.32795332	1.4007
10	1(#66)	40.447638	147 127 638.	147 339 154.	.71847179	.86326829	1.4027
15	1(#66)	40.725788	147 664 052.	148 061 544.	1.08568218	1.35779141	1.4040
20	2(#62,66)	40.86961	148 167 328.	148 660 812.	1.43020745	1.76802945	1.4090
30	2(#62,66)	41.424642	150 381 668.	151 333 390.	2.94606772	3.59758356	1.4362
40	2(#62,66)	41.334370	150 534 864.	151 332 580.	3.05094036	3.59702906	1.4386
50	2(#62,66)	41.834767	151 317 184.	152 440 454.	3.58648947	4.35544109	1.4361

Table H-19

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.000038	110 818 141.	110 818 141.	-	-	.6000
5	3(#45,62,66)	30.586174	110 801 652.	111 341 562.	-.01487933	.47232429	.6007
10	3(#45,62,66)	31.194827	110 808 558.	111 902 012.	-.00864750	.97806279	.6018
15	3(#45,62,66)	31.558185	110 905 092.	112 261 173.	.07846279	1.30216224	.6025
20	4(#45,61, 62,66)	31.812320	111 054 638.	112 610 011.	.213410	1.61694644	.6054
30	4(#45,61, 62,66)	32.191380	111 556 636.	113 410 141.	.66640262	2.33896723	.6166
40	5(#23,45, 61,62,66)	33.121977	111 622 862.	114 185 645.	.72616360	3.0387660	.6142
50	5(#23,45, 61,62,66)	34.005986	111 842 857.	114 968 755.	.92468254	3.74542826	.6121

Table H-20

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.999906	114 595 058.	114 595 058.	-	-	.7000
5	3(#45,62,66)	30.585947	114 666 015.	115 205 646.	.06191977	.53282227	.7008
10	3(#45,62,66)	31.194719	114 766 194.	115 859 494.	.14933977	1.10339487	.7020
15	3(#45,62,66)	31.558420	114 922 983.	116 278 994.	.28615981	1.46946651	.7029
20	4(#45,61,62,66)	31.812308	115 130 275.	116 685 640.	.46705068	1.82432124	.7063
30	3(#45,62,66)	33.014391	115 880 547.	118 364 498.	1.12176652	3.2893565	.7156
40	5(#23,45,61,62,66)	33.122187	115 960 877.	118 523 948.	1.19186553	3.4284986	.7166
50	5(#23,45,61,62,66)	33.668155	116 179 995.	119 108 361.	1.38307622	3.9384796	.7157

Table H-21

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.999969	118 373 452.	118 373 452.	-	-	.8000
5	3(#45,62,66)	30.586009	118 531 371.	119 071 206.	.13340745	.58945142	.8010
10	3(#45,62,66)	31.194779	118 728 160.	119 818 550.	.29711730	1.22079569	.8023
15	3(#45,62,66)	31.558915	118 942 550.	120 298 587.	.48076489	1.62632329	.8033
20	4(#45,61, 62,66)	31.812501	119 207 215.	120 762 571.	.70434965	2.01828959	.8072
30	3(#45,62,66)	33.006857	120 187 446.	122 670 197.	1.53243312	3.62982448	.8179
40	5(#23,45, 61,62,66)	33.123003	120 302 730.	122 865 291.	1.62982321	3.79463378	.8189
50	5(#23,45, 61,62,66)	33.999561	120 769 151.	123 896 731.	2.02384821	4.66597778	.8162

Table H-22

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.000027	122 152 084.	122 152 084.	-	-	.9000
5	3(#45,62,66)	30.586040	122 397 267.	122 937 066.	.20071946	.64262678	.9011
10	3(#45,62,66)	31.194821	122 684 471.	123 777 844.	.43583947	1.33093104	.9027
15	3(#45,62,66)	31.558211	122 960 836.	124 316 763.	.66208612	1.77211793	.9037
20	4(#45,61, 62,66)	31.809079	123 278 769.	124 834 183.	.92236248	2.19570464	.9082
30	3(#45,62,66)	32.993795	124 510 866.	126 989 118.	1.93102068	3.95984563	.9207
40	5(#23,45, 61,62,66)	33.122038	124 638 177.	127 202 634.	2.03524402	4.13464087	.9213
50	5(#23,45, 61,62,66)	34.000834	125 242 920.	128 368 930.	2.53031784	5.08943093	.9182

Table H-23

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 7% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.999997	123 348 802.	123 348 802.	-	-	.9317
5	3(#45,62,66)	30.586205	123 621 795.	124 161 720.	.22131792	.65904004	.9328
10	3(#45,62,66)	31.194644	123 938 434.	125 031 629.	.47802004	1.36428320	.9344
15	3(#45,62,66)	31.558422	124 234 045.	125 590 087.	.71767458	1.81703019	.9355
20	4(#45,61, 62,66)	31.808910	124 569 560.	126 124 971.	.98967965	2.25066552	.9401
30	3(#45,62,66)	33.010909	125 878 484.	128 360 546.	2.05083627	4.0630666	.9525
40	5(#23,45, 61,62,66)	33.122169	126 014 640.	128 577 974.	2.16121918	4.23933744	.9538
50	5(#23,45, 61,62,66)	34.000636	126 650 559.	129 781 249.	2.67676455	5.21484351	.9505

Table H-24

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.998786	129 704 973.	129 704 973.	-	-	1.1000
5	3(#45,62,66)	30.585928	130 126 988.	130 666 697.	.32536532	.74147042	1.1014
10	3(#45,62,66)	31.194227	130 597 870.	131 692 584.	.68840614	1.53240925	1.1032
15	3(#45,62,66)	31.558397	130 997 073.	132 353 329.	.99618386	2.04183072	1.1045
20	4(#45,61, 62,66)	31.811481	131 434 569.	132 990 140.	1.33348472	2.53279957	1.1099
30	4(#45,61, 62,66)	32.193805	132 608 766.	134 463 560.	2.23876765	3.66877839	1.1304
40	5(#23,45, 61,62,66)	33.122061	133 316 804.	135 880 780.	2.78465113	4.76142728	1.1261
50	5(#23,45, 61,62,66)	34.001772	134 180 652.	137 307 456	3.45066103	5.86136663	1.1222

Table H-25

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.999374	133 482 451.	133 482 451.	-	-	1.2000
5	3(#45,62,66)	30.586123	133 990 726.	134 530 644.	.38078039	.78526727	1.2014
10	3(#45,62,66)	31.194305	134 555 530.	135 645 794.	.80391091	1.62369208	1.2035
15	3(#45,62,66)	31.559029	135 018 358.	136 372 784.	1.15064414	2.16532880	1.2049
20	4(#45,61, 62,66)	31.808867	135 506 048.	137 060 348.	1.51600303	2.68042576	1.2108
30	3(#45,62,66)	33.015167	137 465 414.	139 947 814.	2.98388588	4.843606	1.2267
40	5(#23,45, 61,62,66)	33.122211	137 655 650.	140 218 736.	3.12640348	5.04657048	1.2284
50	5(#23,45, 61,62,66)	34.003032	138 650 654.	141 777 132.	3.87182280	6.21406180	1.2242

Table H-26

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	29.997709	137 256 672.	137 256 672.	-	-	1.3000
5	3(#45,62,66)	30.586025	137 855 610.	138 395 878.	.43636348	.82998224	1.3016
10	3(#45,62,66)	31.194635	138 516 310.	139 609 974.	.91772442	1.71452649	1.3038
15	3(#45,62,66)	31.558275	139 035 002.	140 389 910.	1.29562370	2.28275824	1.3053
20	3(#45,62,66)	31.801211	139 541 192.	141 096 432.	1.66441453	2.79750332	1.3112
30	3(#45,62,66)	33.009883	141 770 702.	144 252 378.	3.28875086	5.09680575	1.3290
40	5(#23,45, 61,62,66)	33.122317	142 001 110.	144 561 166.	3.45661736	5.32177699	1.3308
50	5(#23,45, 61,62,66)	33.668661	142 716 064.	145 644 790.	3.97750571	6.11126429	1.3291

Table H-27

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.000062	141 040 840.	141 040 840.	-	-	1.4000
5	3(#45,62,66)	30.584992	141 717 540.	142 258 362.	.47979011	.86324073	1.4017
10	3(#45,62,66)	31.194812	142 476 454.	143 569 662.	1.01787113	1.79297143	1.4041
15	3(#45,62,66)	31.557491	143 051 330.	144 406 588.	1.42546654	2.38636410	1.4057
20	4(#45,61, 62,66)	31.800274	143 611 438.	145 166 984.	1.82259125	2.92549585	1.4121
30	3(#45,62,66)	33.001198	146 059 190.	148 543 208.	3.55808288	5.31928766	1.4312
40	5(#23,45, 61,62,66)	33.122185	146 335 544.	148 898 544.	3.75402185	5.5712260	1.4331
50	5(#23,45, 61,62,66)	33.671604	147 136 336.	150 071 264.	4.32179499	6.40270150	1.4314

Table H-28

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.000041	115 855 059.	115 855 059.	-	-	.6000
5	3(#45,62,66)	21.375386	115 471 328.	116 973 116.	-.33121644	.96504805	.6015
10	7(#23,41,43, 45,61,62,66)	22.296139	115 347 958.	117 758 868.	-.43770294	1.64326790	.6031
15	7(#23,41,43, 45,61,62,66)	22.975985	115 309 092.	118 349 742.	-.47125002	2.15327930	.6041
20	10(#23,36, 41,43,45,61, 62,66,68,77)	23.568107	115 273 125.	118 948 572.	-.50229485	2.67015788	.6082
30	9(#23,36, 41,43,45,61, 62,66,78)	24.891672	115 379 725.	120 278 460.	-.41028333	3.81804731	.6150
40	9(#23,36, 41,43,45,61, 62,66,78)	25.863752	115 424 537.	121 077 093.	-.37160397	4.50738537	.6129
50	9(#23,36, 41,43,45,61, 62,66,78)	26.751573	115 653 108.	121 851 360.	-.17431349	5.17569196	.6113

Table H-29

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.999891	118 372 984.	118 372 984.	-	-	.7000
5	3(#45,62,66)	21.375157	118 175 767.	119 677 276.	-.16660643	1.10184938	.7018
10	7(#23,41,43, 45,61,62,66)	22.295958	118 183 245.	120 593 897.	-.16028911	1.87619922	.7036
15	7(#23,41,43, 45,61,62,66)	22.975594	118 243 383.	121 283 173.	-.10948529	2.45849085	.7048
20	10(#23,36, 41,43,45,61, 62,66,68,77)	23.569342	118 305 891.	121 983 182.	-.05667932	3.04984960	.7096
30	9(#23,36, 41,43,45,61, 62,66,78)	25.302357	118 969 689.	123 912 874.	.50408883	4.68002898	.7140
40	9(#23,36, 41,43,45,61, 62,66,78)	25.864094	118 812 490.	124 465 521.	.37128911	5.14689821	.7151
50	9(#23,36, 41,43,45,61, 62,66,78)	26.419163	119 034 683.	125 046 764.	.55899495	5.63792497	.7145

Table H-30

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.999963	120 891 930.	120 891 930.	-	-	.8000
5	3(#45,62,66)	21.375209	120 880 797.	122 382 511.	-.00920905	1.23298635	.8021
10	5(#23,45, 61,62,66)	22.296118	121 019 390.	123 430 283.	.10543301	2.0996877	.8041
15	5(#23,45, 61,62,66)	22.976064	121 178 734.	124 218 450.	.23723999	2.75164768	.8055
20	9(#23,36,45, 61,62,66, 68,77,43)	23.568905	121 340 830.	125 017 135.	.37132338	3.41230798	.8110
30	8(#23,36,43, 45,61,62, 66,78)	25.300839	122 269 546.	127 219 201.	1.13954338	5.23382407	.8160
40	8(#23,36,43, 45,61,62, 66,78)	25.865769	122 203 659.	127 857 255.	1.08504264	5.76161283	.8173
50	8(#23,36,43, 45,61,62, 66,78)	26.749048	122 673 917.	128 880 874.	1.47403304	6.6083352	.8151

Table H-31

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.000029	123 411 019.	123 411 019.	-	-	.9000
5	3(#45,62,66)	21.375243	125 586 282.	125 087 960.	.14201568	1.3588260	.9023
10	7(#23,41,43, 45,61,62,66)	22.296330	123 855 849.	126 266 912.	.36044594	2.31413129	.9046
15	7(#23,41,43, 45,61,62,66)	22.976034	124 112 673.	127 153 181.	.56855053	3.03227544	.9062
20	10(#23,36,41, 43,45,61,62, 66,68,77)	23.565617	124 369 546.	128 046 916.	.77669483	3.75646928	.9124
30	11(#23,36,41, 43,45,46,61, 62,68,77)	25.280405	125 578 645.	130 522 343.	1.75642824	5.76230884	.9188
40	9(#23,36,41, 43,45,61,62, 66,78)	25.864155	125 588 951.	131 243 931.	1.76477921	6.34701186	.9194
50	9(#23,36,41, 43,45,61,62, 66,78)	26.750266	126 196 460.	132 401 440.	2.25704399	7.28494185	.9170

Table H-32

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 7% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.999995	124 208 820.	124 208 820.	-	-	.9317
5	3(#45,62,66)	21.375418	124 443 280.	125 945 083.	.18876276	1.39785805	.9341
10	7(#23,41,43, 45,61,62,66)	22.296173	124 754 186.	127 165 106.	.43907188	2.38009346	.9364
15	7(#23,41,43, 45,61,62,66)	22.975948	125 042 479.	128 082 729.	.67117536	3.11886385	.9381
20	10(#23,36,41,43, 61,62,66,68,77)	23.565139	125 330 283.	129 007 211.	.90288516	3.86316445	.9444
30	9(#23,36,41,43, 45,61,62,66,78)	25.305124	126 636 199.	131 585 000.	1.95427264	5.93853158	.9503
40	9(#23,36,41,43, 45,61,62,66,78)	25.864073	126 664 525.	132 317 882.	1.97707780	6.52857178	.9518
50	9(#23,36,41,43, 45,61,62,66,78)	26.749755	127 302 855.	133 512 699.	2.49099460	7.49051392	.9492

Table H-33

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.998611	128 445 462.	128 445 462.	-	-	1.1000
5	2(#45,66)	21.375129	128 995 745.	130 497 333.	.42841763	1.59746477	1.1028
10	7(#23,41,43, 45,61,62,66)	22.295171	129 524 045.	131 936 042.	.83972059	2.71755806	1.1056
15	7(#23,41,43, 45,61,62,66)	22.975821	129 980 892.	133 021 258.	1.19539450	3.56244272	1.1075
20	10(#23,41,43, 45,61,62,66, 68,77,36)	23.567124	130 441 139.	134 116 932.	1.55371547	4.41546935	1.1151
30	9(#23,41,43, 36,45,61,62, 66,78)	24.893646	131 661 578.	136 560 702.	2.50387669	6.31804335	1.1275
40	9(#23,36,41, 43,45,61,62, 66,78)	25.864403	132 367 352.	138 022 080.	3.05335039	7.45578545	1.1237
50	9(#23,36,41, 43,45,61,62, 66,78)	26.750410	133 232 084.	139 436 612.	3.73657934	8.55705595	1.1207

Table H-34

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 20% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.999283	130 964 116.	130 964 116.	-	-	1.2000
5	3(#45,62,66)	21.375327	131 699 726.	133 201 524.	.56168821	1.7084130	1.2030
10	4(#45,61, 62,66)	22.295489	132 359 540.	134 771 298.	1.06550102	2.90704209	1.2061
15	7(#23,41,43, 45,61,62,66)	22.976643	132 918 482.	135 956 930.	1.49229121	3.81235269	1.2082
20	10(#23,36, 41,43,45,61, 62,66,68,77)	23.564460	133 470 689.	137 145 398.	1.91393876	4.71982872	1.2164
30	9(#23,36, 41,43,45,61, 62,66,78)	25.303133	135 523 140.	140 464 254.	3.48112452	7.25400072	1.2240
40	9(#23,36, 41,43,45,61, 62,66,78)	25.864194	135 756 466.	141 409 656.	3.65928480	7.97587937	1.2258
50	9(#23,36, 41,43,45,61, 62,66,78)	26.750705	136 751 256.	142 953 808.	4.41887456	9.15494430	1.2226

Table H-35

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	19.997379	133 478 851.	133 478 851.	-	-	1.3000
5	3(#45,62,66)	21.375186	134 404 246.	135 906 392.	.69329035	1.81867163	1.3033
10	7(#23,41,43, 45,61,62,66)	22.296061	135 197 596.	137 608 910.	1.28765418	3.09416807	1.3066
15	7(#23,41,43, 45,61,62,66)	22.976312	135 851 152.	138 890 774.	1.7772868	4.05451798	1.3089
20	10(#23,36, 41,43,61,62, 66,68,77,45)	23.467758	136 410 280.	139 994 090.	2.19617561	4.88110286	1.3175
30	9(#23,36, 41,43,45,61, 62,66,78)	25.298491	138 822 170.	143 764 218.	4.00312102	7.70561618	1.3260
40	9(#23,36, 41,43,45,61, 62,66,78)	25.86461	139 151 574.	144 801 748.	4.24990469	8.48291540	1.3280
50	9(#23,36, 41,43,45,61, 62,66,78)	26.419642	139 866 808.	145 879 330.	4.78574544	9.2902086	1.3270

Table H-36

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 40% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.000069	136 003 576.	136 033 576.	-	-	1.4000
5	3(#45,62,66)	21.373966	137 105 856.	138 608 556.	.81047868	1.91537610	1.4036
10	7(#23,41,43, 45,61,62,66)	22.296357	138 035 016.	140 445 946.	1.49366659	3.26636261	1.4071
15	7(#23,41,43, 45,61,62,66)	22.975547	138 783 426.	141 823 610.	2.04395360	4.27932417	1.4096
20	9,(#23,36, 41,43,45,61, 62,66,77)	23.466317	139 426 828.	143 010 412.	2.51703086	5.15194982	1.4188
30	9(#23,36, 41,43,45,61, 62,66,78)	25.297705	142 109 358.	147 065 222.	4.48942751	8.13334930	1.4280
40	9(#23,36, 41,43,45,61, 62,66,78)	25.864196	142 535 686.	148 188 802.	4.80289572	8.95948935	1.4302
50	9(#23,36, 41,43,45,61, 62,66,78)	26.421464	143 336 064.	149 353 482.	5.39139348	9.81584907	1.4291

Table H-37

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.00	107 039 210.	107 039 210.	-	-	.7000
1	-	50.17	107 419 000.	107 419 000.	.3548	.3548	.7012
2	-	50.38	107 845 970.	107 845 970.	.7537	.7537	.7022
3	1	50.65	107 919 380.	108 202 720.	.8223	1.0870	.7032
4	1	50.94	107 847 230.	108 505 360.	.7599	1.3697	.7041
5	1	50.96	107 856 190.	108 544 690.	.7632	1.4064	.7042
6	1	50.97	107 860 870.	108 555 580.	.7676	1.4166	.7043
7	1	50.97	107 855 380.	108 551 240.	.7625	1.4126	.7044
8	1	50.97	107 860 220.	108 555 130.	.7670	1.4162	.7044
9	1	50.97	107 859 730.	108 555 020.	.7666	1.4161	.7044
10	1	50.97	107 864 930.	108 560 970.	.7714	1.4217	.7044
11	1	50.97	107 867 010.	108 561 560.	.7734	1.4222	.7044
12	1	50.97	107 875 400.	108 570 360.	.7812	1.4305	.7044

Table H-38

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.14	120 050 740.	120 050 740.	-	-	.9014
1	-	50.22	120 272 990.	120 272 990.	.5339	.5339	.9020
2	-	50.26	120 376 330.	120 376 330.	.6203	.6203	.9024
3	-	50.27	120 414 100.	120 414 100.	.6519	.6519	.9026
4	-	50.27	120 425 260.	120 425 260.	.6612	.6612	.9027
5	1	50.35	120 413 880.	120 552 490.	.6517	.7425	.9030
6	1	50.37	120 391 140.	120 546 520.	.6327	.7626	.9032
7	1	50.38	120 385 230.	120 548 200.	.6278	.7640	.9032
8	1	50.38	120 381 880.	120 548 480.	.6250	.7642	.9032
9	1	50.38	120 380 306.	120 548 840.	.6236	.7645	.9032
10	1	50.38	120 379 560.	120 548 980.	.6230	.7646	.9032
11	1	50.38	120 379 230.	120 549 080.	.6227	.7647	.9032
12	1	50.38	120 378 970.	120 549 150.	.6225	.7648	.9032

Table H-39

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.00	132 224 000.	132 224 000.	-	-	1.1000
1	-	50.12	132 663 440.	132 663 440.	.3323	.3323	1.1016
2	-	50.11	132 636 540.	132 636 540.	.3120	.3120	1.1016
3	-	50.12	132 657 560.	132 657 560.	.3279	.3279	1.1016
4	-	50.12	132 649 090.	132 649 090.	.3215	.3215	1.1016
5	-	50.12	132 657 120.	132 657 120.	.3276	.3276	1.1016
6	-	50.12	132 655 640.	132 655 640.	.3264	.3264	1.1016
7	-	50.12	132 656 260.	132 656 260.	.3269	.3269	1.1016
8	-	50.12	132 656 060.	132 656 060.	.3268	.3268	1.1016
9	-	50.12	132 656 160.	132 656 160.	.3268	.3268	1.1016
10	-	50.12	132 656 070.	132 656 070.	.3268	.3268	1.1016
11	-	50.12	132 656 150.	132 656 150.	.3268	.3268	1.1016
12	-	50.12	132 656 070.	132 656 070.	.3268	.3268	1.1016

Table H-40

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 50% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	50.00	144 812 320.	144 812 320.	-	-	1.3000
1	-	50.10	145 252 350.	145 252 350.	.3039	.3039	1.3016
2	-	50.05	145 065 140.	145 065 140.	.1746	.1746	1.3011
3	-	50.07	145 147 100.	145 147 100.	.2312	.2312	1.3014
4	-	50.06	145 085 870.	145 085 870.	.1889	.1889	1.3012
5	-	50.06	145 109 280.	145 109 280.	.2051	.2051	1.3013
6	-	50.06	145 094 180.	145 094 180.	.1946	.1946	1.3012
7	-	50.06	145 108 610.	145 108 610.	.2046	.2046	1.3013
8	-	50.06	145 097 790.	145 097 790.	.1971	.1971	1.3012
9	-	50.06	145 105 540.	145 105 540.	.2025	.2025	1.3013
10	-	50.06	145 099 120.	145 099 120.	.1981	.1981	1.3012
11	-	50.06	145 105 300.	145 105 300.	.2023	.2023	1.3013
12	-	50.06	145 100 650.	145 100 650.	.1991	.1991	1.3012

Table H-41

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.00	110 817 140.	110 817 140.	-	-	.7000
1	-	40.27	111 304 510.	111 304 510.	.4398	.4398	.7018
2	6	41.23	111 374 200.	112 390 980.	.5027	1.4202	.7044
3	6	41.50	111 423 930.	112 717 470.	.5476	1.7148	.7054
4	10	41.61	111 436 860.	112 852 690.	.5592	1.8369	.7059
5	10	41.70	111 433 620.	112 950 320.	.5563	1.9250	.7062
6	10	41.71	111 444 820.	112 973 500.	.5664	1.9459	.7063
7	10	41.71	111 454 990.	112 977 670.	.5756	1.9497	.7064
8	10	41.70	111 475 370.	112 974 920.	.5940	1.9472	.7064
9	10	41.69	111 480 610.	112 963 670.	.5987	1.9370	.7064
10	10	41.68	111 482 170.	112 954 470.	.6001	1.9287	.7064
11	10	41.67	111 491 410.	112 950 830.	.6085	1.9260	.7064
12	10	41.66	111 505 410.	112 949 090.	.6211	1.9238	.7064

Table H-42

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.00	120 893 150.	120 893 150.	-	-	.9000
1	-	40.23	121 440 670.	121 440 670.	.4529	.4529	.9021
2	3	40.52	121 679 550.	121 917 330.	.6505	.8472	.9035
3	6	40.94	121 643 580.	122 445 190.	.6207	1.2838	.9049
4	6	40.94	121 642 210.	122 451 360.	.6196	1.2889	.9049
5	6	40.94	121 643 720.	122 449 790.	.6209	1.2876	.9049
6	6	40.94	121 645 170.	122 448 330.	.6221	1.2864	.9049
7	6	40.94	121 646 060.	122 447 260.	.6228	1.2855	.9049
8	6	40.94	121 646 470.	122 446 480.	.6231	1.2849	.9049
9	6	40.94	121 646 760.	122 446 010.	.6234	1.2845	.9049
10	6	40.94	121 647 120.	122 445 490.	.6337	1.2841	.9049
11	6	40.94	121 647 280.	122 445 240.	.6232	1.2839	.9049
12	6	40.94	121 648 770.	122 446 370.	.6250	1.2848	.9049

Table H-43

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.00	130 964 480.	130 964 480.	-	-	1.1
1	-	40.21	131 565 820.	131 565 820.	.4592	.4592	1.615
2	-	40.19	131 534 450.	131 534 450.	.4352	.4352	1.1025
3	1	40.20	131 556 850.	131 560 550.	.4523	.4551	1.1026
4	1	40.20	131 560 430.	131 564 700.	.4550	.4583	1.1026
5	1	40.20	131 559 500.	131 563 850.	.4543	.4577	1.1026
6	1	40.20	131 560 330.	131 564 640.	.4550	.4583	1.1026
7	1	40.20	131 560 410.	131 564 730.	.4550	.4583	1.1026
8	1	40.20	131 560 190.	131 564 500.	.4549	.4582	1.1026
9	1	40.20	131 560 340.	131 564 660.	.4550	.4583	1.1026
10	1	40.20	131 560 230.	131 564 540.	.4549	.4582	1.1026
11	1	40.20	131 560 260.	131 564 570.	.4549	.4582	1.1026
12	1	40.20	131 560 290.	131 564 610.	.4549	.4582	1.1026

Table H-44

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 60% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	40.00	141 034 490.	141 034 490.	-	-	1.3000
1	-	40.18	141 663 690.	141 663 690.	.4461	.4461	1.3026
2	-	40.08	141 330 890.	141 330 890.	.2102	.2102	1.3016
3	-	40.13	141 497 370.	141 497 370.	.3282	.3282	1.3022
4	-	40.10	141 398 050.	141 398 050.	.2578	.2578	1.3017
5	-	40.12	141 473 170.	141 473 170.	.3110	.3110	1.3021
6	-	40.10	141 406 710.	141 406 710.	.2639	.2639	1.3018
7	-	40.12	141 465 760.	141 465 760.	.3058	.3058	1.3021
8	-	40.10	141 406 580.	141 406 580.	.2638	.2638	1.3018
9	-	40.11	141 459 360.	141 459 360.	.3013	.3013	1.3021
10	-	40.10	141 407 740.	141 407 740.	.2647	.2647	1.3018
11	-	40.11	141 456 480.	141 456 480.	.2992	.2992	1.3021
12	-	40.10	141 408 730.	141 408 730.	.2654	.2654	1.3018

Table H-45

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	114 595 060.	114 595 060.	-	-	.7000
1	6	30.98	114 798 230.	115 704 510.	-.1773	.9682	.7038
2	12	33.01	114 261 130.	117 730 230.	-.2914	2.7359	.7038
3	14	33.28	114 231 320.	118 017 200.	-.3174	2.9863	.7097
4	14	33.39	114 225 770.	118 141 620.	-.3223	3.0949	.7102
5	14	33.42	114 237 010.	118 175 740.	-.3124	3.1246	.7104
6	15	33.47	114 228 740.	118 233 780.	-.3197	3.1753	.7107
7	15	33.49	114 228 900.	118 258 440.	-.3195	3.1968	.7108
8	15	33.50	114 227 190.	118 267 540.	-.3210	3.2047	.7108
9	15	33.50	114 227 320.	118 272 760.	-.3209	3.2093	.7108
10	15	33.51	114 227 200.	118 275 180.	-.3210	3.2114	.7108
11	15	33.51	114 227 170.	118 276 300.	-.3210	3.2124	.7109
12	15	33.51	114 227 130.	118 276 880.	-.3210	3.2129	.7109

Table H-46

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	122 152 080.	122 152 080.	-	-	.9000
1	6	30.78	122 677 460.	123 330 020.	.4301	.9643	.9043
2	12	32.08	122 592 050.	124 955 090.	.3602	2.2947	.9083
3	12	32.23	122 603 900.	125 144 840.	.3691	2.4500	.9088
4	12	32.22	122 612 470.	125 144 150.	.3769	2.4495	.9089
5	12	32.21	122 619 660.	125 136 760.	.3828	2.4434	.9089
6	12	32.21	122 618 600.	125 130 210.	.3819	2.4381	.9089
7	12	32.20	122 618 040.	125 126 220.	.3815	2.4348	.9089
8	12	32.20	122 617 740.	125 123 890.	.3812	2.4329	.9089
9	12	32.20	122 626 830.	125 125 740.	.3887	2.4344	.9089
10	12	32.20	122 627 080.	125 125 420.	.3889	2.4341	.9089
11	12	32.20	122 627 260.	125 125 140.	.3890	2.4339	.9089
12	12	32.20	122 627 370.	125 124 950.	.3891	2.4337	.9089

Table H-47

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	129 704 970.	129 704 970.	-	-	1.1000
1	6	30.59	130 429 470.	130 855 370.	.5586	.8869	1.1046
2	6	30.76	130 341 780.	131 079 300.	.4910	1.0596	1.1055
3	6	30.82	130 358 610.	131 164 510.	.5039	1.1253	1.1057
4	6	30.79	130 341 420.	131 125 610.	.4907	1.0953	1.1056
5	6	30.80	130 347 710.	131 145 470.	.4955	1.1106	1.1056
6	6	30.80	130 344 170.	131 133 910.	.4928	1.1017	1.1056
7	6	30.80	130 346 010.	131 141 020.	.4942	1.1072	1.1056
8	6	30.80	130 345 070.	131 137 290.	.4935	1.1043	1.1056
9	6	30.80	130 345 680.	131 139 830.	.4940	1.1062	1.1056
10	6	30.80	130 345 350.	131 138 280.	.4937	1.1050	1.1056
11	6	30.80	130 345 580.	131 139 460.	.4939	1.1060	1.1056
12	6	30.80	130 345 450.	131 138 740.	.4938	1.1054	1.1056

Table H-48

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	137 256 670.	137 256 670.	-	-	1.3000
1	5	30.43	138 104 780.	138 324 890.	.6179	.7783	1.3048
2	2	30.19	137 624 160.	137 750 100.	.2677	.3555	1.3030
3	4	30.34	137 888 870.	138 095 280.	.4606	.6110	1.3042
4	2	30.21	137 694 940.	137 822 320.	.3193	.4121	1.3034
5	5	30.32	137 858 900.	138 054 420.	.4388	.5812	.13040
6	2	30.22	137 712 560.	137 840 620.	.3321	.4254	1.3035
7	5	30.31	137 832 510.	138 026 740.	.4195	.5610	1.3039
8	2	30.22	137 715 990.	137 844 520.	.3346	.4283	1.3036
9	5	30.31	137 827 260.	138 022 090.	.4157	.5577	1.3038
10	2	30.22	137 718 270.	137 847 070.	.3363	.4301	1.3037
11	5	30.31	137 825 710.	138 022 040.	.4146	.5576	1.3037
12	2	30.23	137 735 690.	137 864 690.	.3490	.4430	1.3038

Table H-49

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.00	118 372 980.	118 372 980.	-	-	.7000
1	15	23.30	117 325 940.	121 551 320.	-.8845	2.6850	.7096
2	17	25.37	116 700 840.	123 539 580.	-1.4126	4.3647	.7142
3	18	25.56	116 672 100.	123 745 700.	-1.4369	4.5388	.7152
4	18	25.70	116 650 810.	123 874 820.	-1.4549	4.6479	.7159
5	18	25.72	116 659 080.	123 923 490.	-1.4479	4.6890	.7162
6	18	25.73	116 666 800.	123 943 900.	-1.4414	4.7062	.7165
7	18	25.73	116 666 230.	123 944 080.	-1.4418	4.7064	.7166
8	18	25.73	116 672 280.	123 945 150.	-1.4367	4.7073	.7166
9	18	25.73	116 681 510.	123 949 140.	-1.4289	4.7107	.7166
10	18	25.73	116 683 450.	123 946 190.	-1.4273	4.7082	.7166
11	18	25.72	116 685 150.	123 943 470.	-1.4259	4.7059	.7166
12	18	25.72	116 686 580.	123 941 730.	-1.4247	4.7044	.7166

Table H-50

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.00	123 411 020.	123 411 020.	-	-	.9000
1	17	23.12	123 280 510.	127 276 780.	-.1057	3.1324	.9118
2	17	24.37	123 142 920.	128 792 630.	-.2172	4.3607	.9153
3	17	24.45	123 138 640.	128 894 780.	-.2207	4.4435	.9156
4	17	24.46	123 141 080.	128 900 820.	-.2187	4.4484	.9156
5	17	24.46	123 142 720.	128 901 470.	-.2174	4.4489	.9156
6	17	24.46	123 143 310.	128 900 840.	-.2169	4.4484	.9156
7	17	24.46	123 143 680.	128 900 810.	-.2166	4.4480	.9156
8	17	24.46	123 142 740.	128 899 070.	-.2174	4.4470	.9156
9	17	24.46	123 142 940.	128 898 840.	-.2172	4.4468	.9156
10	17	24.46	123 143 100.	128 898 540.	-.2171	4.4465	.9156
11	17	24.46	123 143 270.	128 898 370.	-.2170	4.4464	.9156
12	17	24.46	123 143 370.	128 898 250.	-.2169	4.4463	.9156

Table H-51

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.00	128 445 460.	128 445 460.	-	-	1.1000
1	15	22.95	129 130 040.	132 914 500.	.5330	3.4793	1.1137
2	15	22.62	129 010 960.	132 405 290.	.4403	3.0829	1.1127
3	15	22.74	129 043 830.	132 588 540.	.4659	3.2256	1.1131
4	15	22.68	129 026 170.	132 502 010.	.4521	3.1582	1.1129
5	15	22.71	129 034 410.	132 546 390.	.4585	3.1927	1.1130
6	15	22.70	129 028 860.	132 518 980.	.4542	3.1714	1.1129
7	15	22.71	129 031 960.	132 535 810.	.4566	3.1845	1.1130
8	15	22.70	129 029 670.	132 523 910.	.4548	3.1752	1.1129
9	15	22.70	129 031 140.	132 532 130.	.4556	3.1816	1.1130
10	15	22.70	129 030 050.	132 526 370.	.4551	3.1771	1.1130
11	15	22.70	129 030 840.	132 530 760.	.4557	3.1806	1.1130
12	15	22.70	129 030 220.	132 527 230.	.4553	3.1778	1.1130

Table H-52

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 80% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.24

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	20.00	133 478 850.	133 478 850.	-	-	1.3000
1	15	22.78	134 890 560.	138 455 050.	1.0576	3.7281	1.3154
2	8	20.93	134 028 890.	135 235 070.	.4121	1.3157	1.3038
3	15	21.50	134 376 160.	136 294 800.	.6722	2.1097	1.3104
4	8	21.05	134 115 020.	135 450 820.	.4766	1.4774	1.3099
5	15	21.42	134 331 060.	136 074 230.	.6385	1.9444	1.3095
6	10	21.07	134 134 910.	135 515 420.	.4915	1.5258	1.3106
7	16	21.51	134 359 480.	136 228 510.	.6598	2.0600	1.3096
8	10	21.07	134 138 570.	135 509 910.	.4942	1.5216	1.3107
9	16	21.55	134 350 260.	136 287 160.	.6528	2.1039	1.3095
10	10	21.07	134 139 850.	135 508 390.	.4952	1.5205	1.3108
11	16	21.59	134 377 950.	136 351 380.	.6736	2.1520	1.3095
12	8	21.07	134 148 140.	135 517 120.	.5014	1.5270	1.3110

Table H-53

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.75

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	118 510 810.	118 510 810.	-	-	.7000
5	-	30.02	118 697 090.	118 697 090.	.1572	.1572	.7040
10	2	30.45	118 955 030.	119 378 600.	.3748	.7322	.7104
15	7	32.60	118 982 600.	121 571 330.	.3981	2.5829	.7099
20	8	32.60	119 120 190.	121 678 520.	.5142	2.6729	.7120
30	8	33.43	119 331 870.	122 675 050.	.6928	3.5138	.7145
40	8	33.92	119 735 080.	123 388 580.	1.0330	4.1159	.7175
50	8	34.29	119 951 420.	123 886 280.	1.2156	4.5358	.7190

Table H-54

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.75

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	126 324 830.	126 324 830.	-	-	.9000
5	-	30.02	126 564 280.	126 564 280.	.1896	.1896	.9051
10	2	30.45	127 018 070.	127 441 490.	.5488	.8840	.9133
15	7	32.15	127 569 700.	129 707 790.	.9855	2.6780	.9137
20	8	32.80	127 868 750.	130 654 420.	1.2222	3.4274	.9156
30	8	33.44	128 354 180.	131 694 940.	1.6065	4.2510	.9186
40	8	33.93	128 952 030.	132 610 630.	2.0797	4.9759	.9225
50	8	34.13	129 251 040.	133 034 610.	2.3164	5.3115	.9248

Table H-55

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.75

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	134 134 641.	134 134 634.	-	-	1.1000
5	-	30.02	134 428 422.	134 428 422.	.2190	.2190	1.1062
10	2	30.45	135 081 270.	135 504 560.	.7057	1.0213	1.1163
15	7	32.15	136 121 682.	138 263 438.	1.4814	3.0781	1.1168
20	7	32.80	136 636 798.	139 427 208.	1.8654	3.9457	1.1191
30	8	33.44	137 353 366.	140 696 866.	2.3996	4.8923	1.1228
40	8	33.92	138 158 564.	141 809 690.	2.9999	5.7219	1.1275
50	8	34.13	138 555 574.	142 340 748.	3.2959	6.1178	1.1303

Table H-56

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.75

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	141 945 610.	141 945 610.	-	-	1.3000
5	-	30.02	142 292 790.	142 292 790.	.2446	.2446	1.3073
10	2	30.45	143 144 240.	143 567 370.	.8444	1.1425	1.3193
15	7	32.15	144 687 060.	146 828 300.	1.9313	3.4398	1.3198
20	8	32.80	145 414 800.	148 203 730.	2.4440	4.4088	1.3226
30	8	33.44	146 355 300.	149 698 860.	3.1066	5.4621	1.3269
40	8	34.07	147 494 740.	151 290 530.	3.9093	6.5835	1.3319
50	8	34.14	147 858 640.	151 652 540.	4.1657	6.8385	1.3358

Table H-57

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	117 900 410.	117 900 410.	-	-	.7000
5	1	29.95	118 057 380.	118 063 480.	.1331	.1383	.7059
10	5	31.73	118 103 900.	119 906 020.	.1726	1.7011	.7073
15	5	32.12	118 290 100.	120 392 907.	.3305	2.1141	.7084
20	6	33.06	118 467 890.	121 420 030.	.4813	2.9852	.7092
30	8	33.42	118 785 170.	122 001 907.	.7504	3.4788	.7131
40	8	33.86	119 087 290.	122 665 440.	1.0067	4.0416	.7168
50	8	34.19	119 343 630.	123 168 340.	1.2241	4.4681	.7195

Table H-58

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	125 675 640.	125 675 640.	-	-	.9000
5	1	29.95	125 877 860.	125 883 960.	.1609	.1658	.9075
10	3	31.05	126 302 020.	127 406 700.	.4984	1.3774	.9100
15	4	32.12	126 774 530.	128 877 650.	.8744	2.5478	.9108
20	6	33.05	127 244 730.	130 195 540.	1.2485	3.5965	.9118
30	8	33.42	127 732 970.	130 952 750.	1.6370	4.1990	.9168
40	8	33.87	128 207 200.	131 806 180.	2.0144	4.8781	.9216
50	8	34.31	128 685 130.	132 599 330.	2.3946	5.5092	.9247

Table H-59

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	133 447 670.	133 447 670.	-	-	1.1000
5	1	29.95	133 697 750.	133 703 960.	.1874	.1920	1.1092
10	3	31.05	134 460 720.	135 564 650.	.7591	1.5864	1.1122
15	3	32.12	135 258 690.	137 361 960.	1.3571	2.9332	1.1132
20	7	32.78	135 792 240.	138 544 420.	1.7569	3.8193	1.1159
30	7	33.42	136 669 130.	139 894 130.	2.4140	4.8307	1.1206
40	8	34.03	137 470 790.	141 196 900.	3.0148	5.8069	1.1259
50	8	34.19	137 913 810.	141 731 510.	3.3467	6.2076	1.1295

Table H-60

RANDOM ERROR IN DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

% RMS ERROR IN DISPATCH PRICE	NO. OF UNITS USING LESS THAN BASE ALLOCATION (UNIT NOS.)	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	141 222 150.	141 222 150.	-	-	1.3000
5	1	29.95	141 518 060.	141 524 030.	.2095	.2138	1.3109
10	4	31.05	142 620 670.	143 724 400.	.3903	1.7719	1.3144
15	5	32.12	143 742 470.	145 845 990.	1.7847	3.2742	1.3156
20	7	32.78	144 489 180.	147 240 830.	2.3134	4.2619	1.3188
30	8	33.46	145 616 740.	148 907 760.	3.1118	5.4422	1.3244
40	8	33.87	146 476 740.	150 076 470.	3.7208	6.2698	1.3312
50	8	34.20	147 195 790.	151 017 410.	4.2300	6.9361	1.3362

Table H-61

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	117 900 410.	117 900 410.	-	-	.7000
1	-	30.44	118 151 000.	118 151 000.	.2125	.2125	.6917
2	2	30.90	118 176 260.	118 629 350.	.2340	.6183	.6922
3	3	31.14	118 200 110.	118 889 780.	.2542	.8392	.6929
4	4	31.22	118 226 690.	118 997 630.	.2767	.9306	.6934
5	4	31.40	118 183 090.	119 184 730.	.2397	1.0893	.6940
6	4	31.42	118 205 830.	119 213 250.	.2590	1.1135	.6942
7	4	31.42	118 222 850.	119 223 860.	.2735	1.1225	.6944
8	4	31.42	118 236 990.	119 228 080.	.2854	1.1261	.6945
9	4	31.41	118 255 990.	119 234 180.	.3016	1.1313	.6946
10	5	31.43	118 253 000.	119 258 430.	.2991	1.1518	.6947
11	5	31.52	118 225 040.	119 344 890.	.2753	1.2252	.6949
12	5	31.53	118 221 548.	119 358 569.	.2724	1.2368	.6950

Table H-62

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% LESS THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	125 675 640.	125 675 640.	-	-	.9000
1	-	30.42	125 970 780.	125 970 780.	.2348	.2348	.8897
2	2	30.61	125 973 190.	126 218 940.	.2368	.4323	.8905
3	2	30.64	125 998 470.	126 263 840.	.2569	.4680	.8906
4	2	30.64	126 001 160.	126 264 650.	.2590	.4687	.8907
5	2	30.64	126 004 110.	126 266 830.	.2614	.4704	.8907
6	2	30.64	126 005 260.	126 267 200.	.2623	.4707	.8907
7	2	30.64	126 006 280.	126 267 640.	.2631	.4711	.8907
8	2	30.64	126 007 300.	126 268 130.	.2639	.4714	.8907
9	2	30.64	126 008 140.	126 268 530.	.2646	.4718	.8907
10	2	30.64	126 008 400.	126 268 430.	.2648	.4717	.8907
11	2	30.64	126 007 430.	126 275 840.	.2640	.4776	.8907
12	2	30.64	126 007 377.	126 277 042.	.2640	.4785	.8907

Table H-63

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 10% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	133 447 670.	133 447 670.	-	-	1.1000
1	-	30.40	133 791 620.	133 791 620.	.2577	.2577	1.0878
2	-	30.33	133 698 270.	133 698 270.	.1878	.1878	1.0894
3	-	30.36	133 730 740.	133 730 740.	.2121	.2121	1.0886
4	-	30.33	133 700 920.	133 700 920.	.1898	.1898	1.0892
5	-	30.35	133 725 440.	133 725 440.	.2081	.2081	1.0887
6	-	30.33	133 701 370.	133 701 370.	.1901	.1901	1.0892
7	-	30.35	133 724 360.	133 724 360.	.2073	.2073	1.0887
8	-	30.33	133 701 660.	133 701 660.	.1903	.1903	1.0892
9	-	30.35	133 724 000.	133 724 000.	.2071	.2071	1.0887
10	-	30.33	133 701 990.	133 701 990.	.1906	.1906	1.0891
11	-	30.35	133 723 840.	133 723 840.	.2069	.2069	1.0888
12	-	30.33	133 702 201.	133 702 201.	.1907	.1907	1.0891

Table H-64

WEIGHTED-AVERAGE PRICE USED FOR DISPATCH PRICE

AUXILIARY FUEL PRICE = 30% MORE THAN THE BASE FUEL PRICE

BASE FUEL = 70% OF TOTAL FUEL CONSUMED

CORRELATION FACTOR = 0.95

OPTIMIZATION PERIOD NUMBER (MONTH NUMBER)	NO. OF UNITS USING LESS THAN BASE ALLOCATION	AUXILIARY FUEL USED (% OF TOTAL CONSUMPTION)	FUEL COST 1 ($)	FUEL COST 2 ($)	% INCREASE IN COST OVER THE BASE CASE		RATIO OF THE WEIGHTED AVE. AUX. FUEL PRICE TO THE WEIGHTED AVE. BASE FUEL PRICE
					USING FUEL COST 1	USING FUEL COST 2	
BASE CASE	-	30.00	141 222 150.	141 222 150.	-	-	1.3000
1	-	30.38	141 592 210.	141 592 210.	.2620	.2620	1.2860
2	-	30.22	141 382 090.	141 382 090.	.1133	.1133	1.2909
3	-	30.32	141 510 950.	141 610 950.	.2045	.2045	1.2875
4	-	30.24	141 415 190.	141 415 190.	.1367	.1367	1.2901
5	-	30.31	141 492 900.	141 492 900.	.1917	.1917	1.2878
6	-	30.26	141 440 100.	141 440 100.	.1543	.1543	1.2898
7	-	30.32	141 512 860.	141 512 860.	.2059	.2059	1.2881
8	-	30.26	141 441 450.	141 441 450.	.1553	.1553	1.2898
9	1	30.34	141 528 910.	141 548 160.	.2172	.2308	1.2880
10	-	30.25	141 425 820.	141 425 820.	.1442	.1442	1.2898
11	1	30.33	141 521 350.	141 540 700.	.2119	.2256	1.2880
12	-	30.26	141 443 910.	141 443 910.	.1570	.1570	1.2898

Appendix I

GRAPHICAL RESULTS OF SIMULATION STUDIES

This appendix contains a number of computer-generated figures showing the results of a number of simulation studies modeling the relationship between total fuel costs and dispatch fuel price policies and errors. The interpretation and significance of the tables is explained in Section 5.

For the reader's convenience, an ordered list of figures in this appendix is given below.

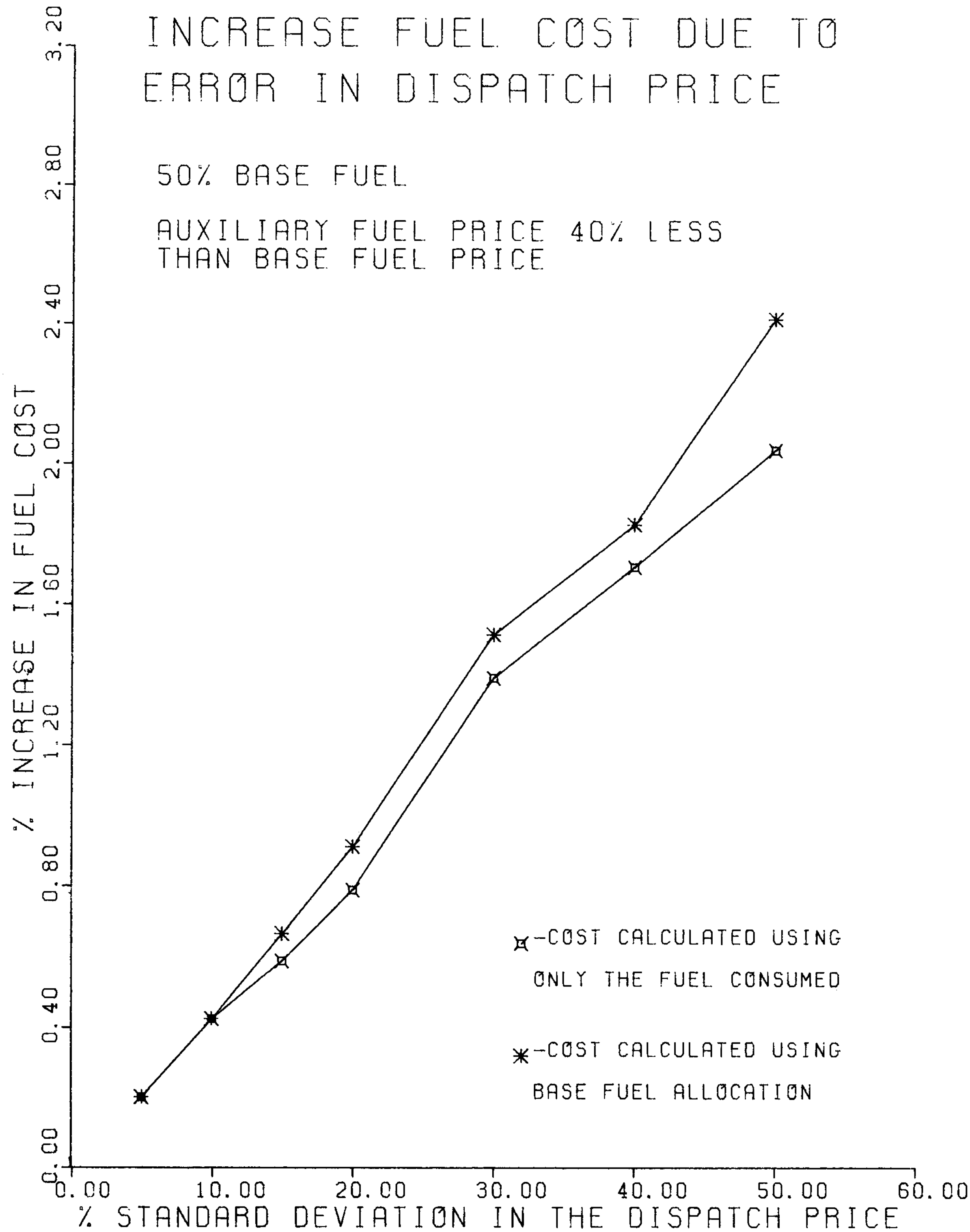


Figure I-1. Increased Fuel Cost Due to Random Dispatch Error

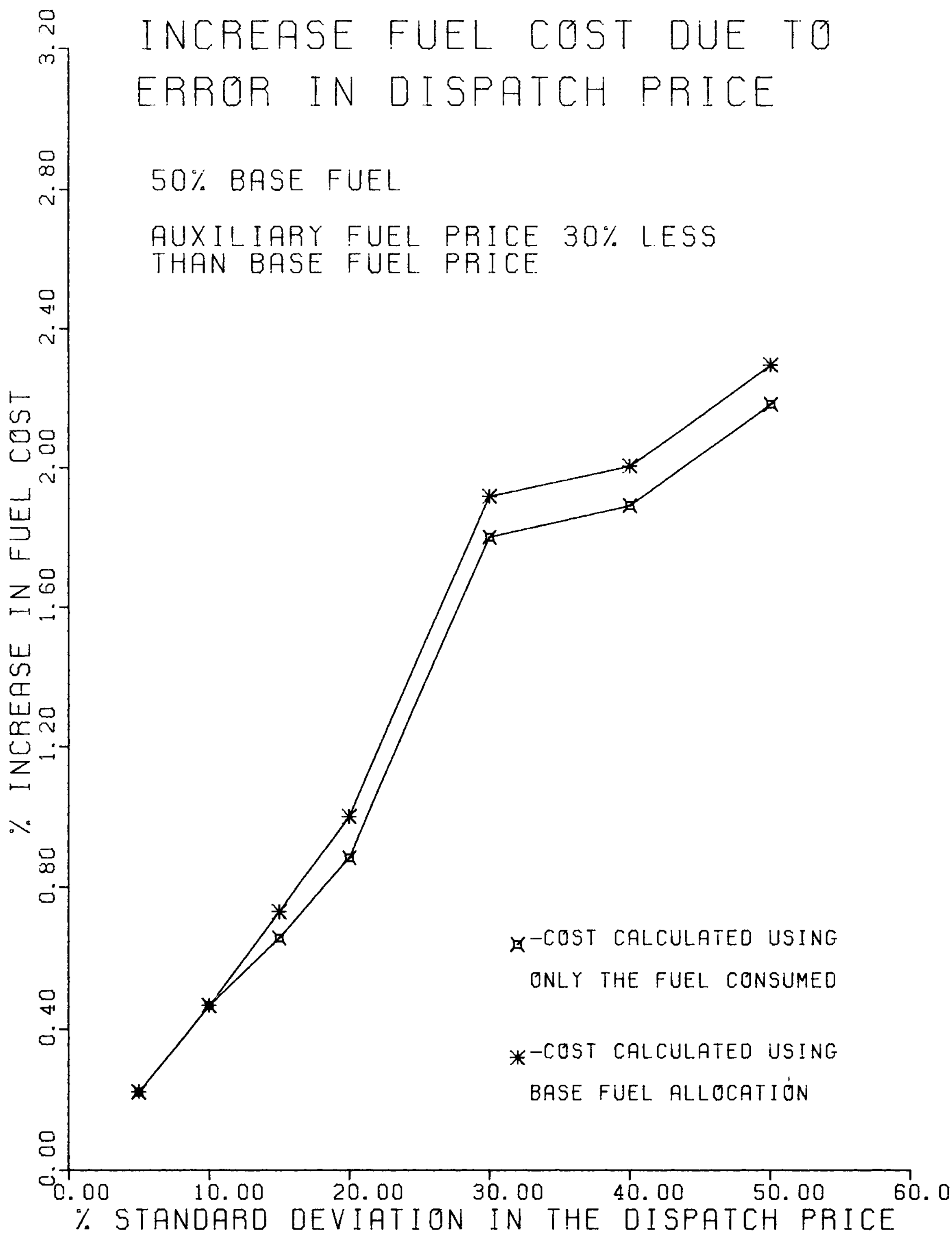


Figure I-2. Increased Fuel Cost Due to Random Dispatch Error

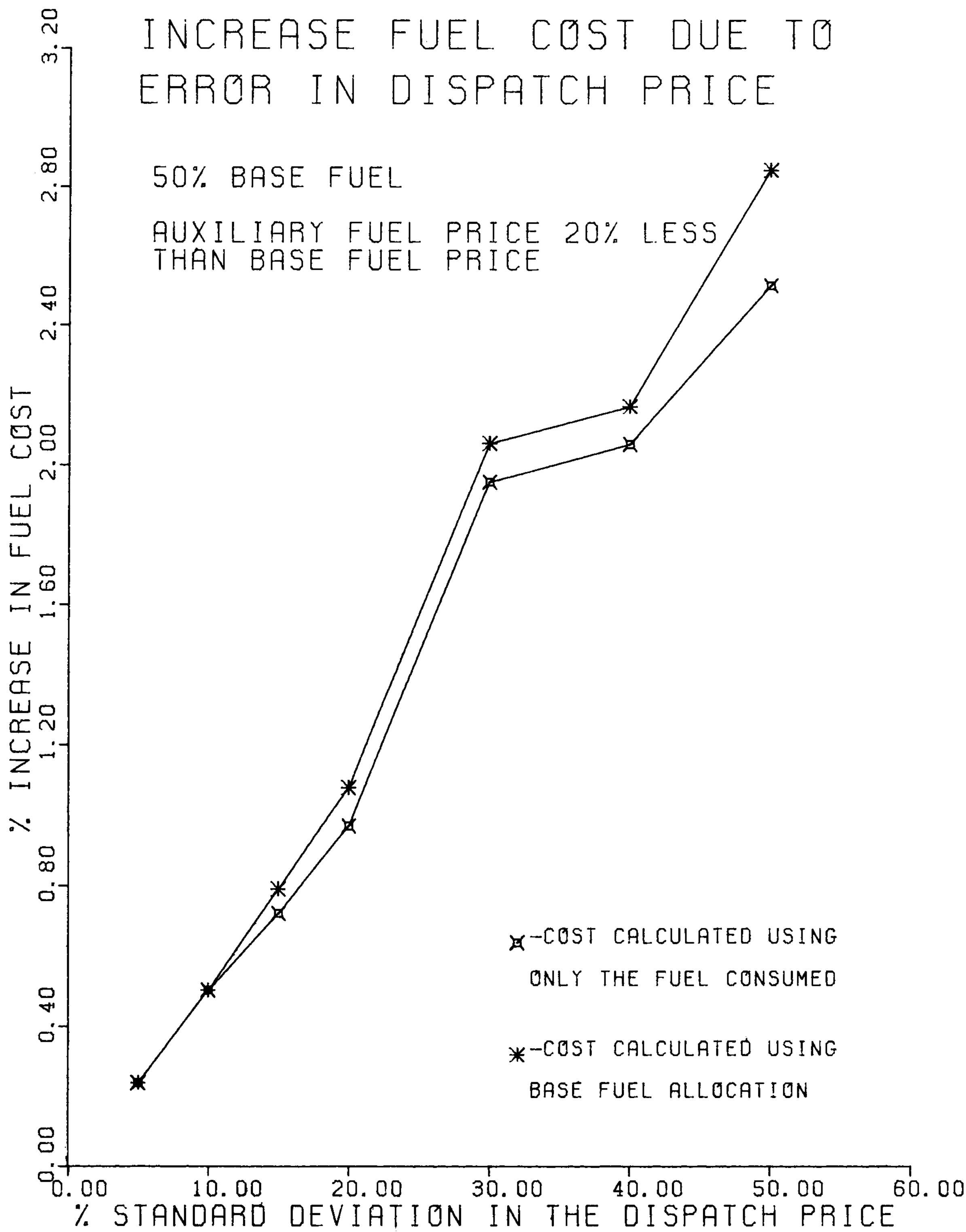


Figure I-3. Increased Fuel Cost Due to Random Dispatch Error

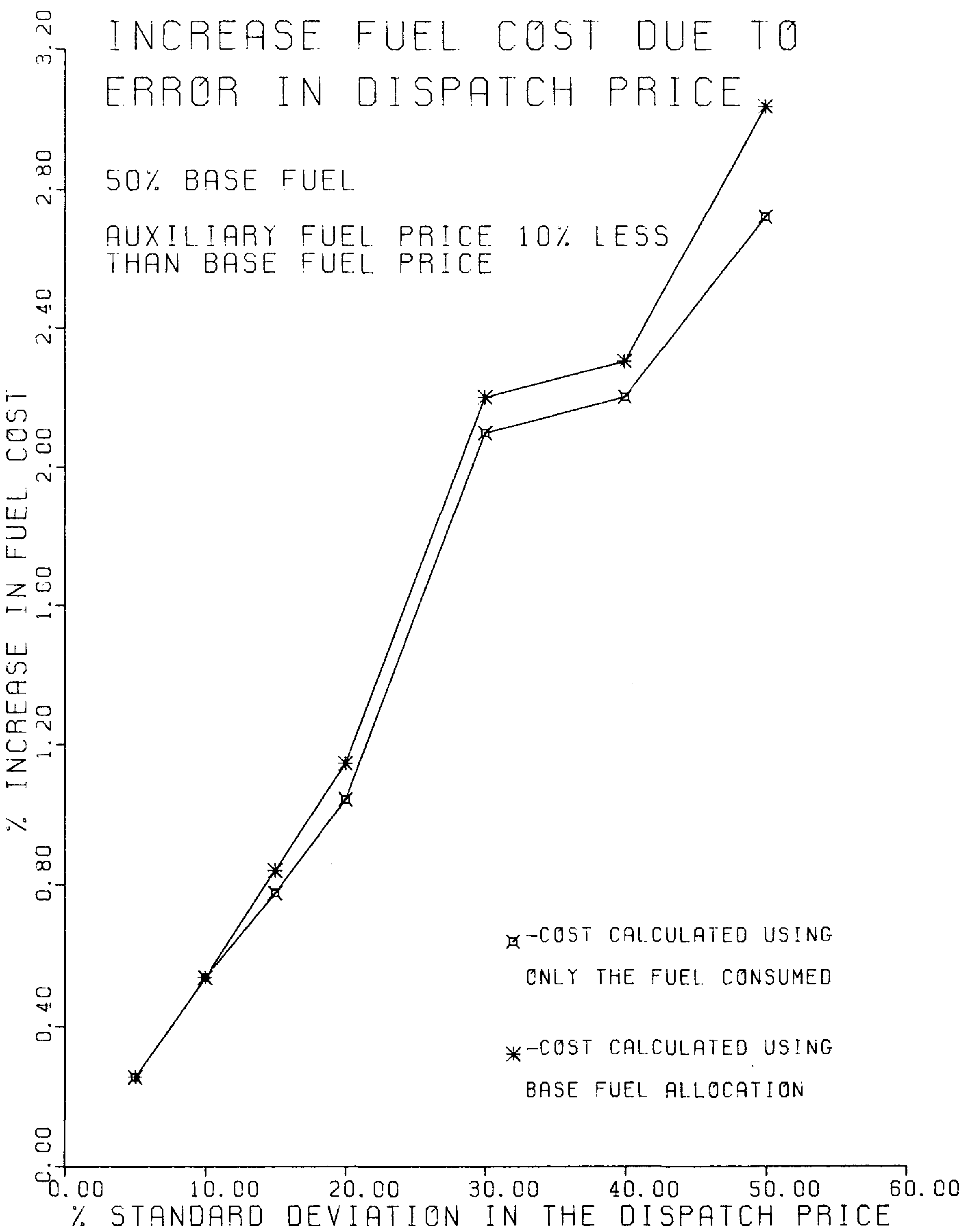


Figure I-4. Increased Fuel Cost Due to Random Dispatch Error

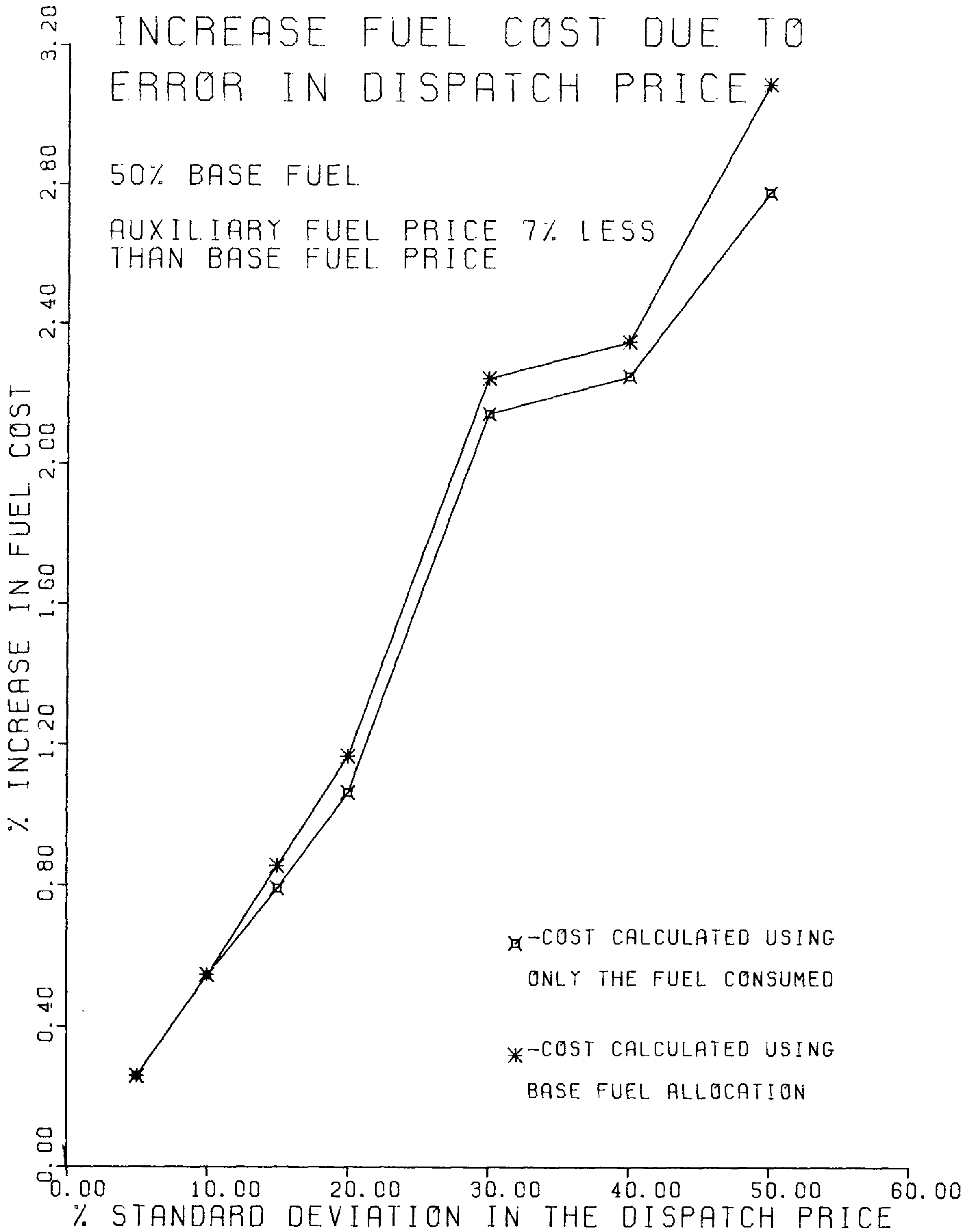


Figure I-5. Increased Fuel Cost Due to Random Dispatch Error

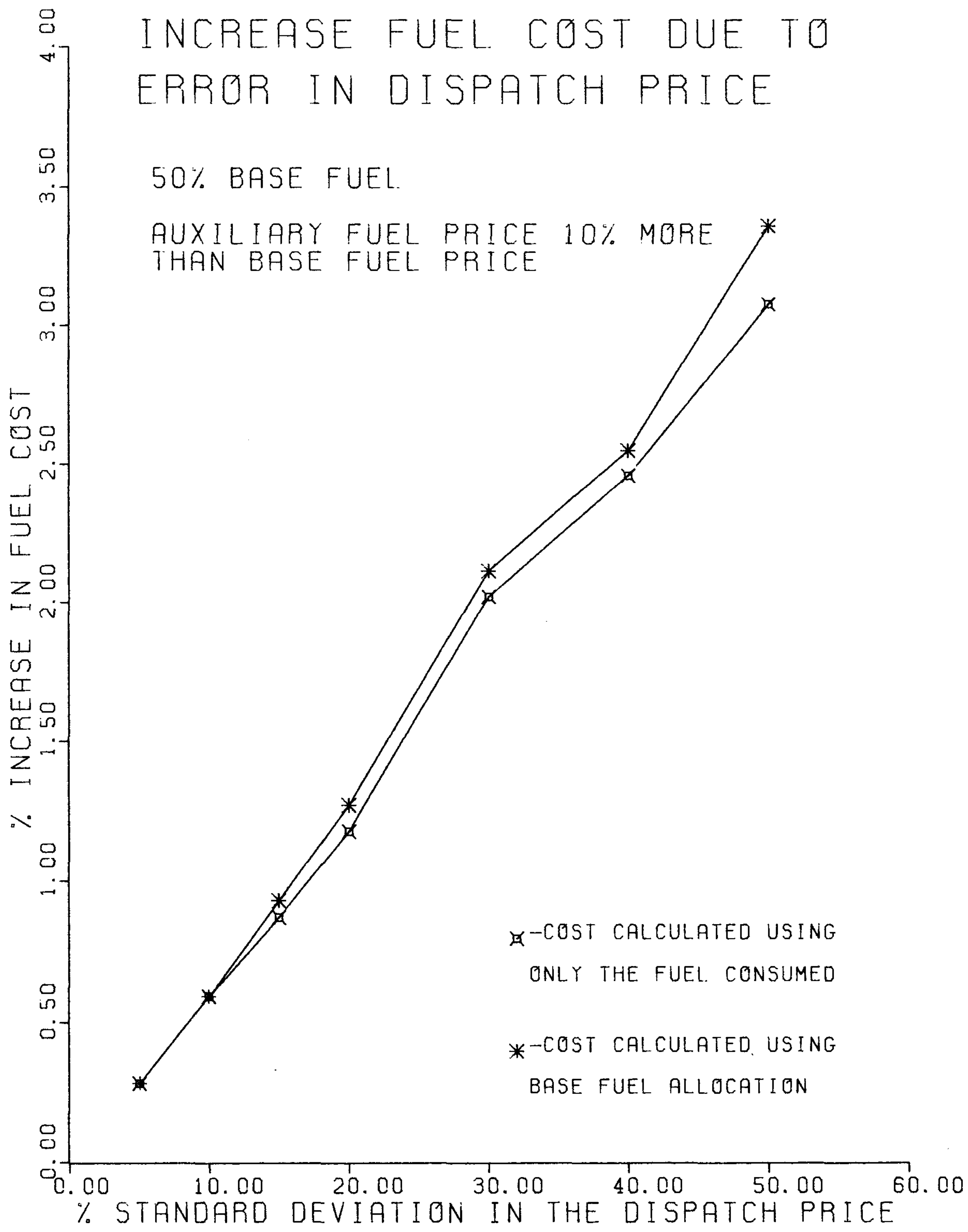


Figure I-6. Increased Fuel Cost Due to Random Dispatch Error

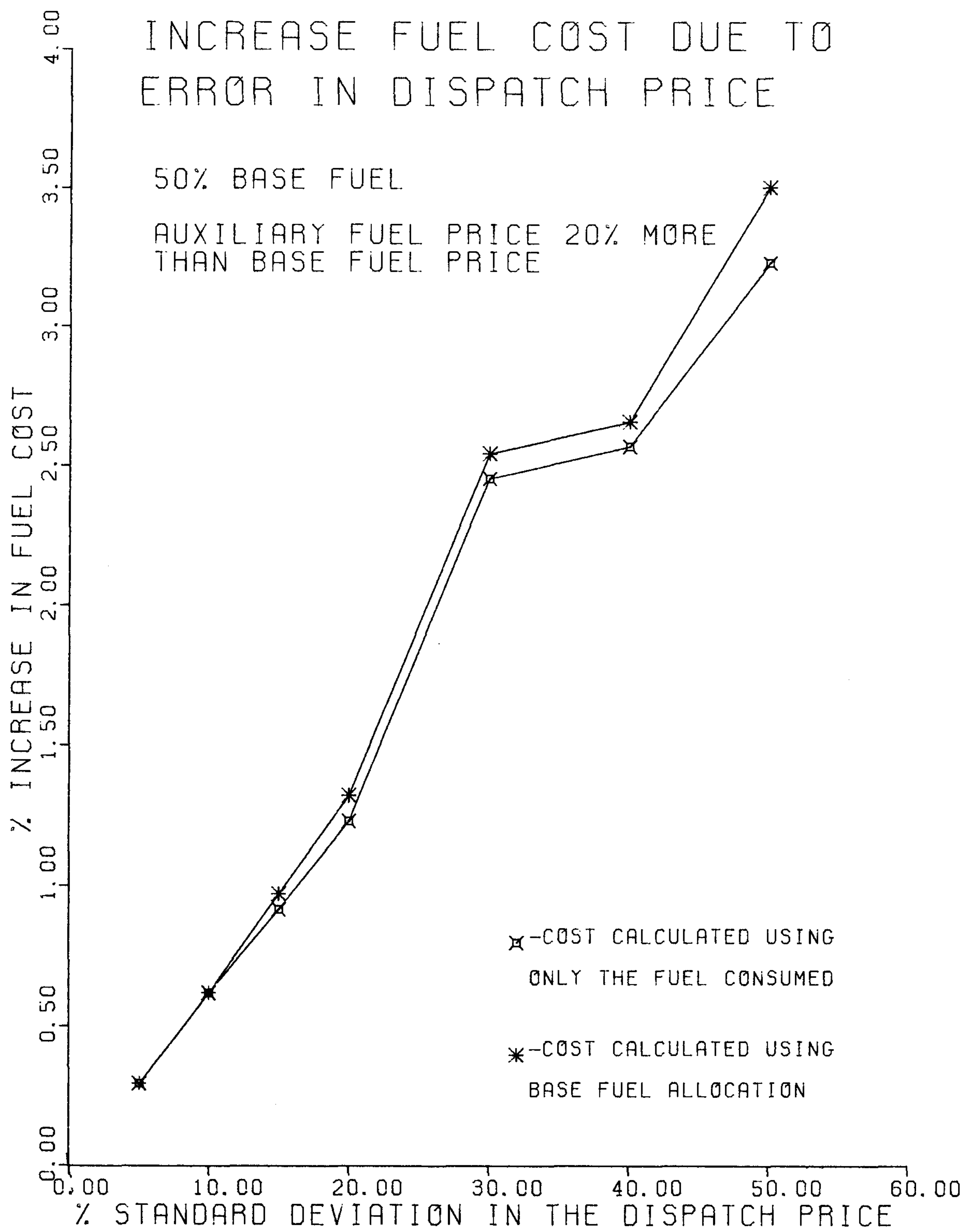


Figure I-7. Increased Fuel Cost Due to Random Dispatch Error

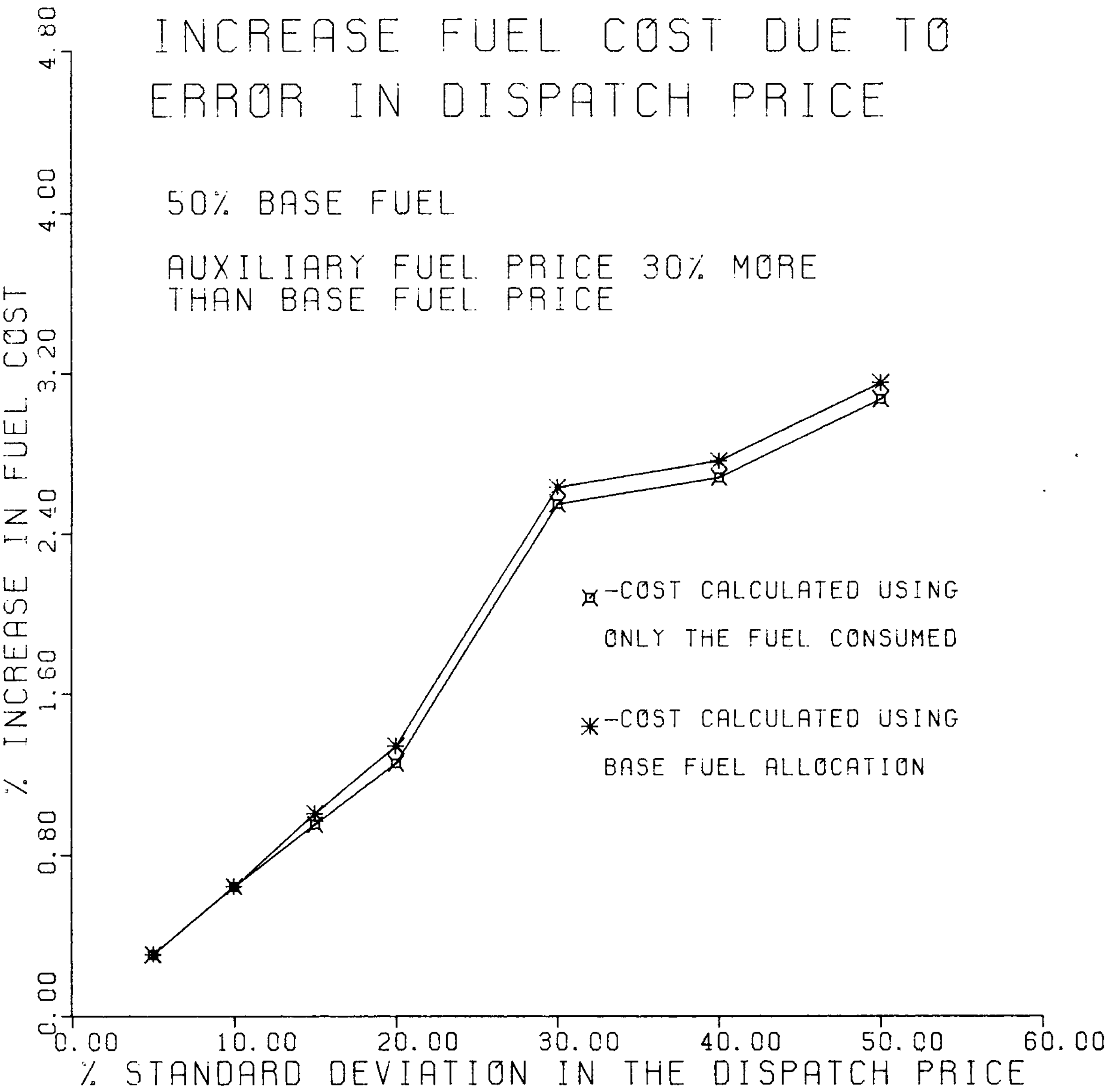


Figure I-8. Increased Fuel Cost Due to Random Dispatch Error

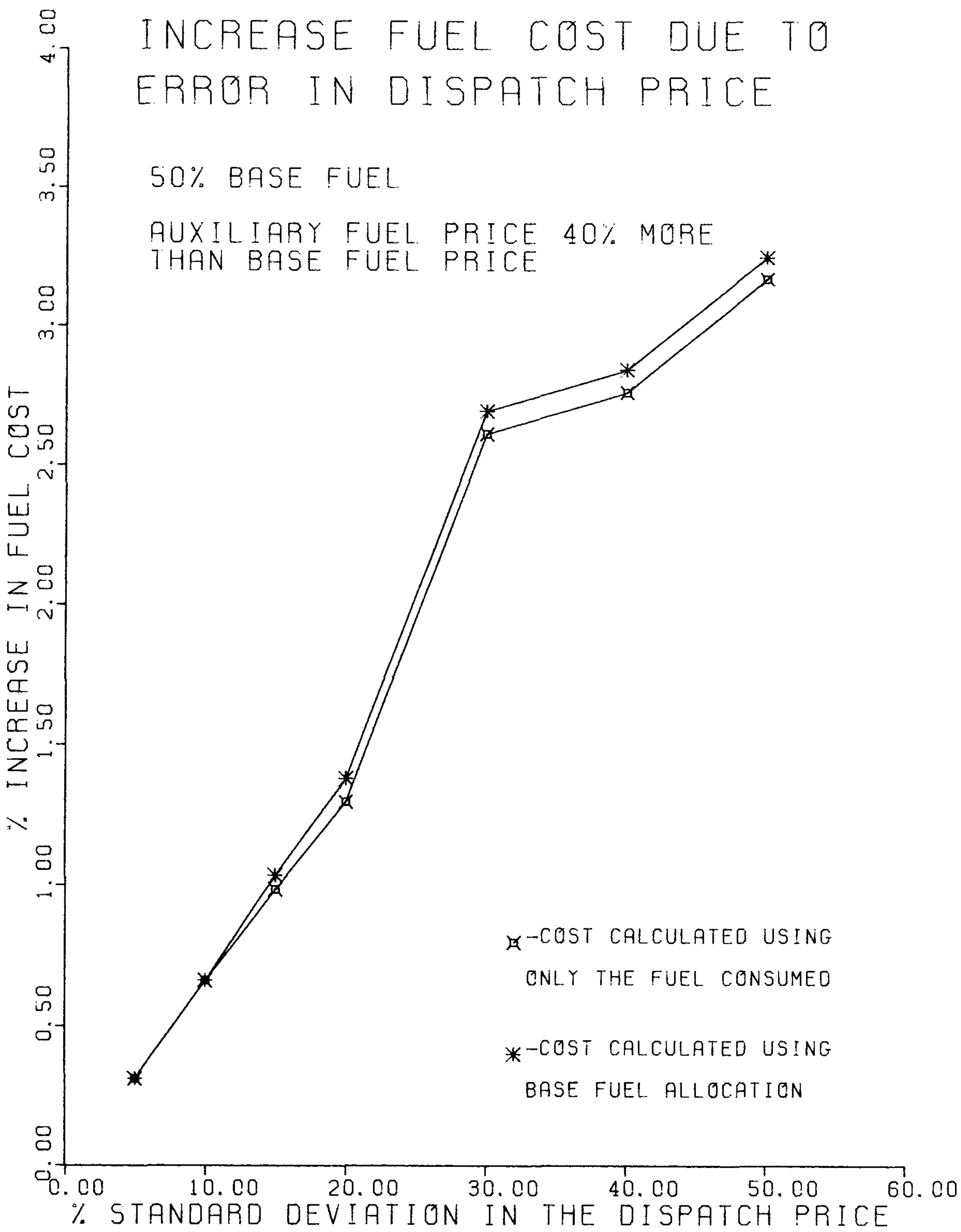


Figure I-9. Increased Fuel Cost Due to Random Dispatch Error

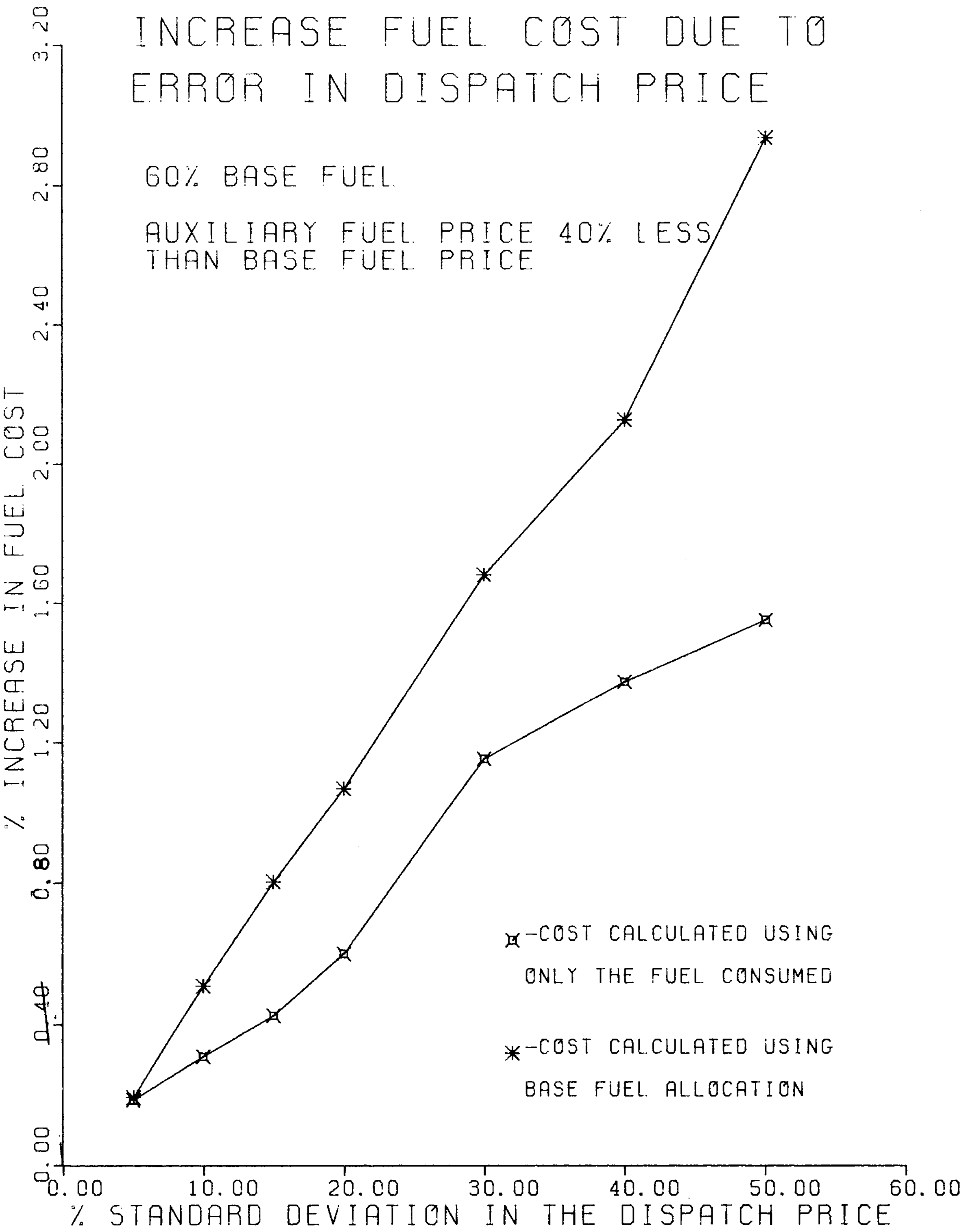


Figure I-10. Increased Fuel Cost Due to Random Dispatch Error

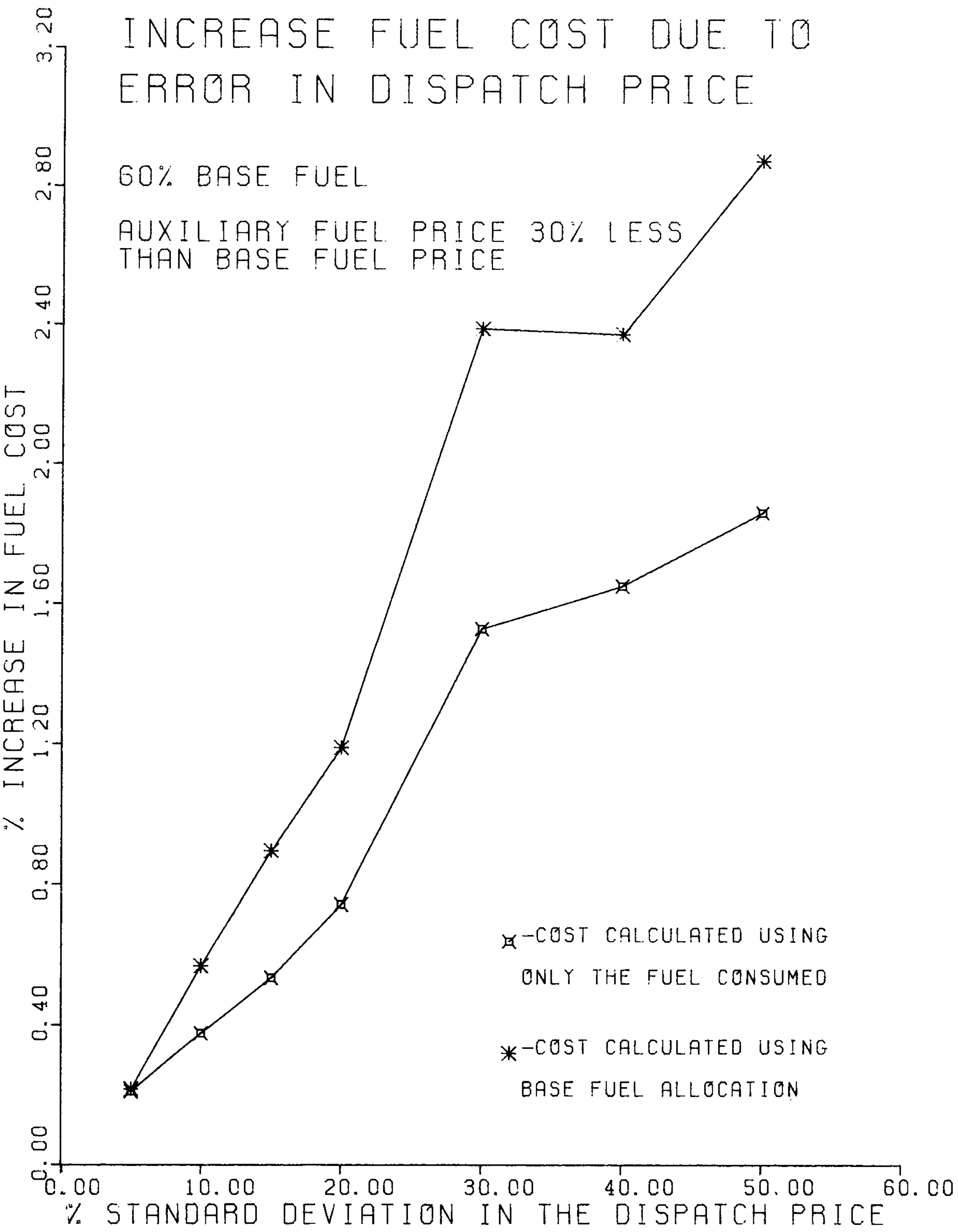


Figure I-11. Increased Fuel Cost Due to Random Dispatch Error

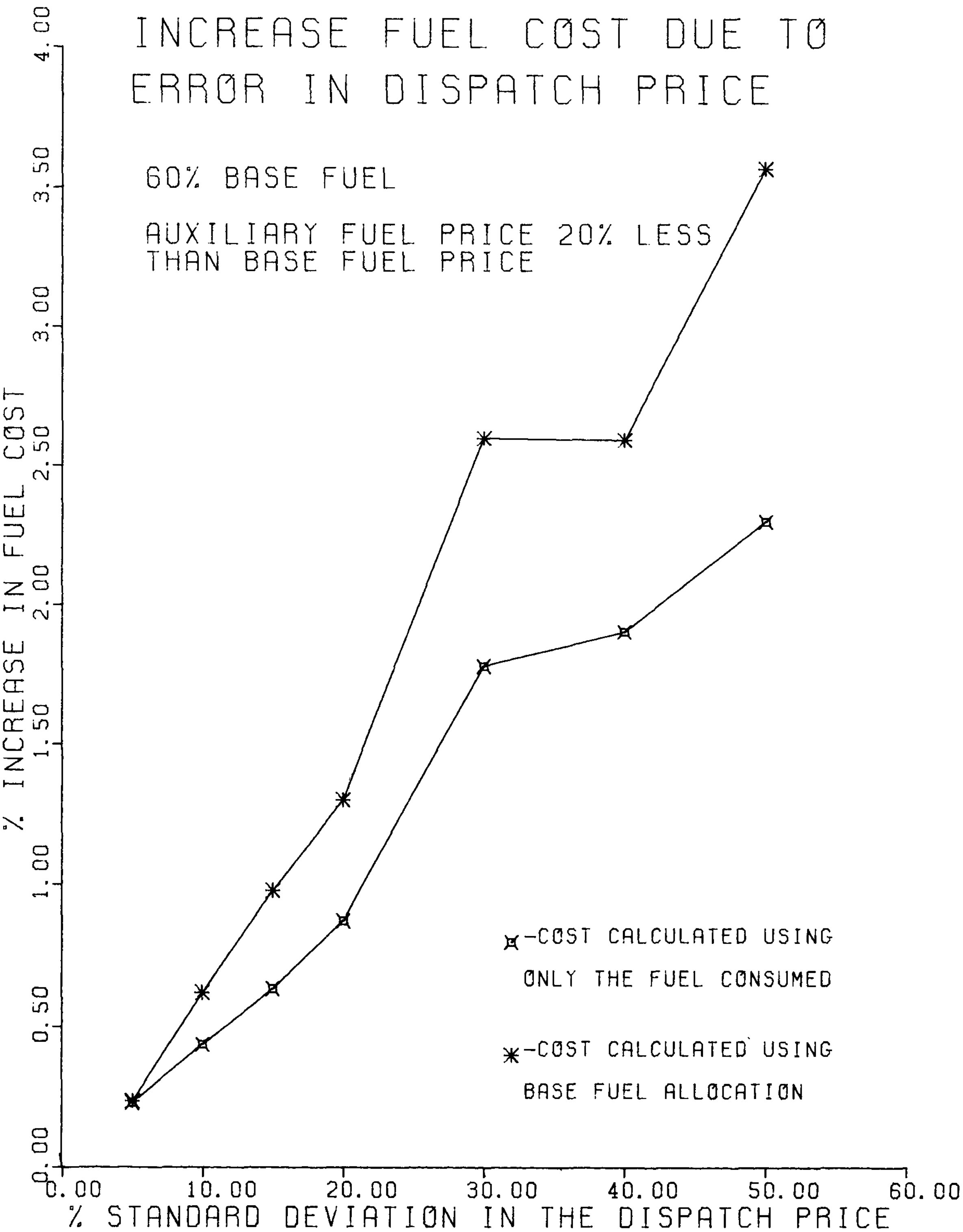


Figure I-12. Increased Fuel Cost Due to Random Dispatch Error

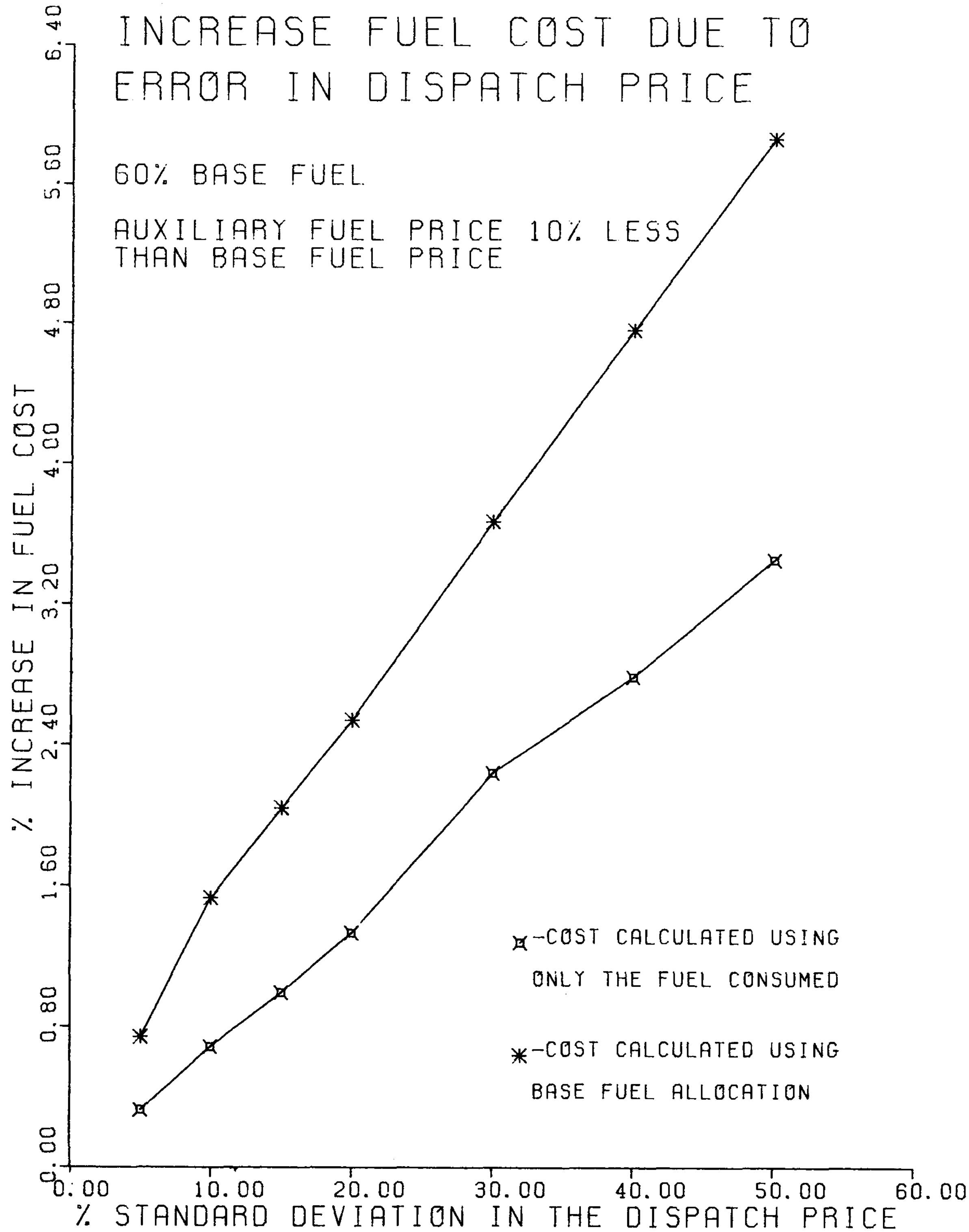


Figure I-13. Increased Fuel Cost Due to Random Dispatch Error

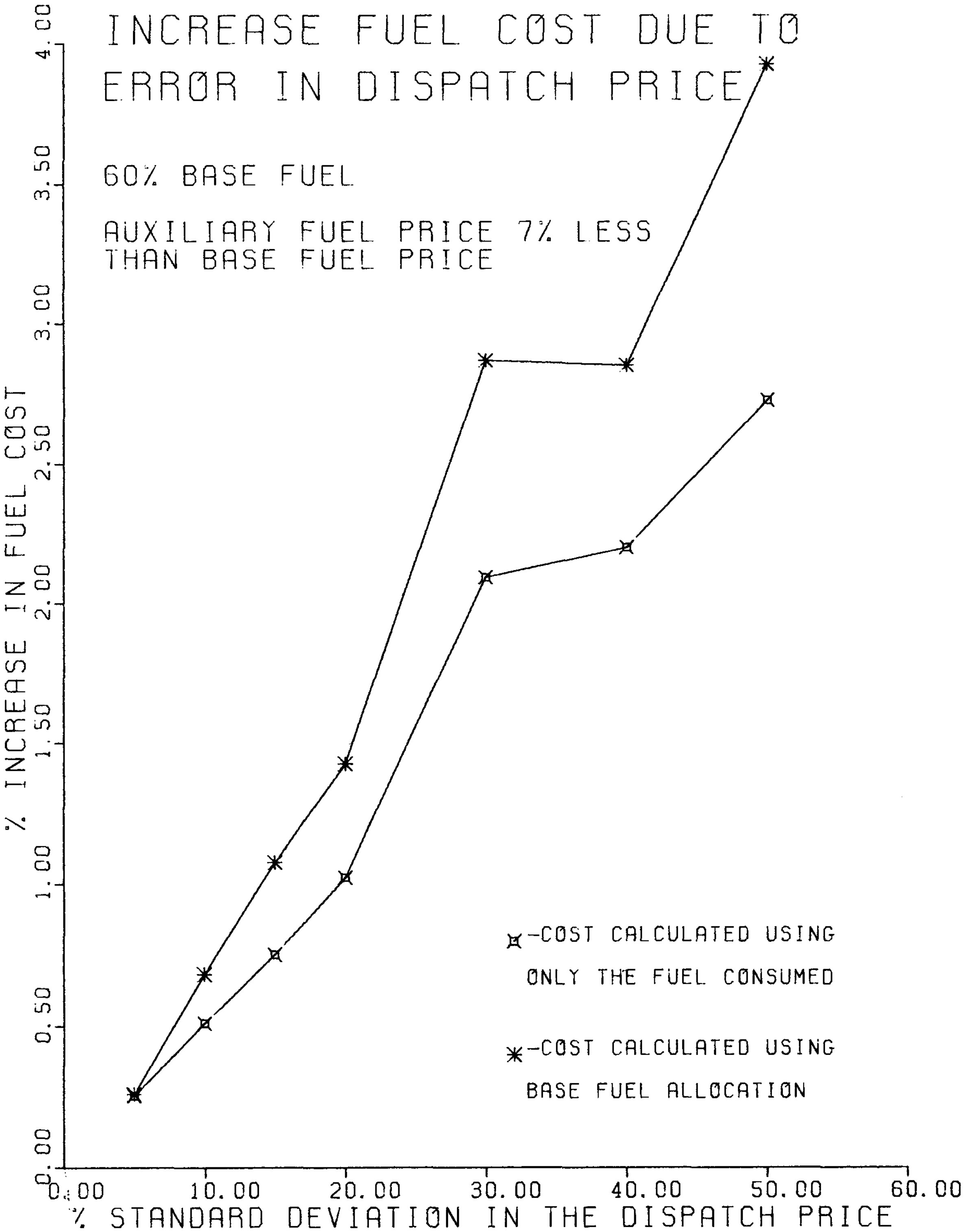


Figure I-14. Increased Fuel Cost Due to Random Dispatch Error

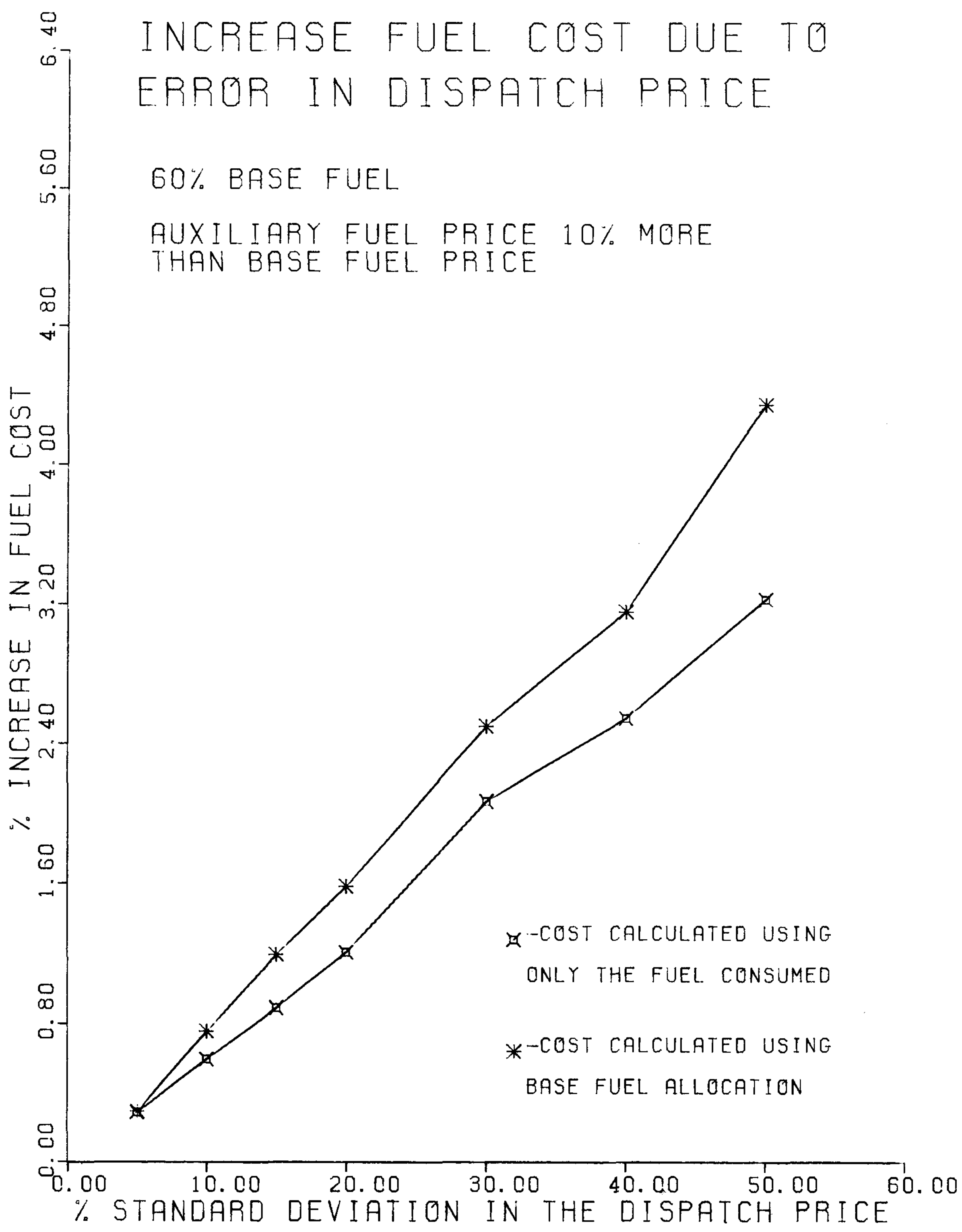


Figure I-15. Increased Fuel Cost Due to Random Dispatch Error

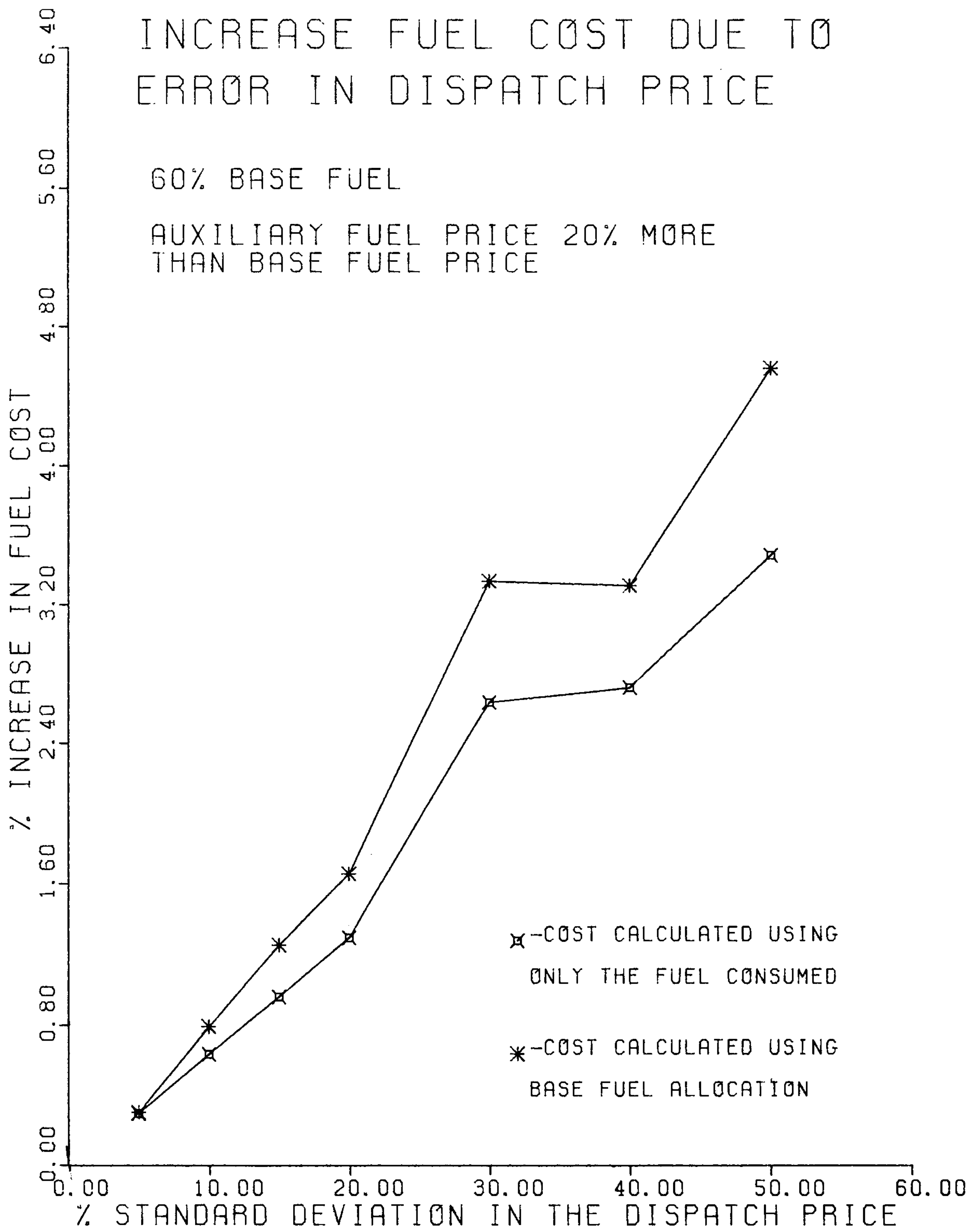


Figure I-16. Increased Fuel Cost Due to Random Dispatch Error

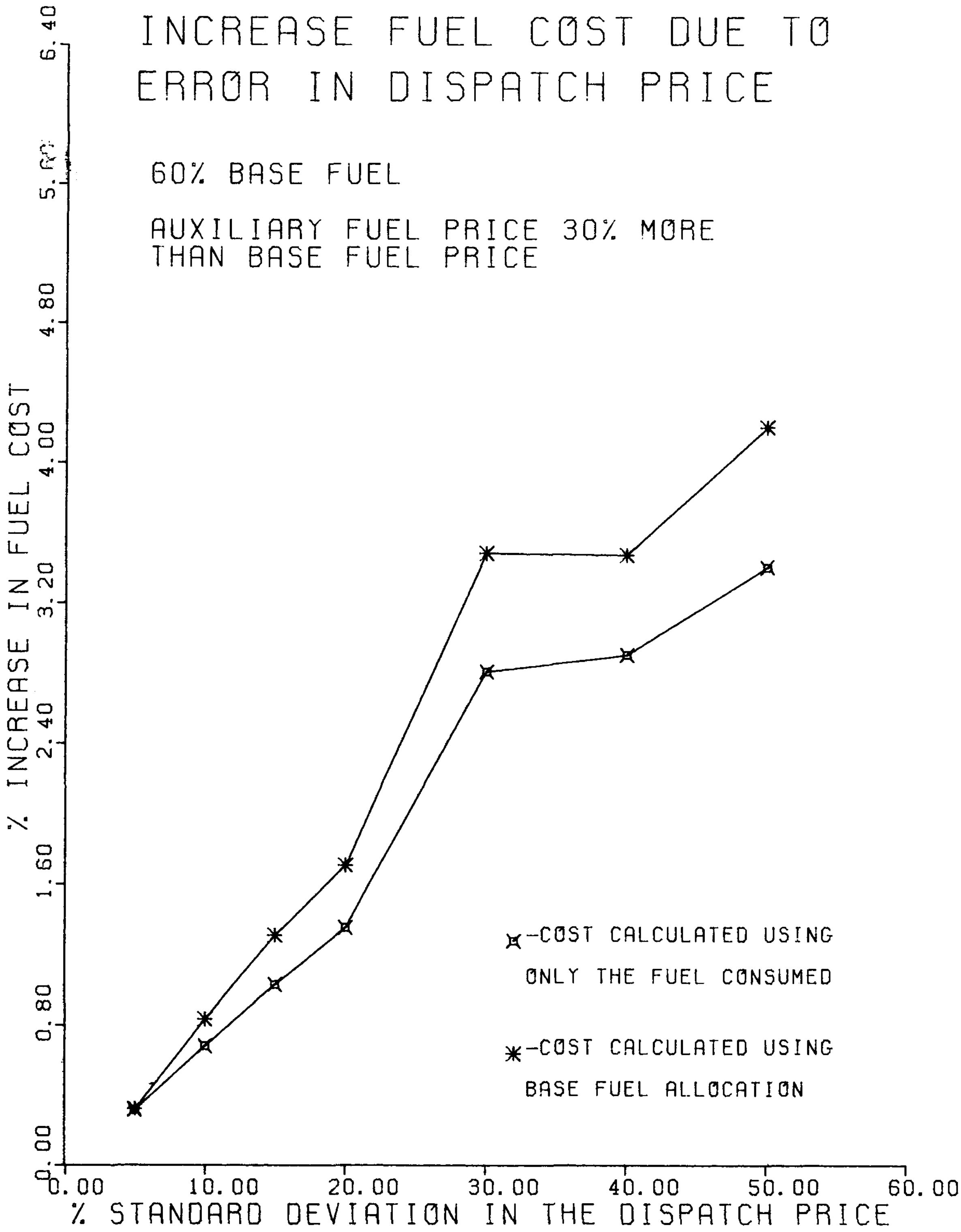


Figure I-17. Increased Fuel Cost Due to Random Dispatch Error

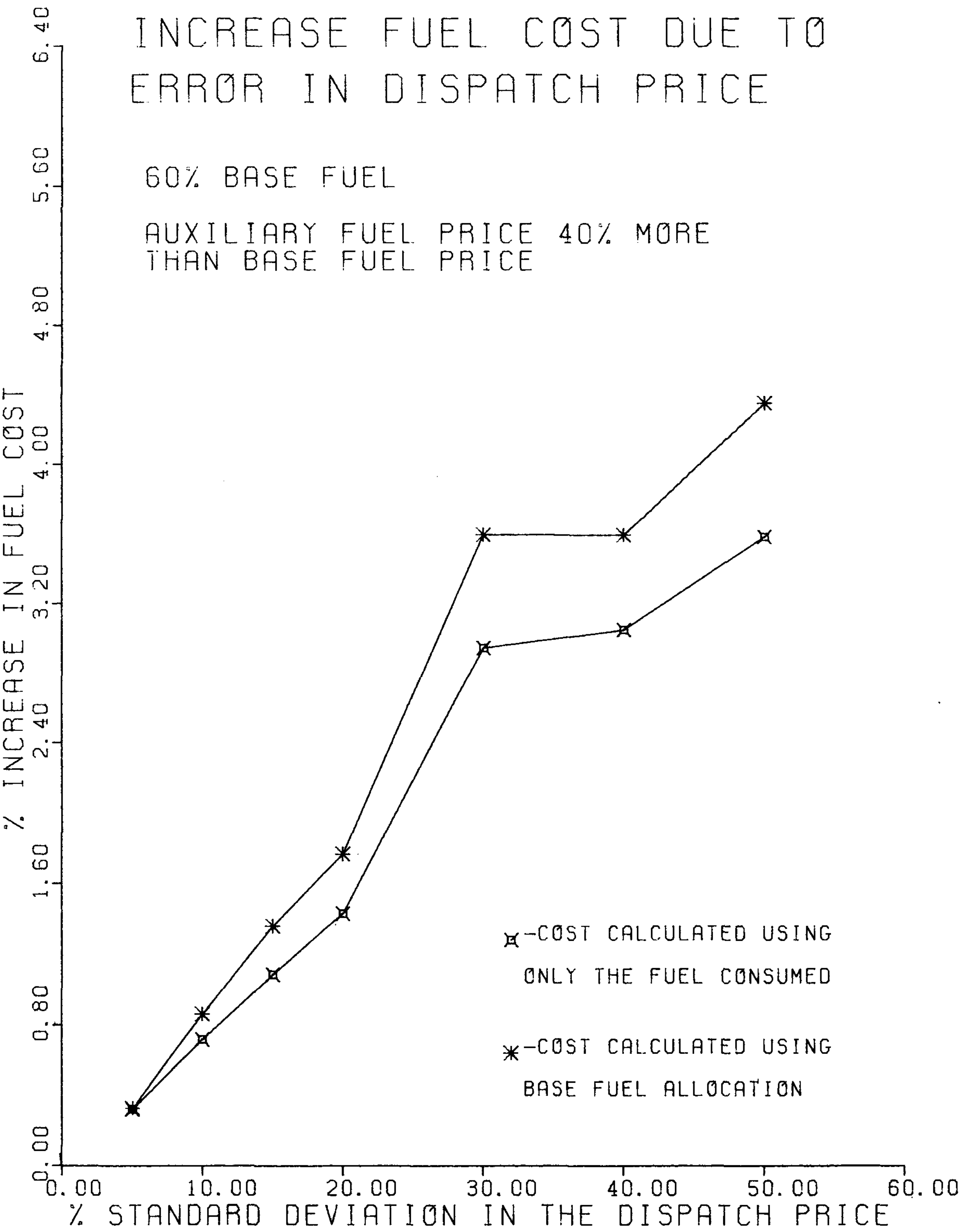


Figure I-18. Increased Fuel Cost Due to Random Dispatch Error

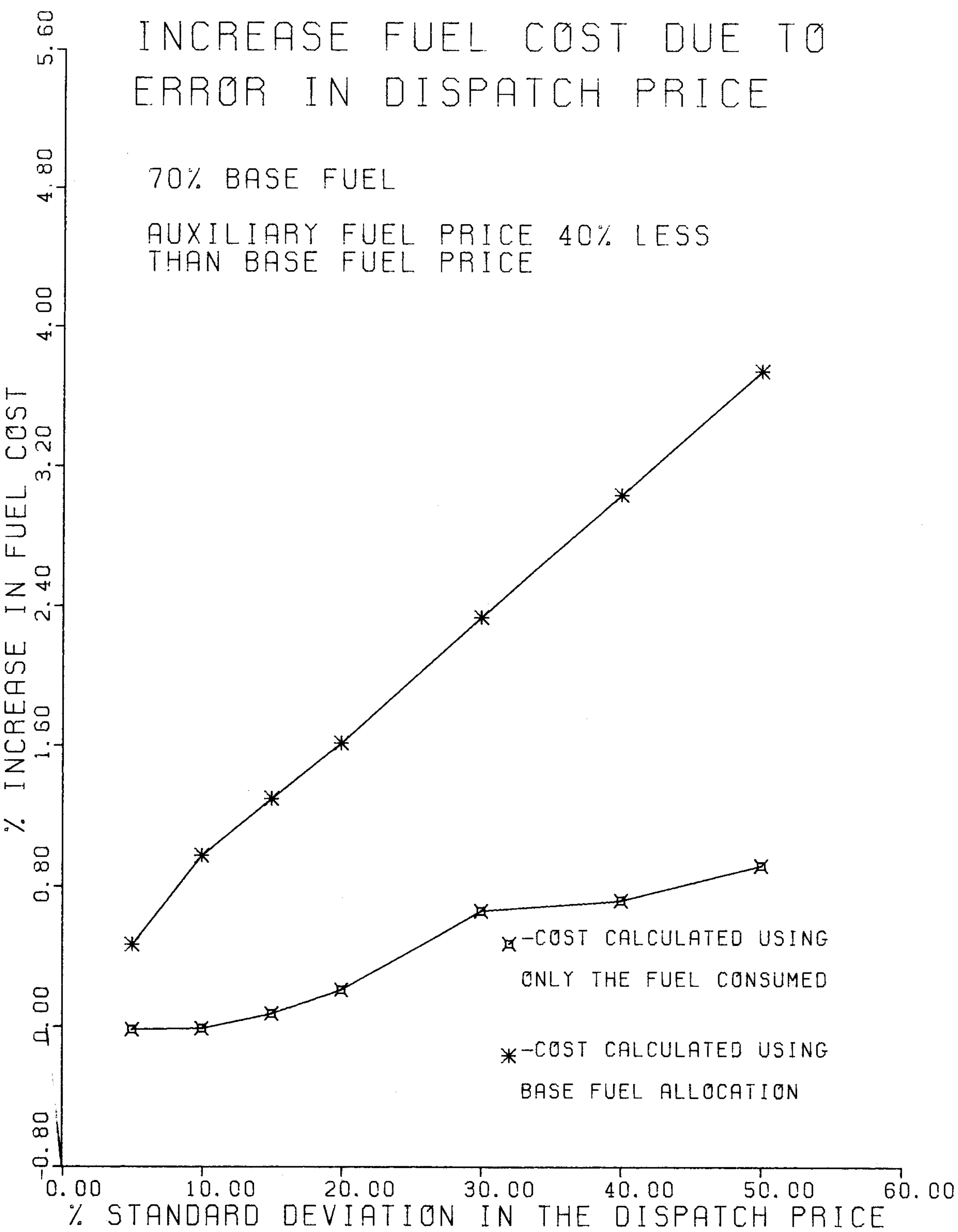


Figure I-19. Increased Fuel Cost Due to Random Dispatch Error

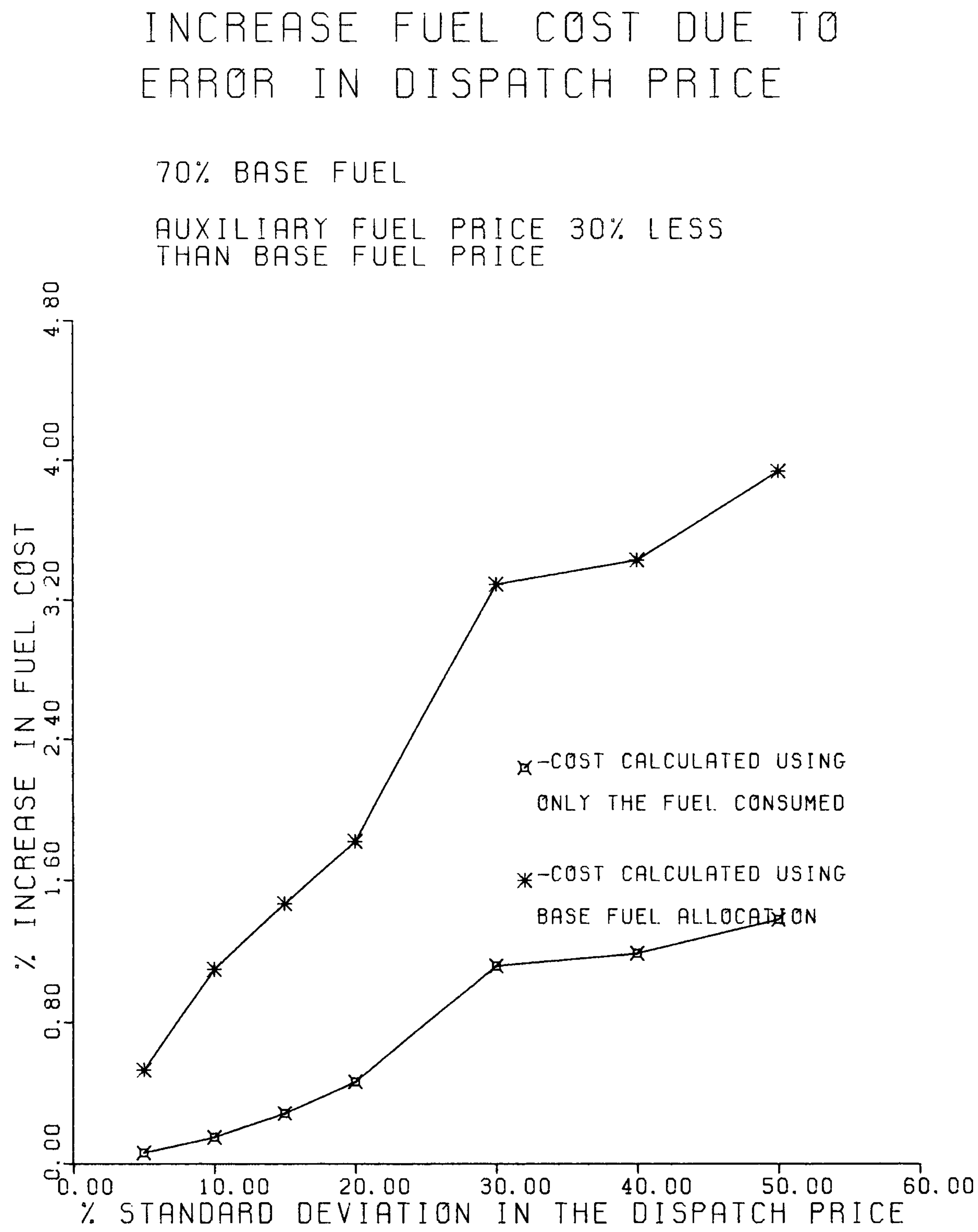


Figure I-20. Increased Fuel Cost Due to Random Dispatch Error

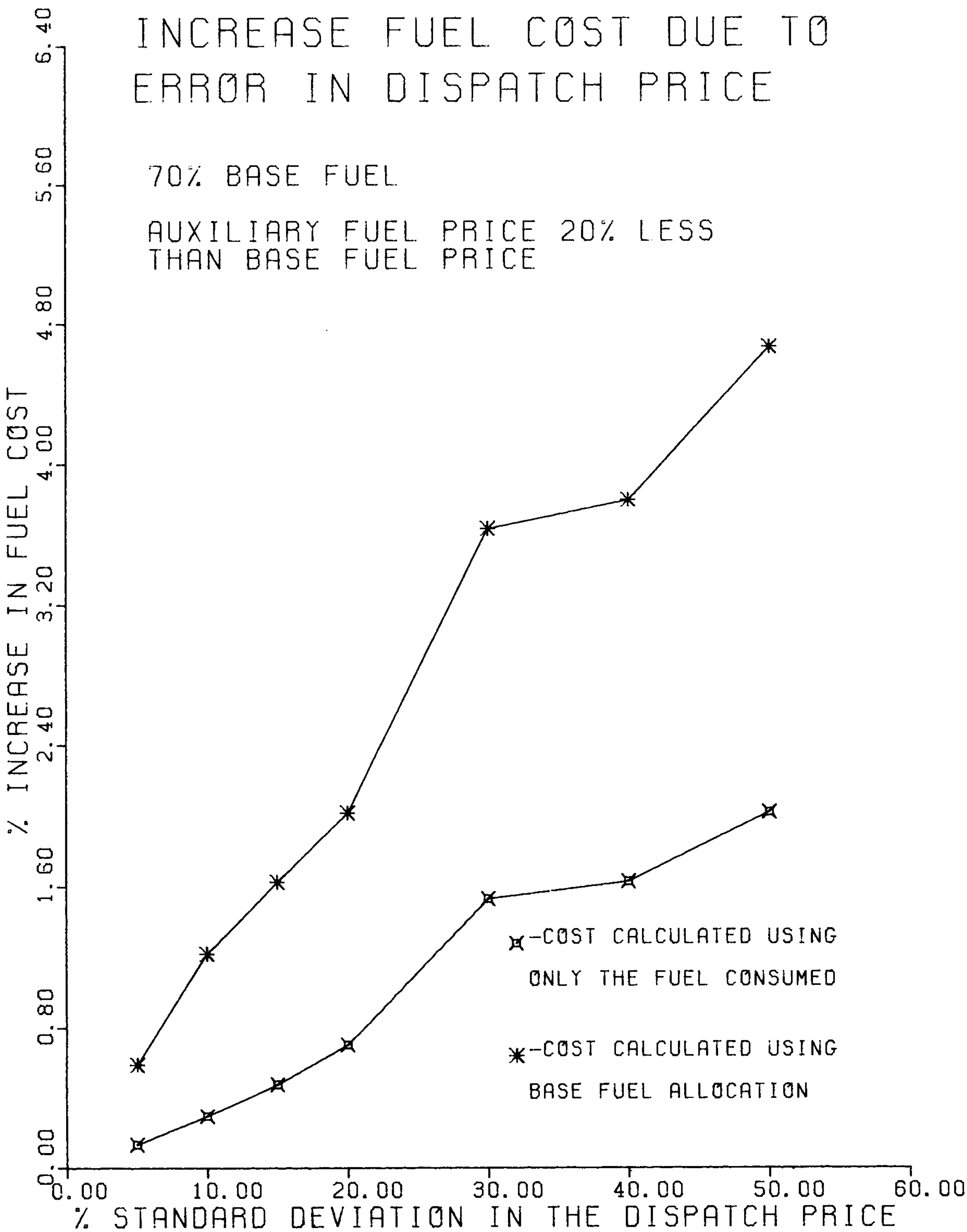


Figure I-21. Increased Fuel Cost Due to Random Dispatch Error

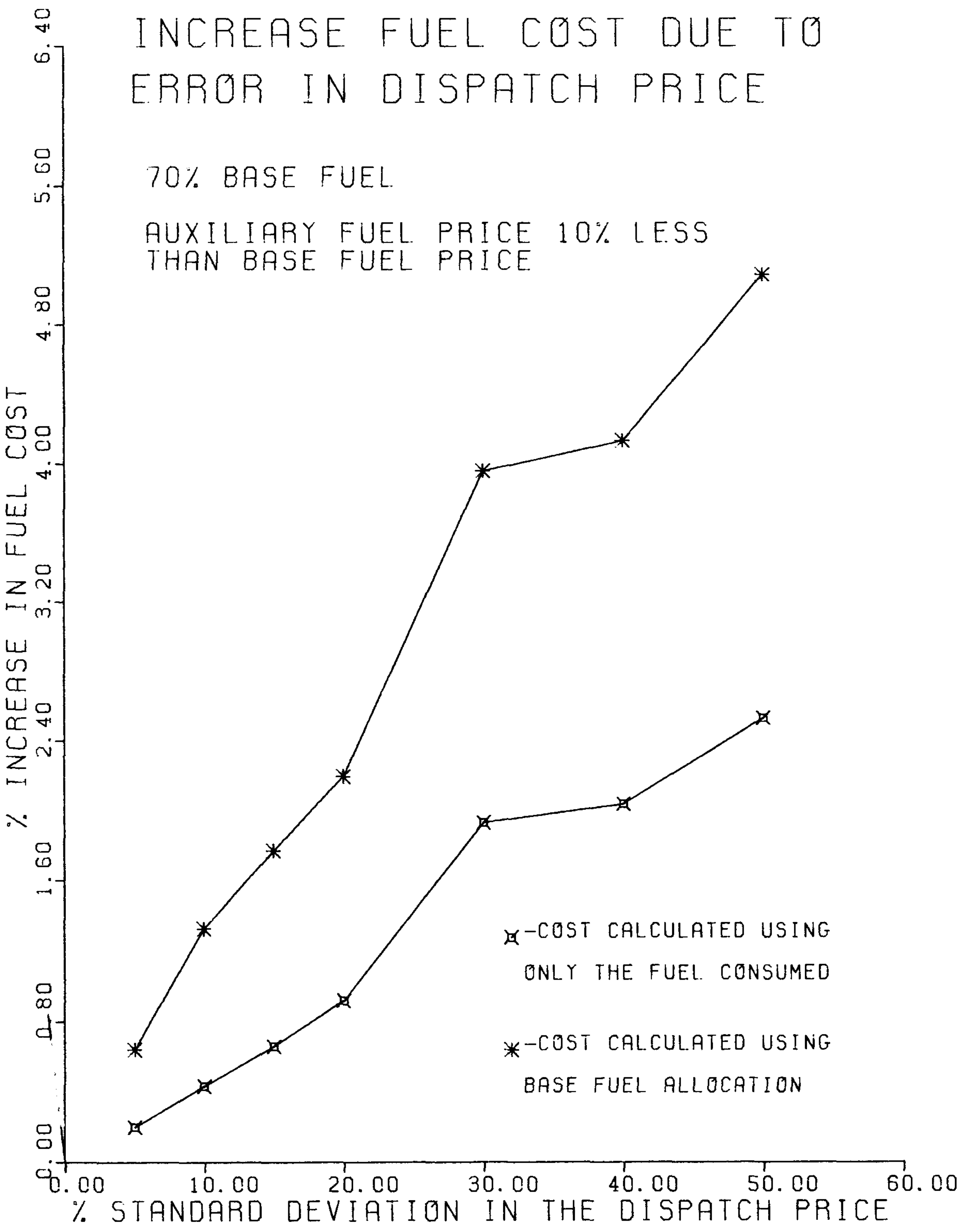


Figure I-22. Increased Fuel Cost Due to Random Dispatch Error

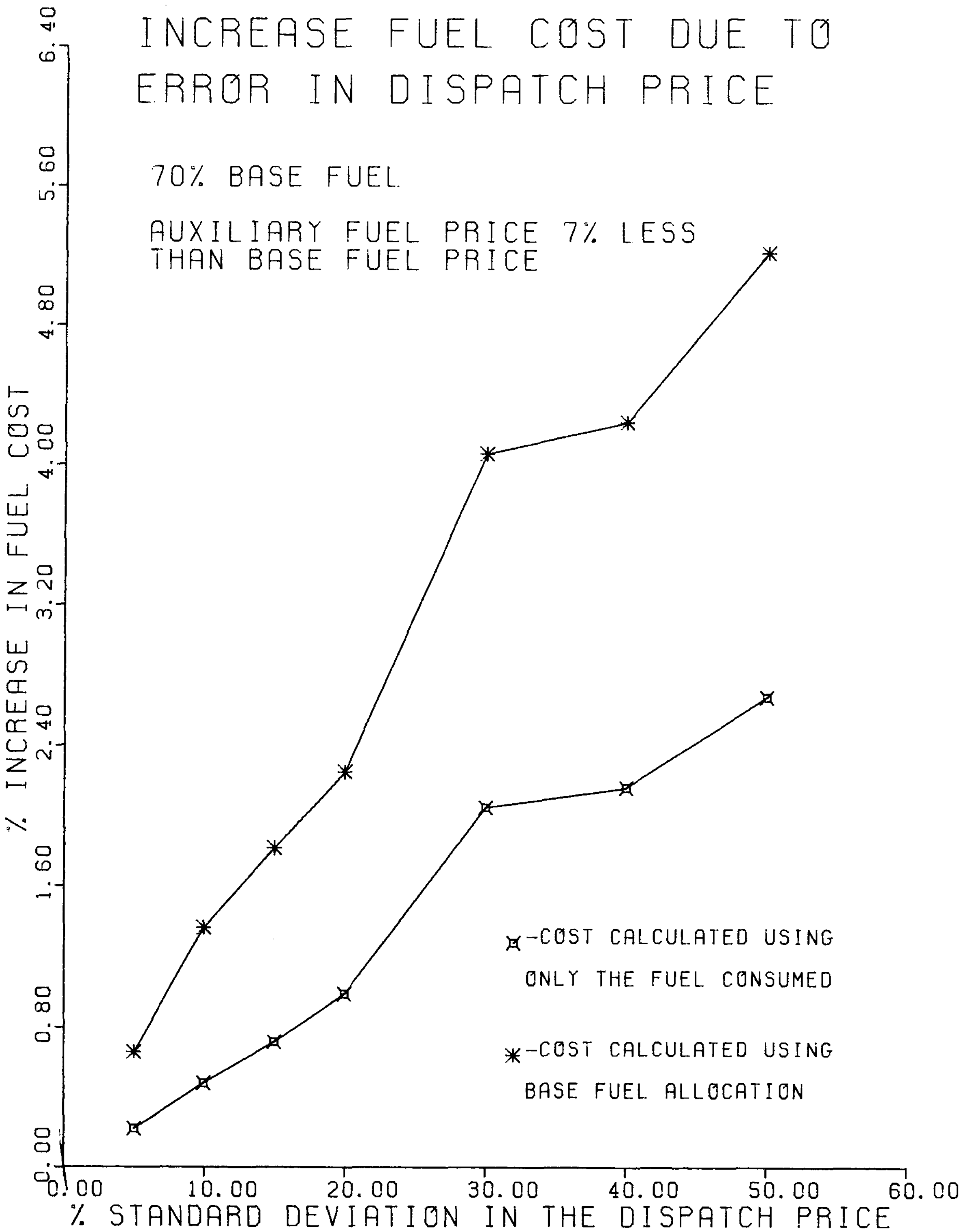


Figure I-23. Increased Fuel Cost Due to Random Dispatch Error

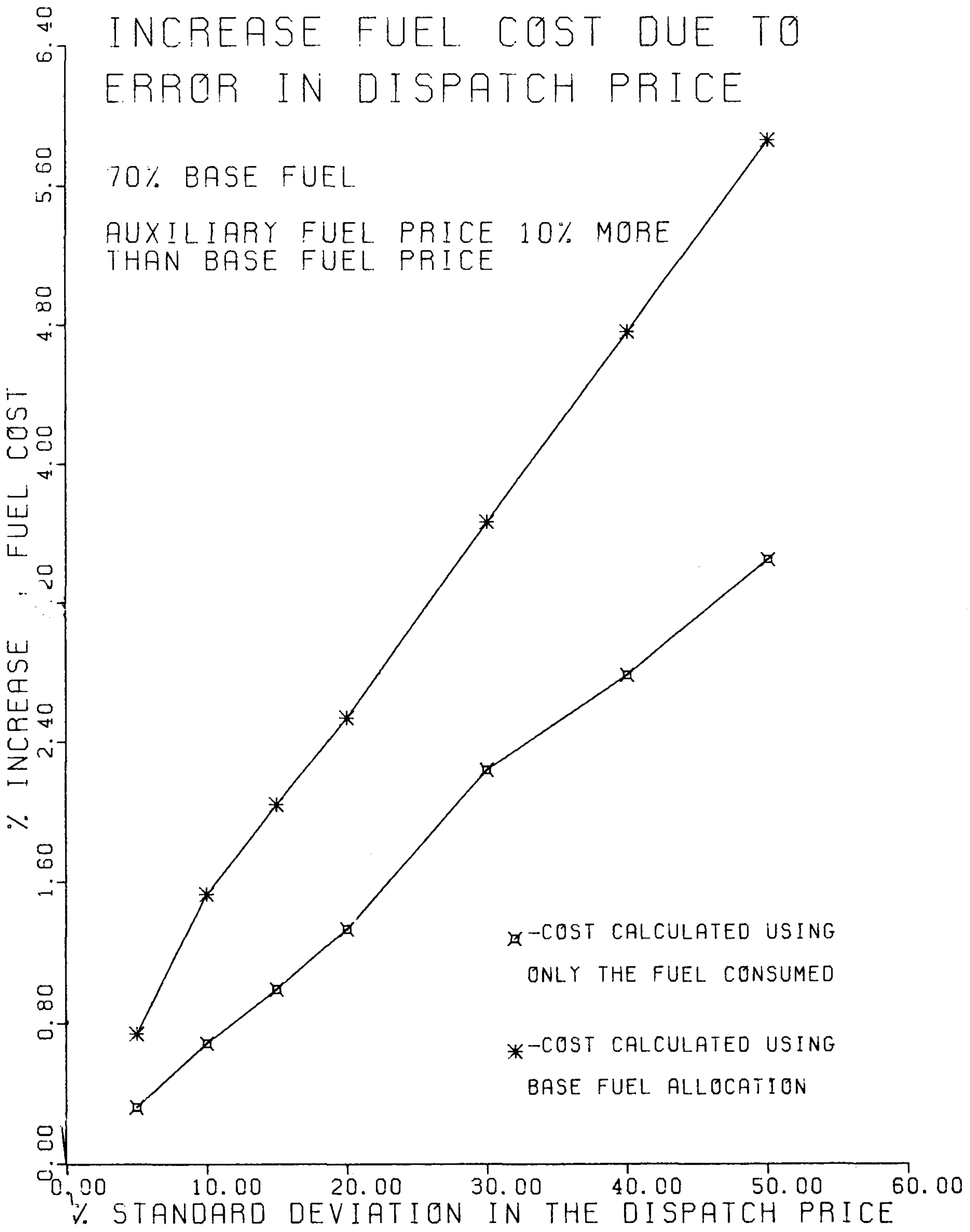


Figure I-24. Increased Fuel Cost Due to Random Dispatch Error

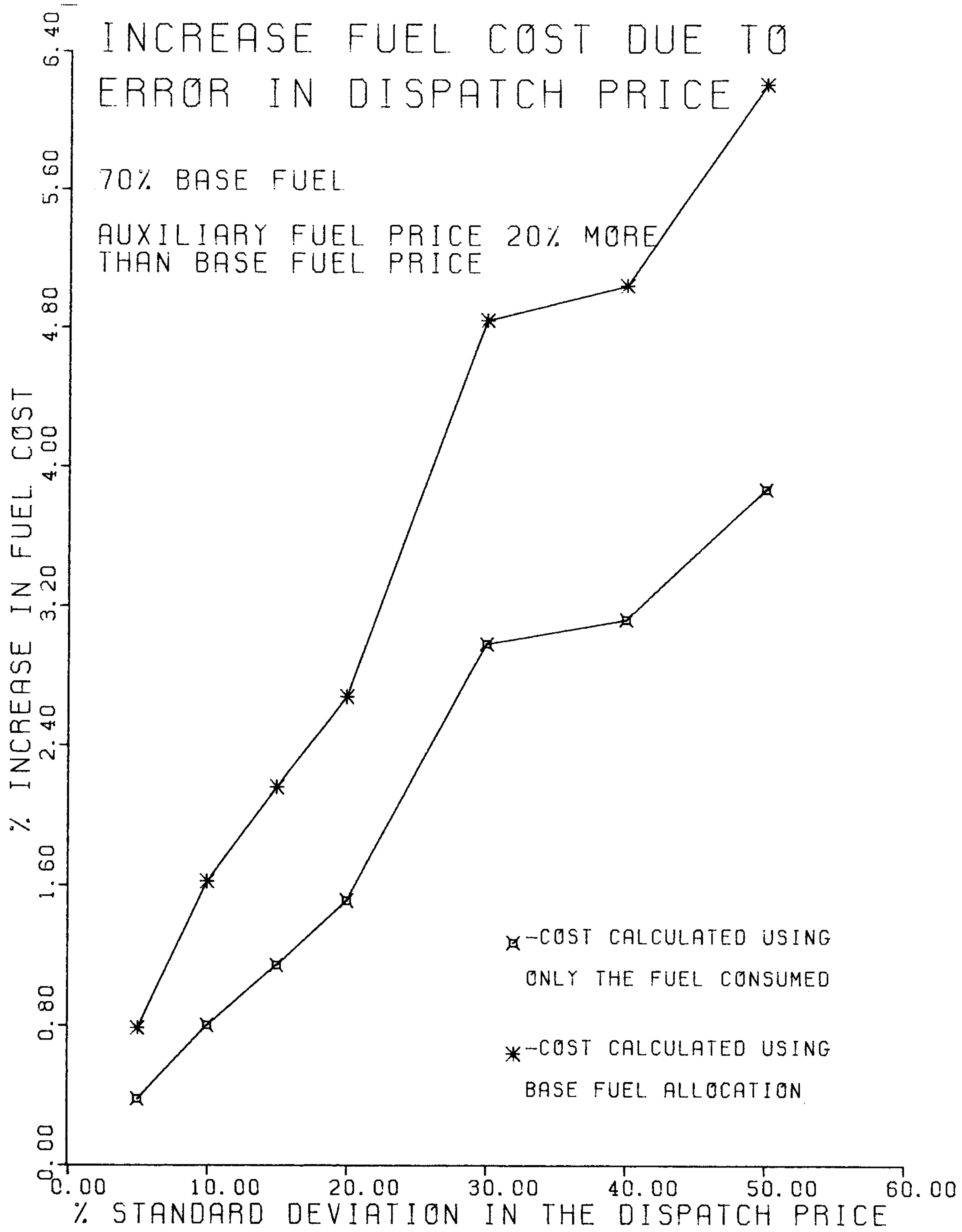


Figure I-25. Increased Fuel Cost Due to Random Dispatch Error

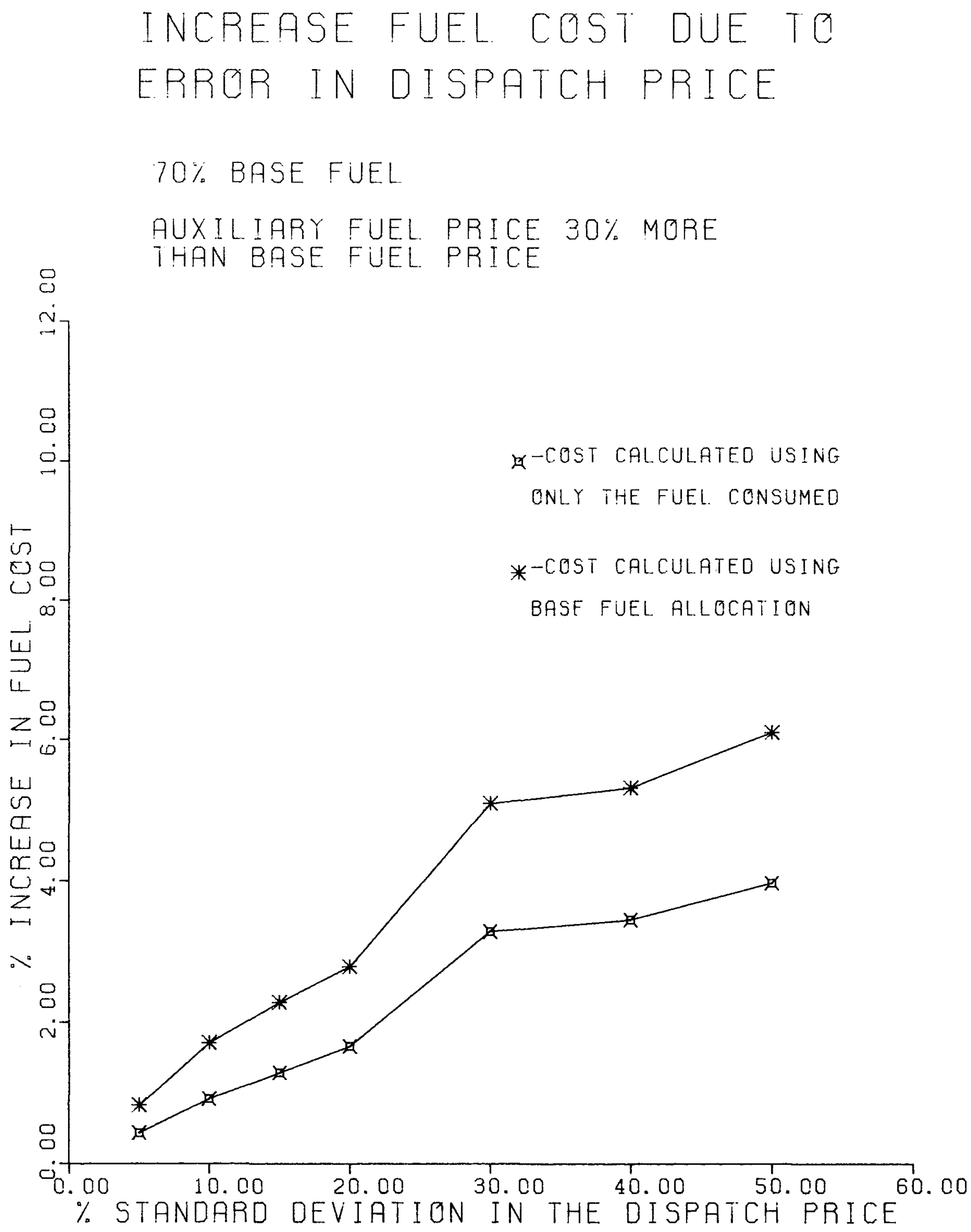


Figure I-26. Increased Fuel Cost Due to Random Dispatch Error

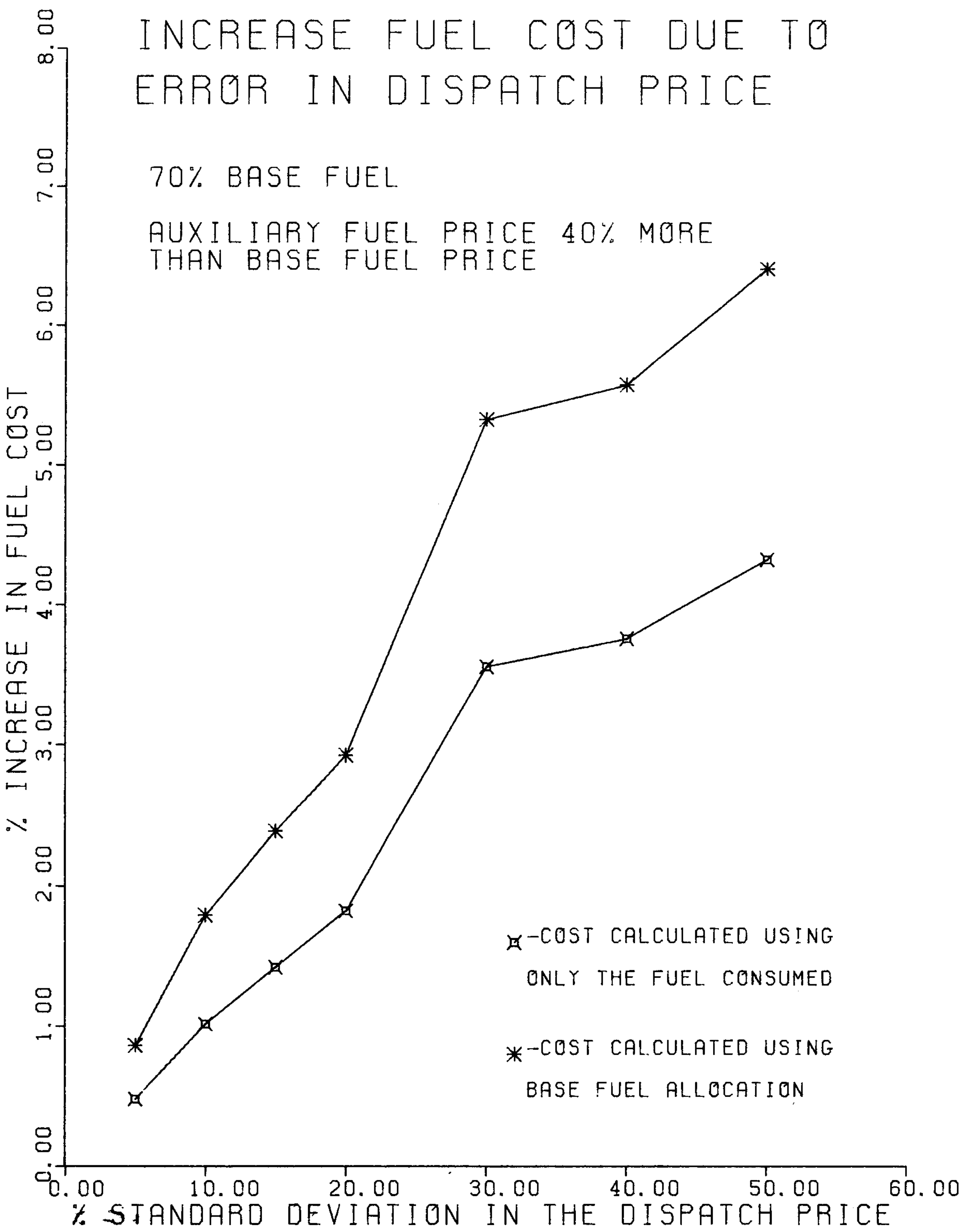


Figure I-27. Increased Fuel Cost Due to Random Dispatch Error

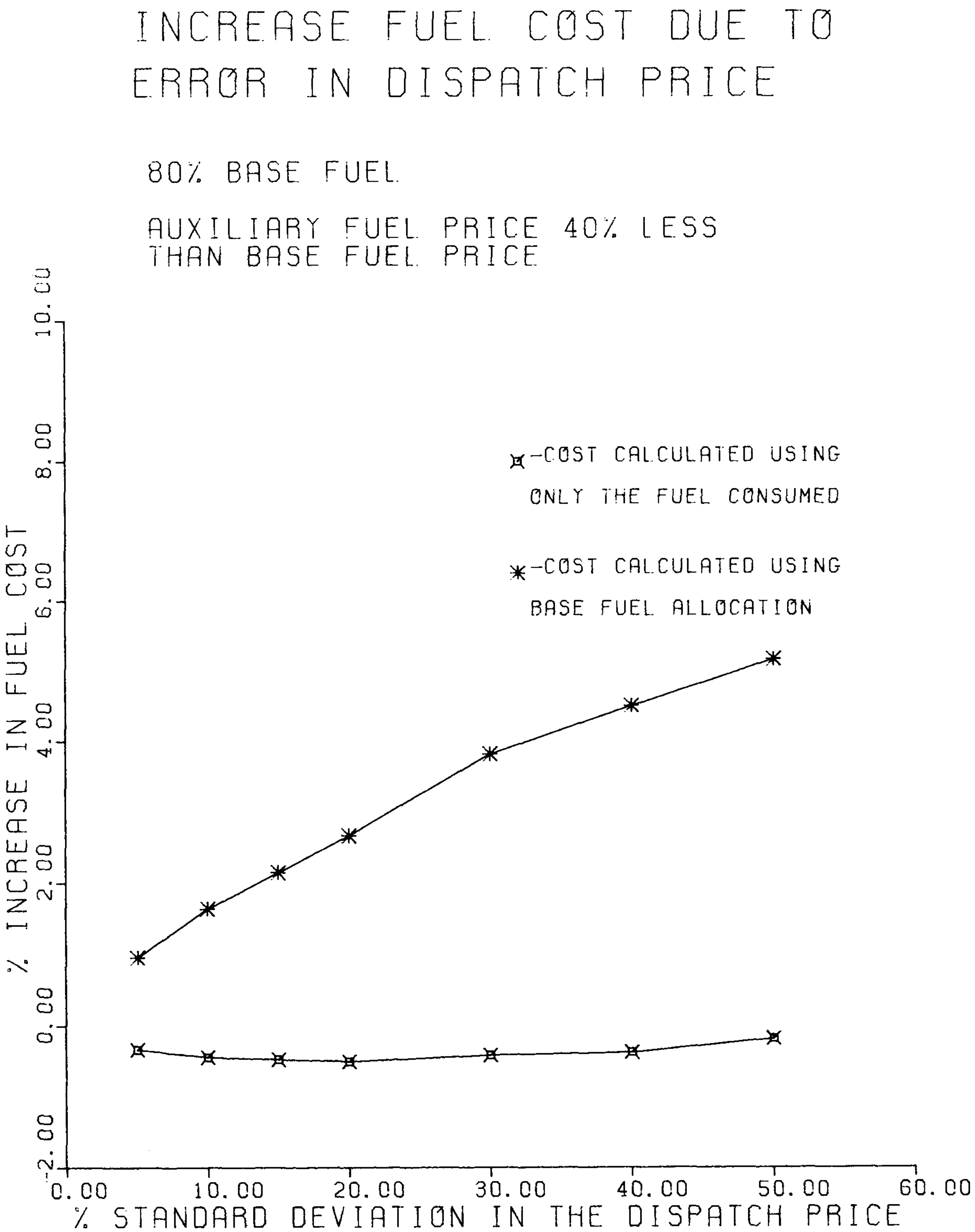


Figure I-28. Increased Fuel Cost Due to Random Dispatch Error

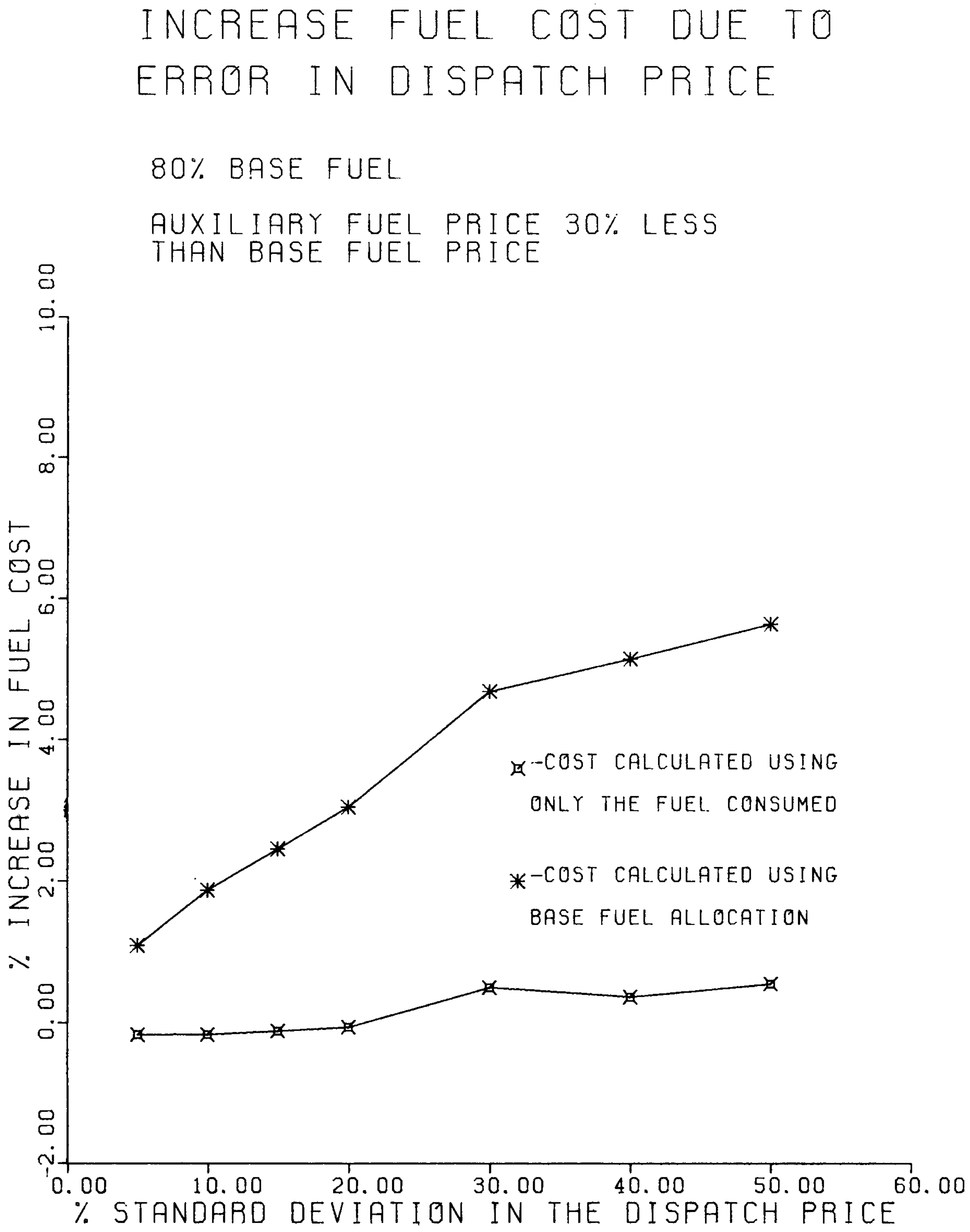


Figure I-29. Increased Fuel Cost Due to Random Dispatch Error

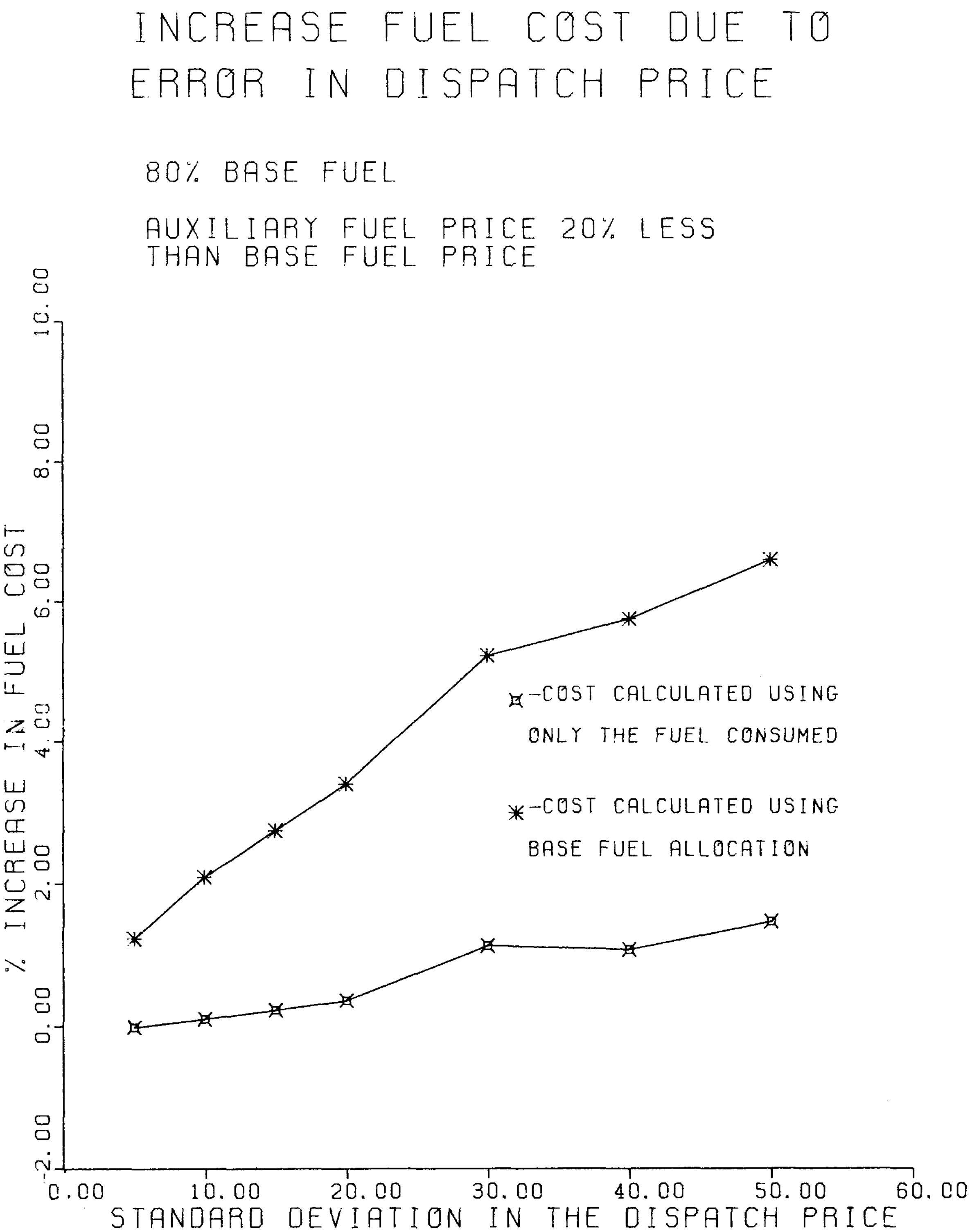


Figure I-30. Increased Fuel Cost Due to Random Dispatch Error

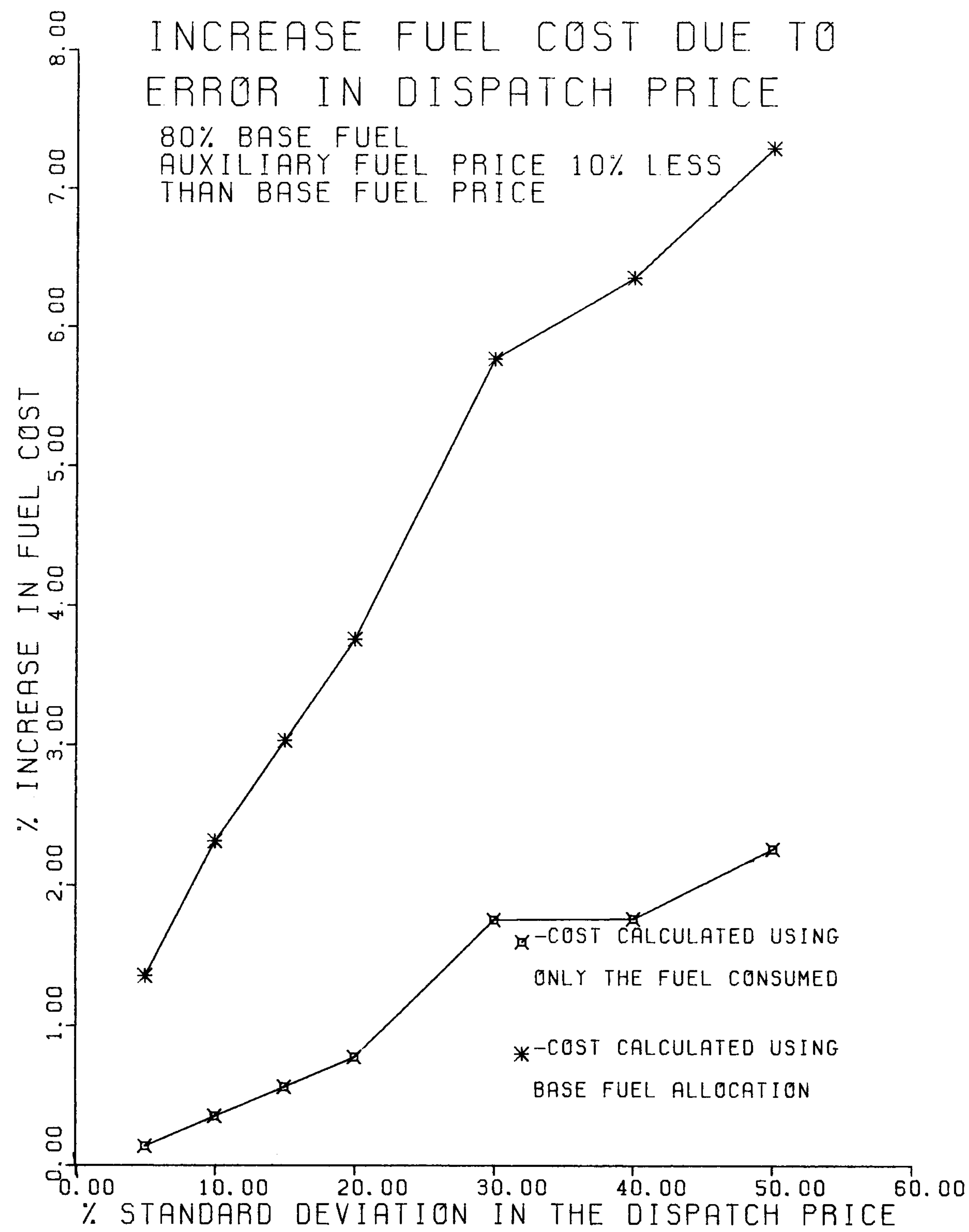


Figure I-31. Increased Fuel Cost Due to Random Dispatch Error

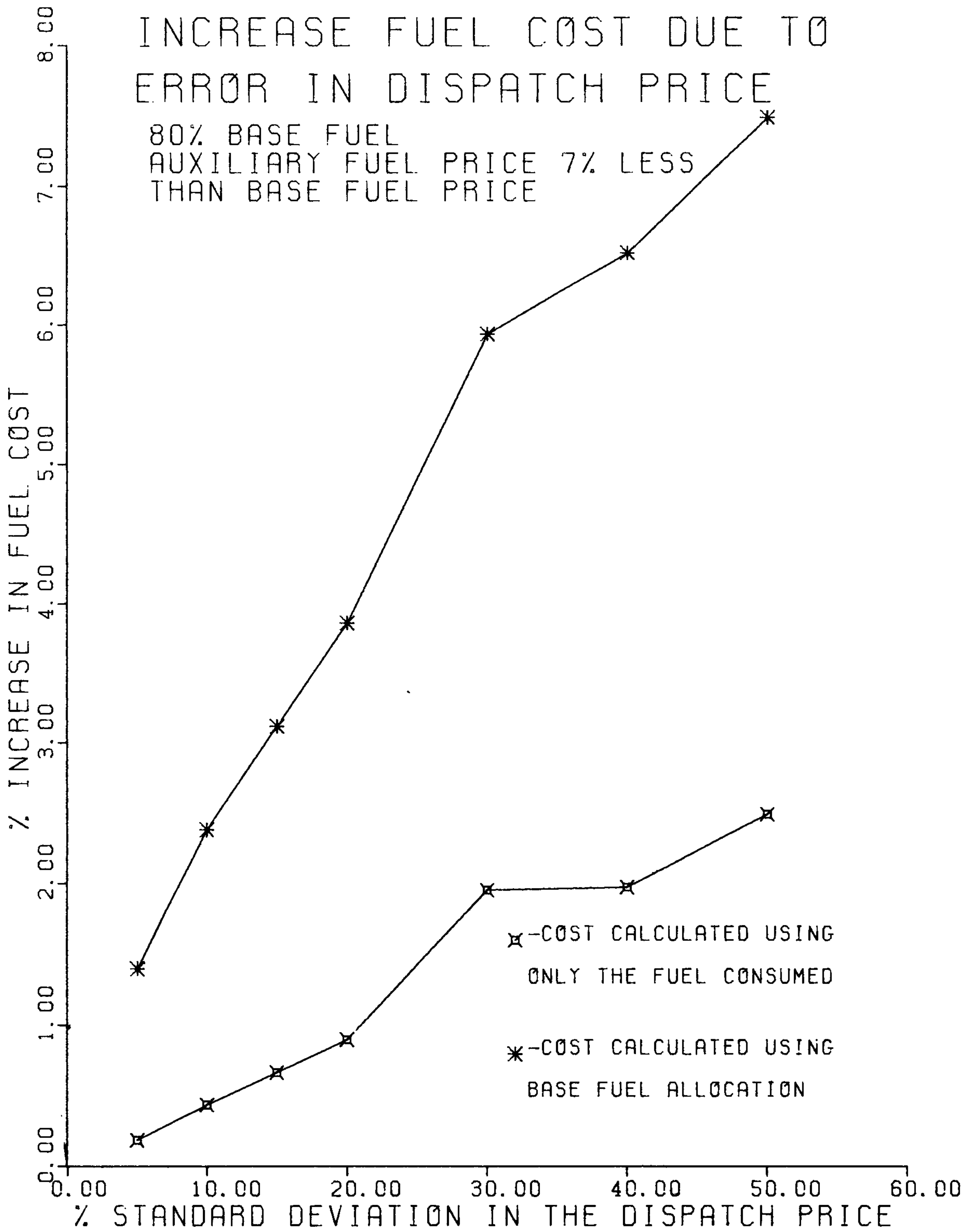


Figure I-32. Increased Fuel Cost Due to Random Dispatch Error

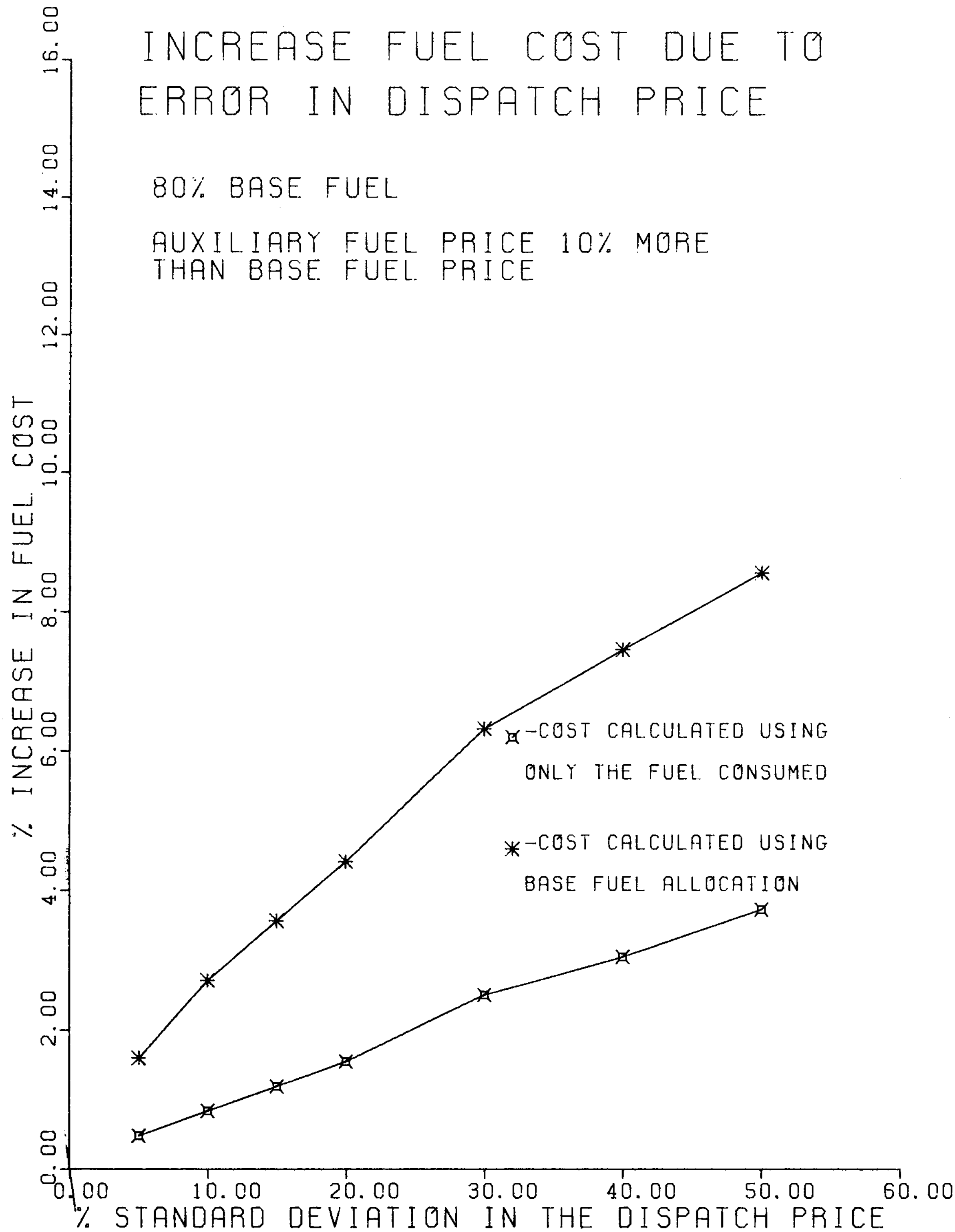


Figure I-33. Increased Fuel Cost Due to Random Dispatch Error

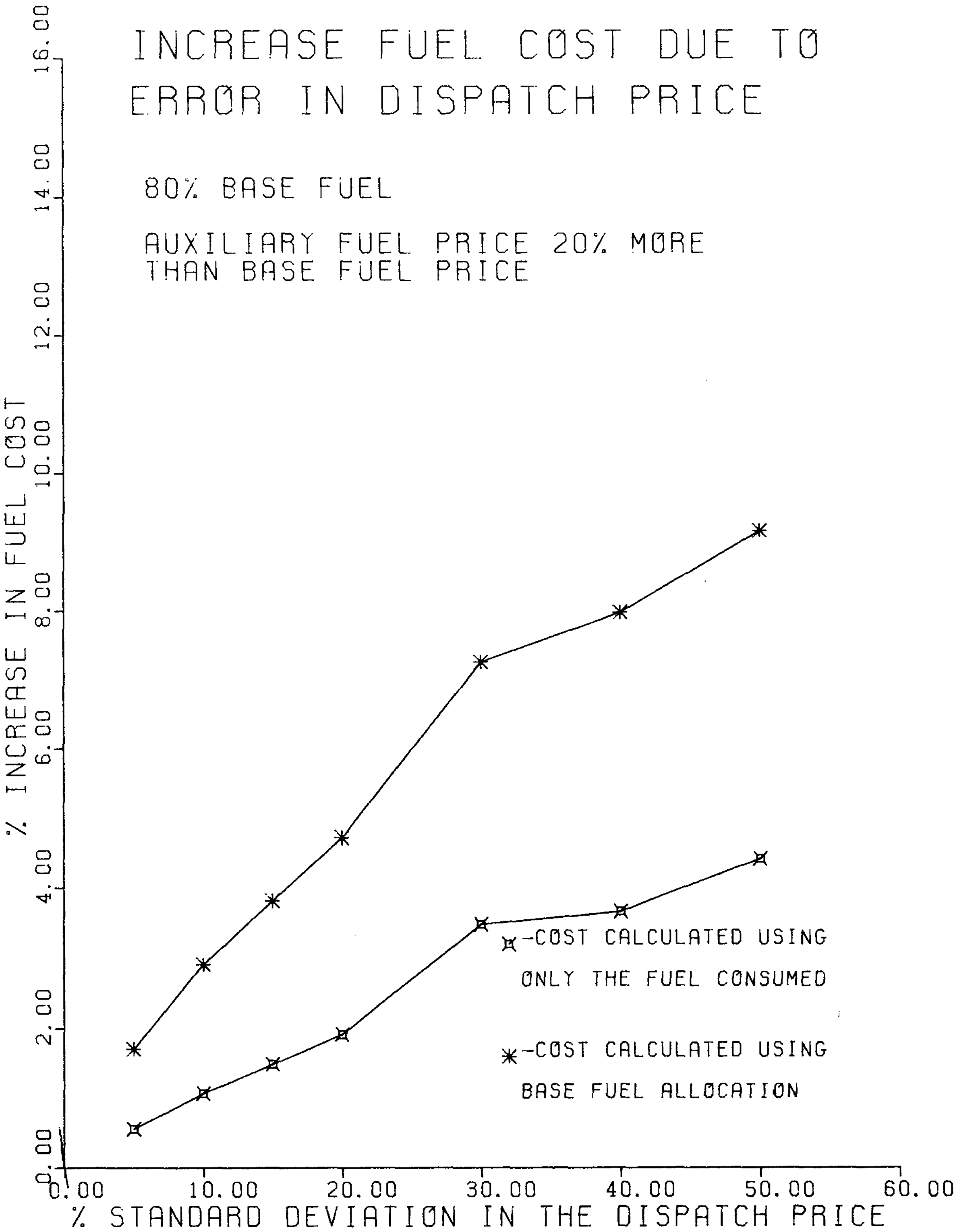


Figure I-34. Increased Fuel Cost Due to Random Dispatch Error

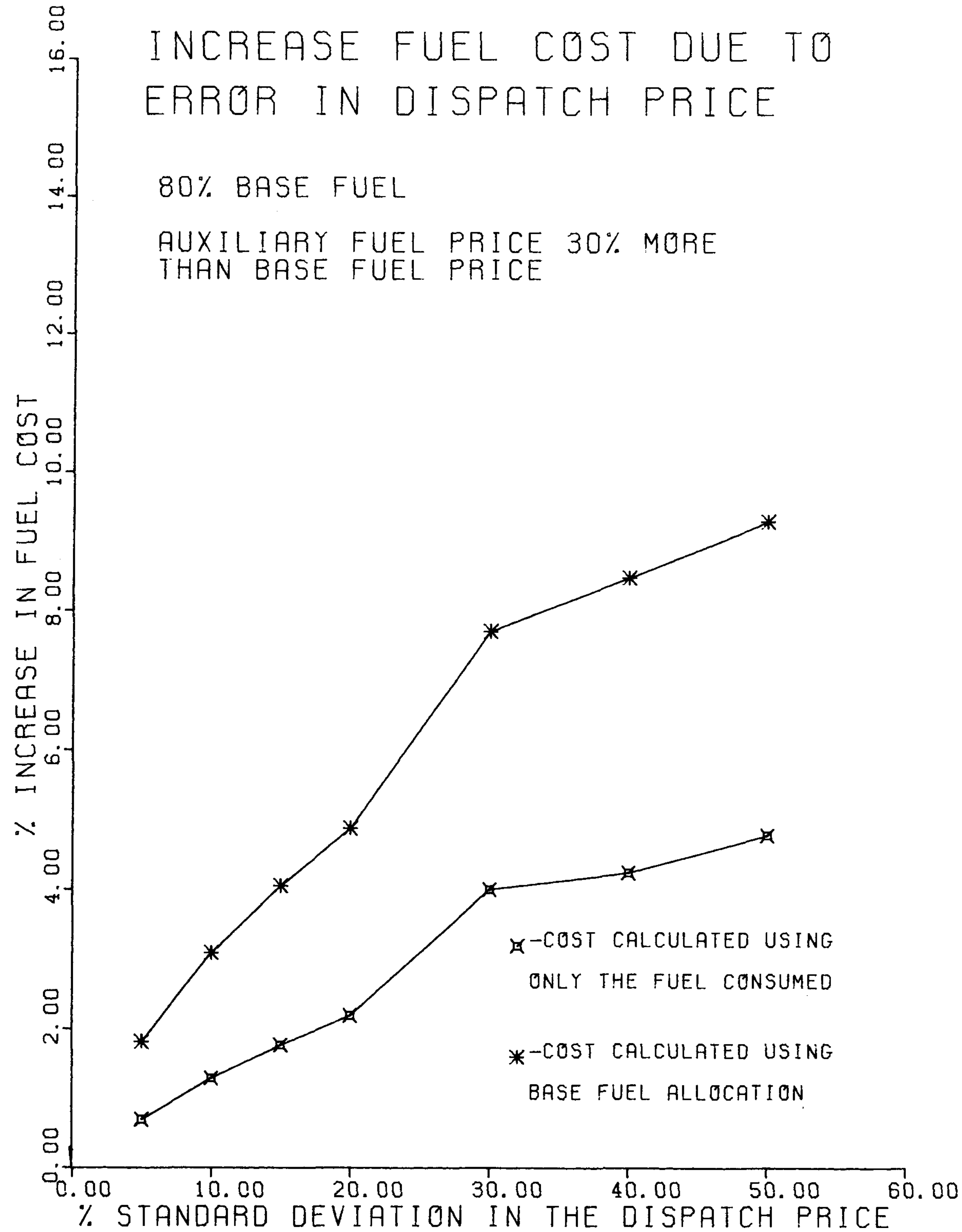


Figure I-35. Increased Fuel Cost Due to Random Dispatch Error

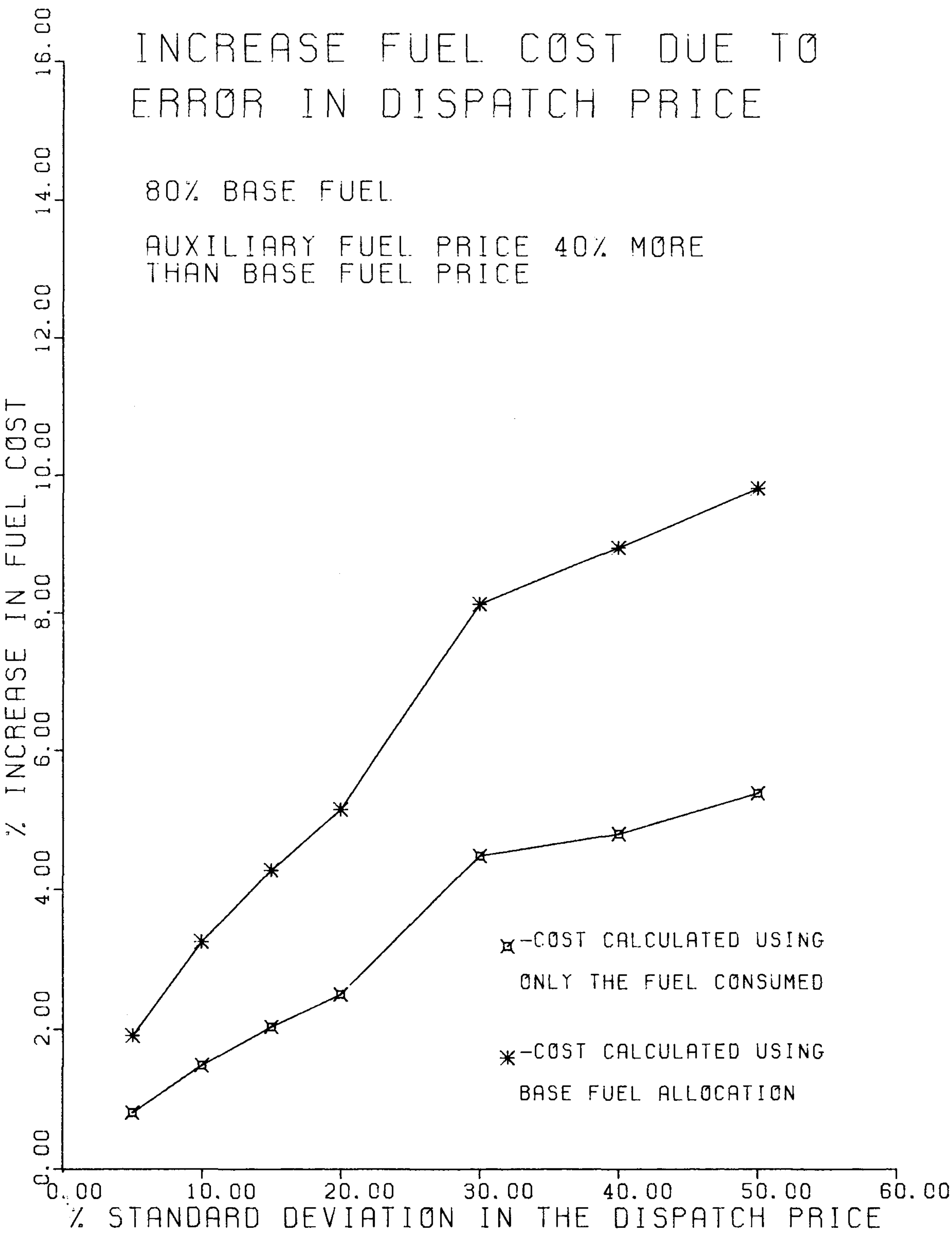


Figure I-36. Increased Fuel Cost Due to Random Dispatch Error

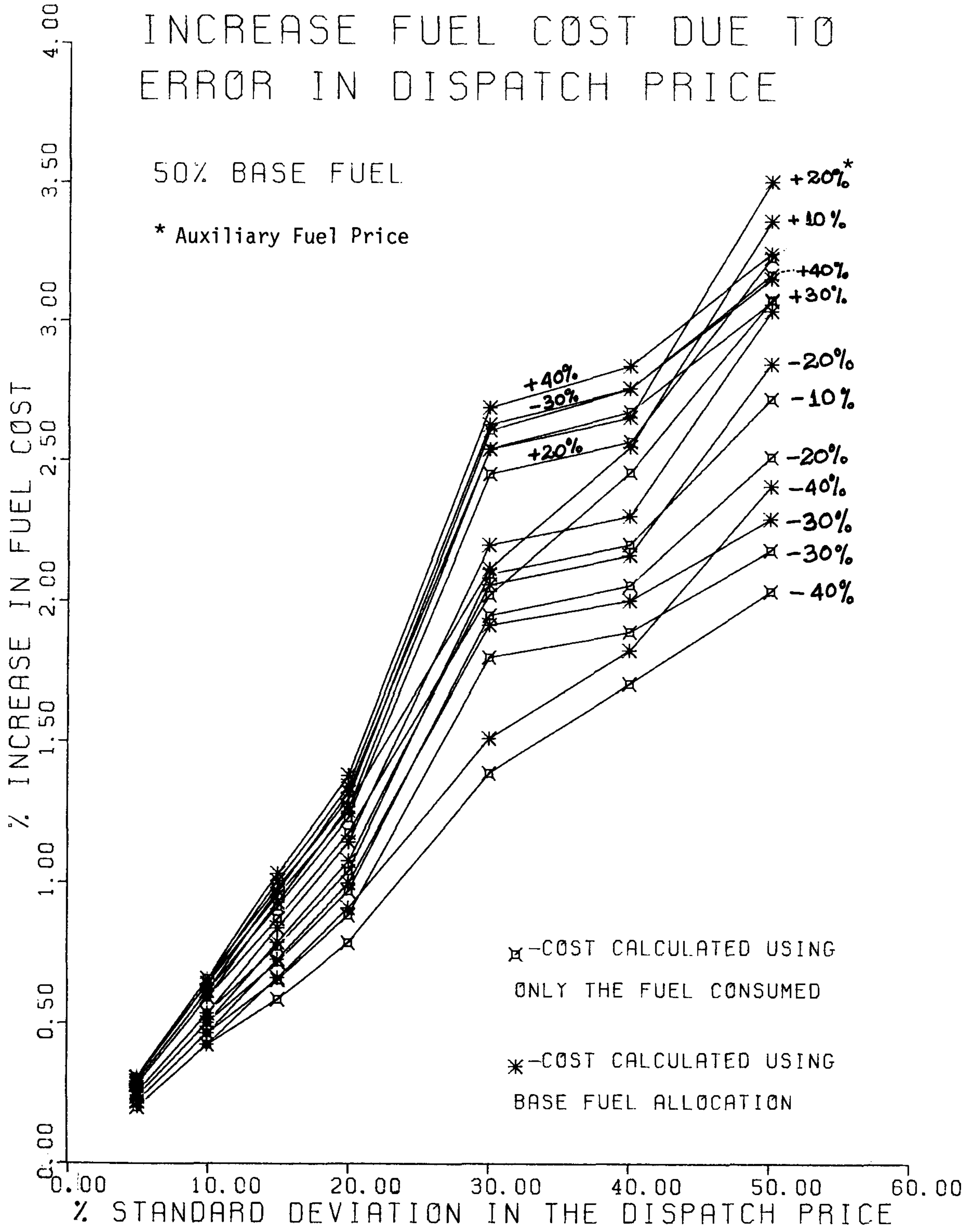


Figure I-37. Increased Fuel Cost Due to Random Dispatch Error

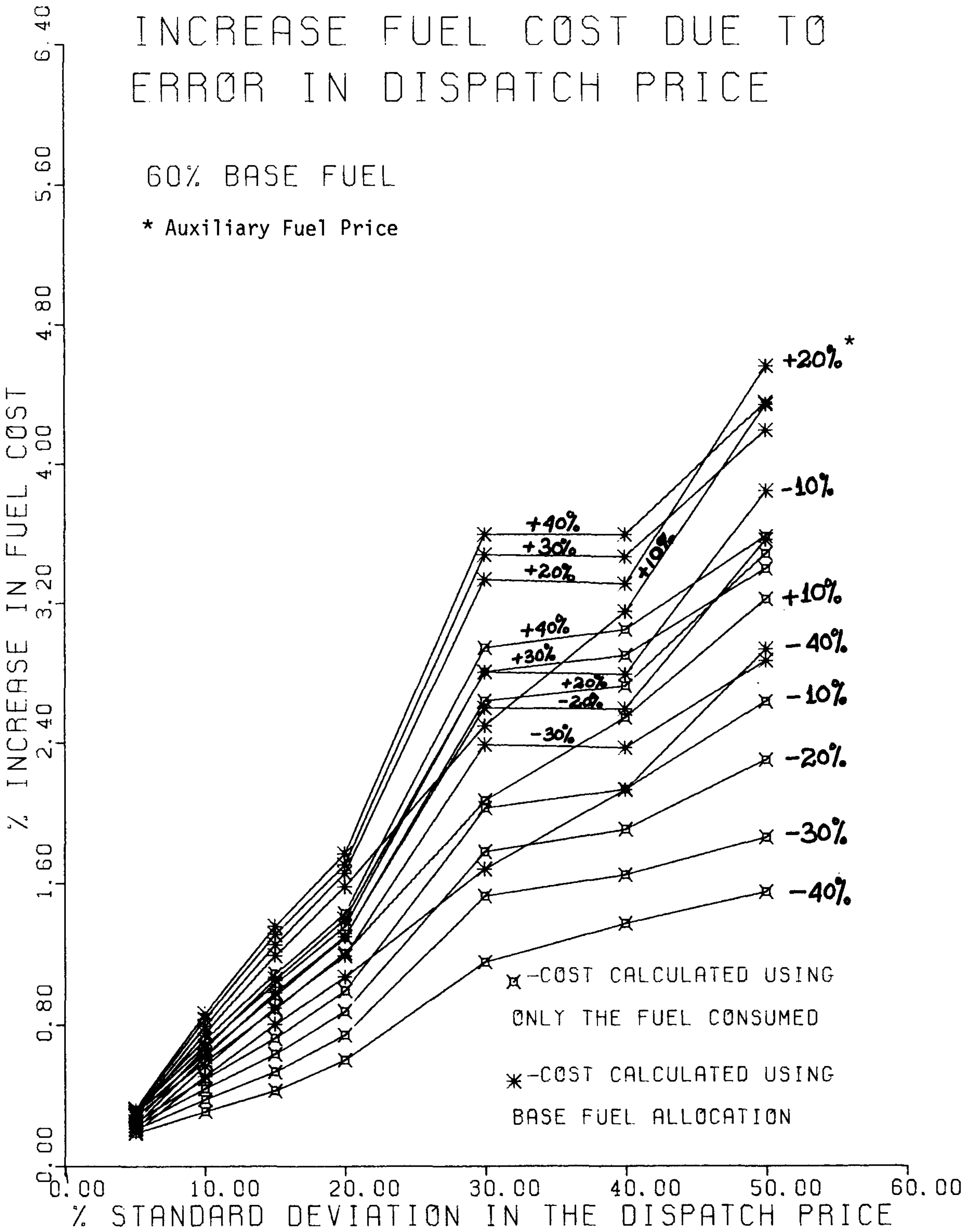


Figure I-38. Increased Fuel Cost Due to Random Dispatch Error

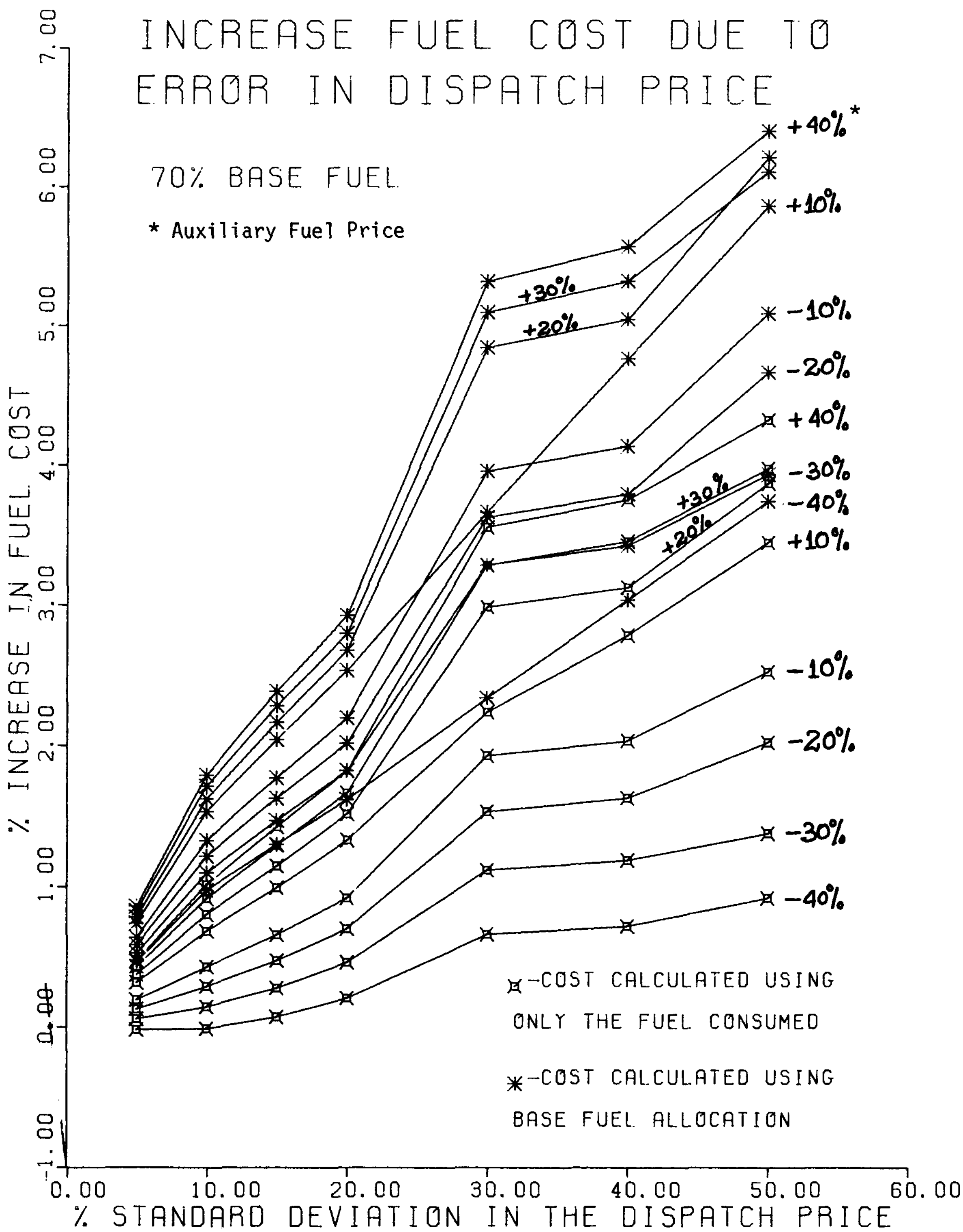
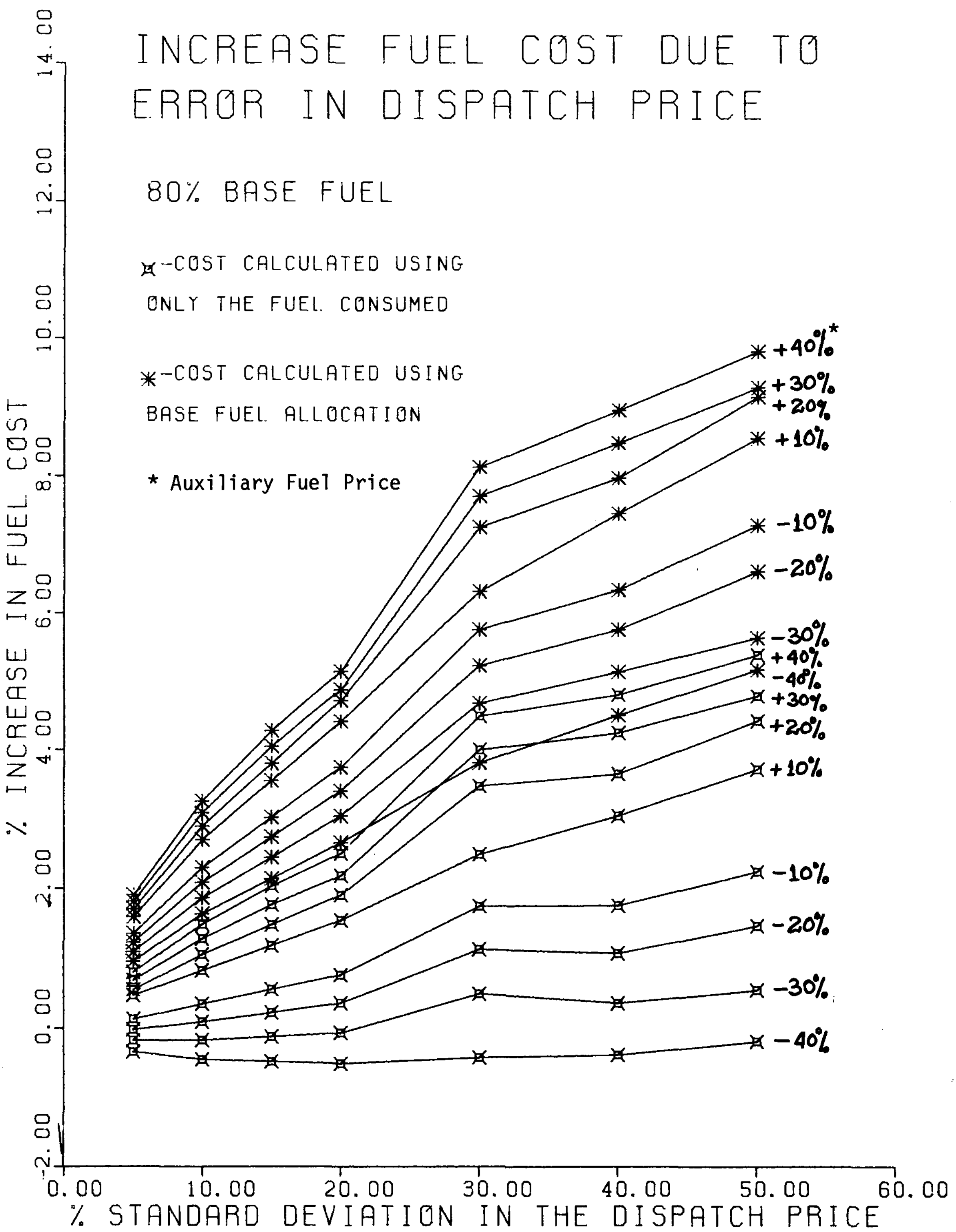


Figure I-39. Increased Fuel Cost Due to Random Dispatch Error



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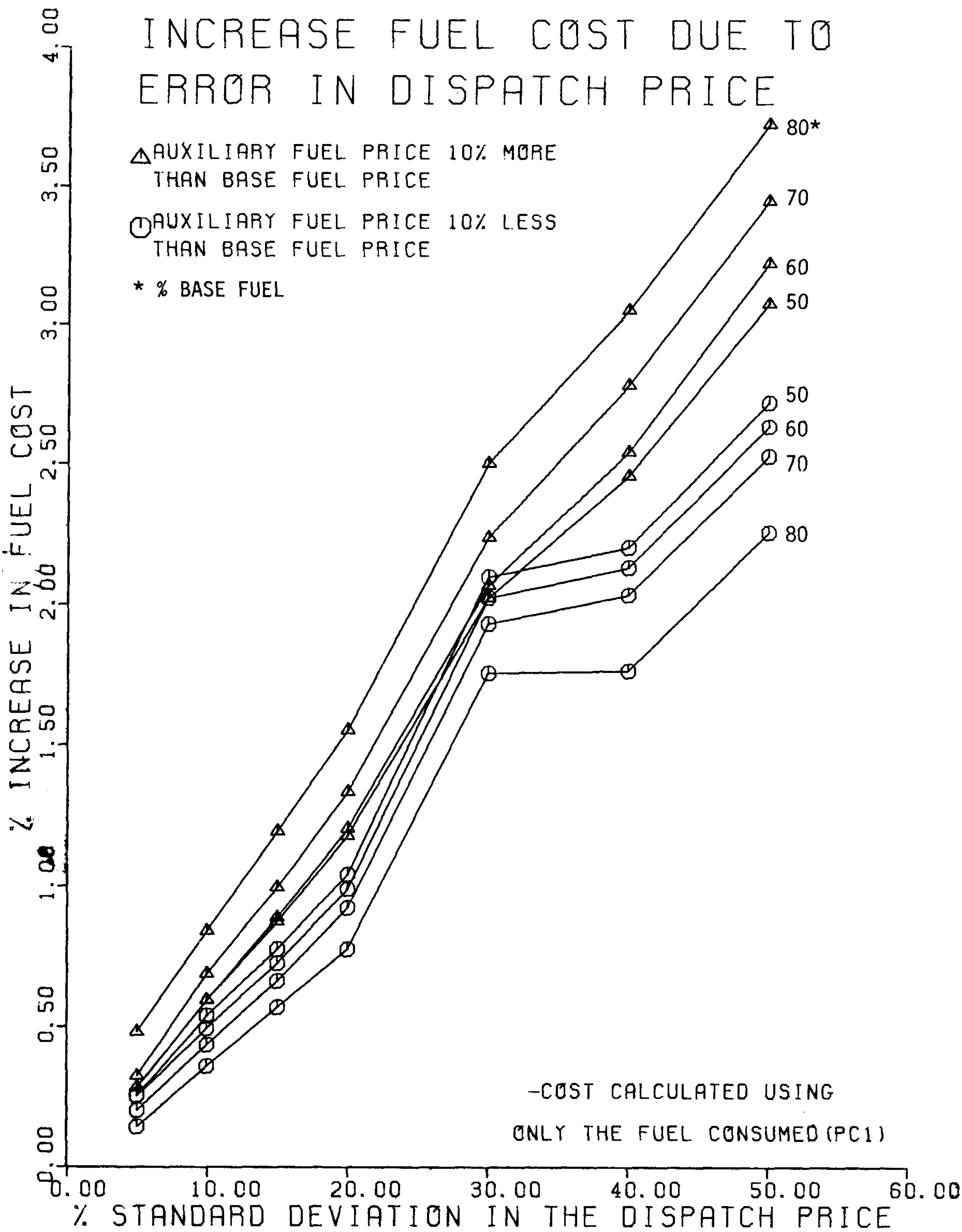


Figure I-41. Increased Fuel Cost Due to Random Dispatch Error

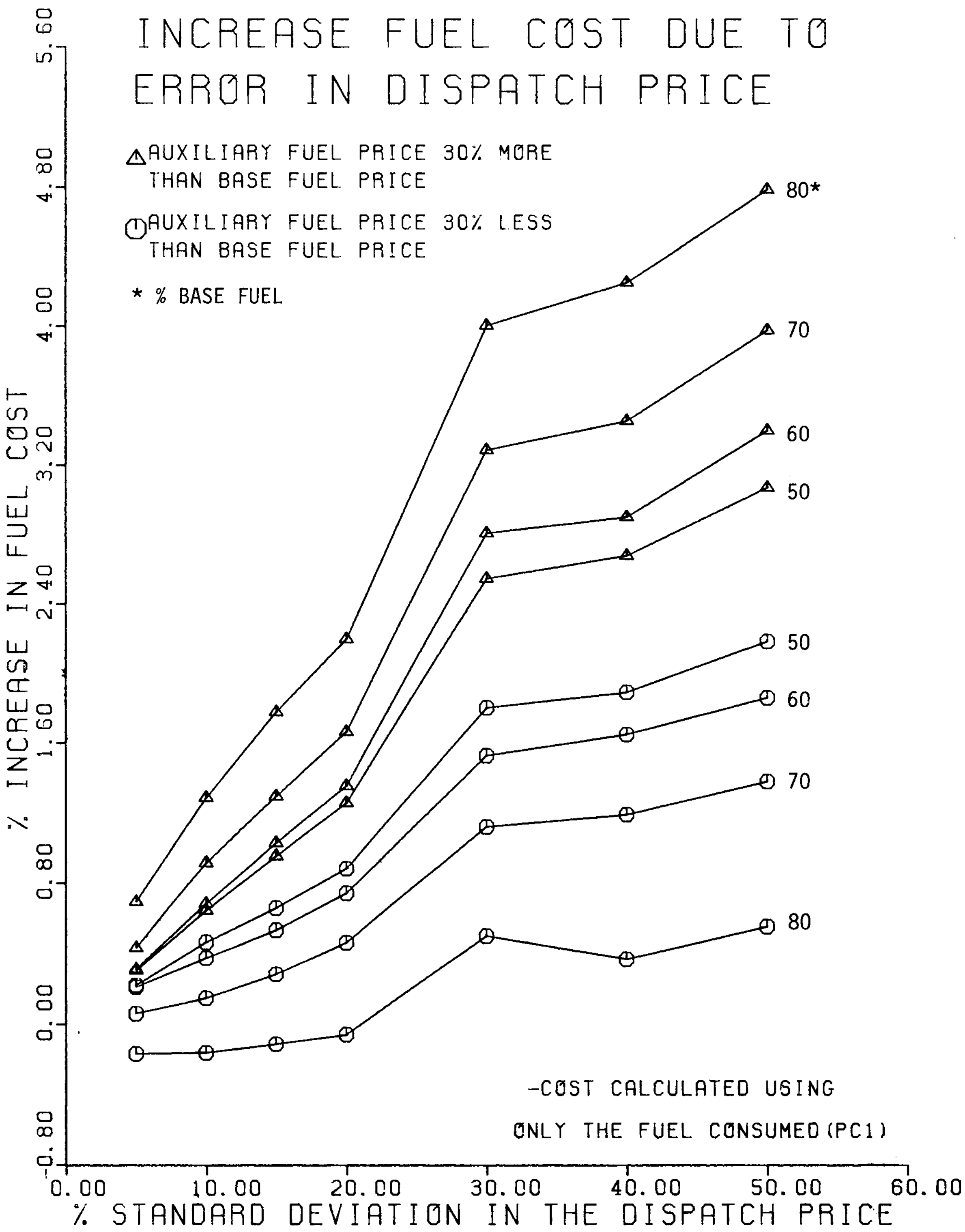


Figure I-42. Increased Fuel Cost Due to Random Dispatch Error

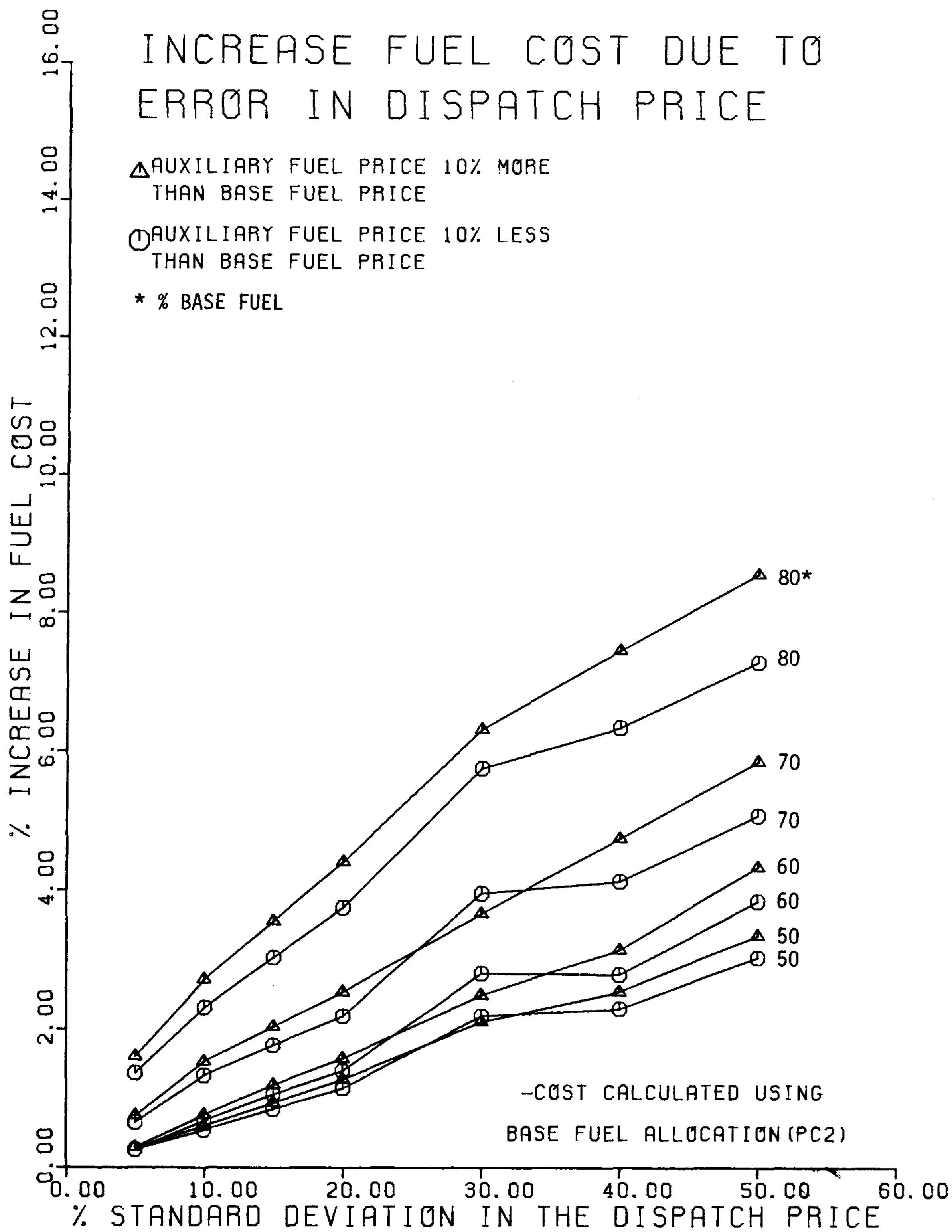


Figure I-43. Increased Fuel Cost Due to Random Dispatch Error

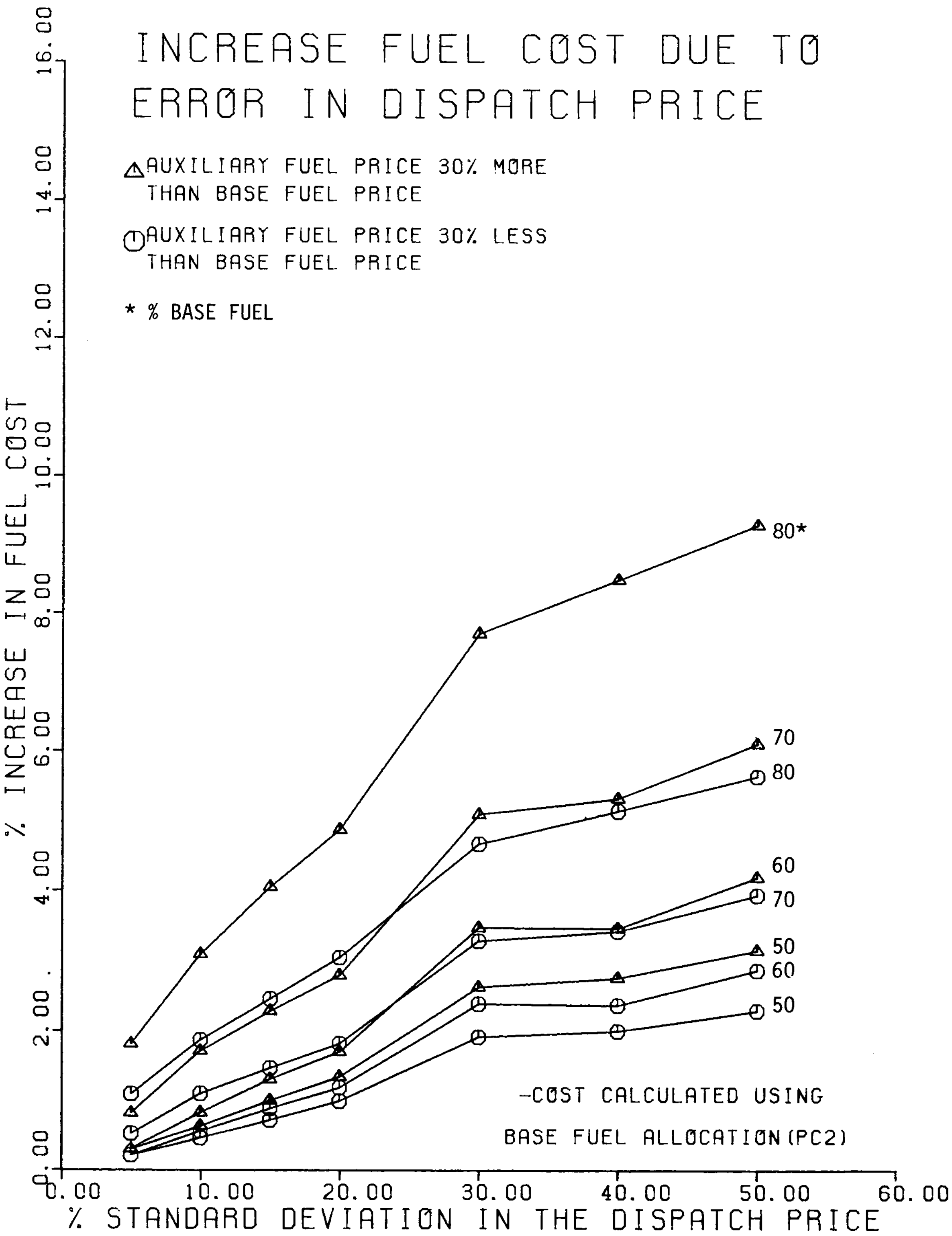


Figure I-44. Increased Fuel Cost Due to Random Dispatch Error

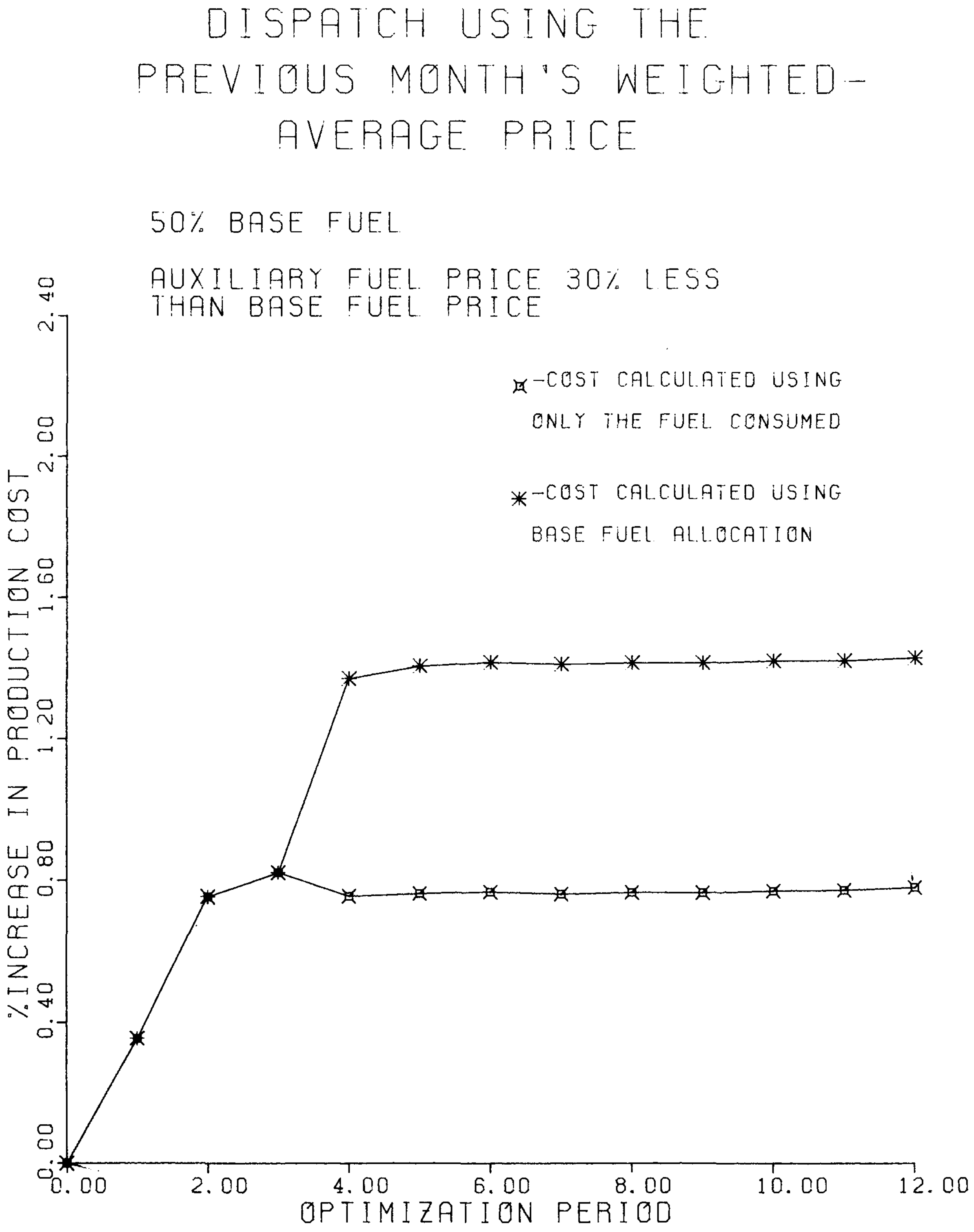


Figure I-45. Use of the Unit's Weighted-Average Fuel Price for Dispatch

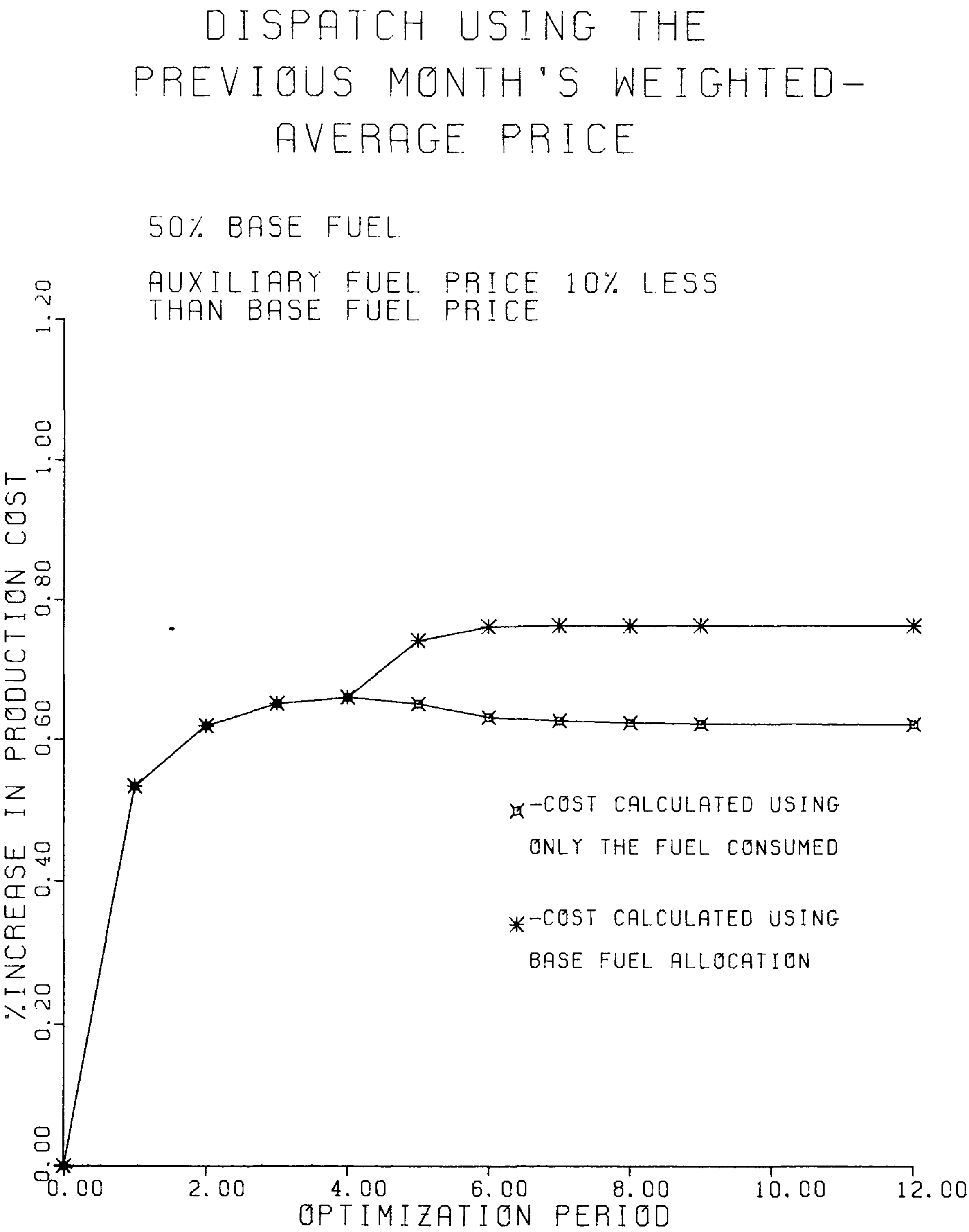
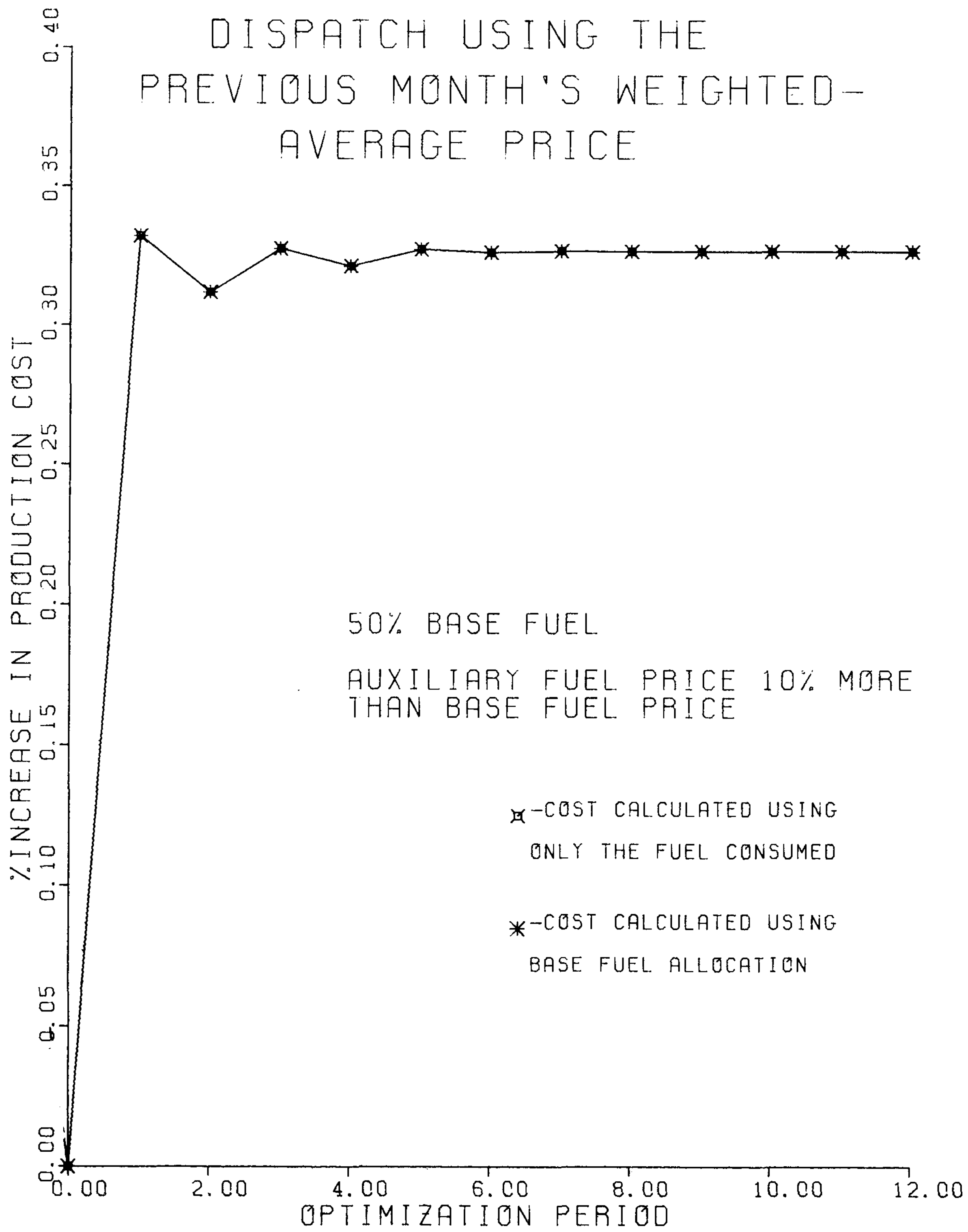


Figure I-46. Use of the Unit's Weighted-Average Fuel Price for Dispatch



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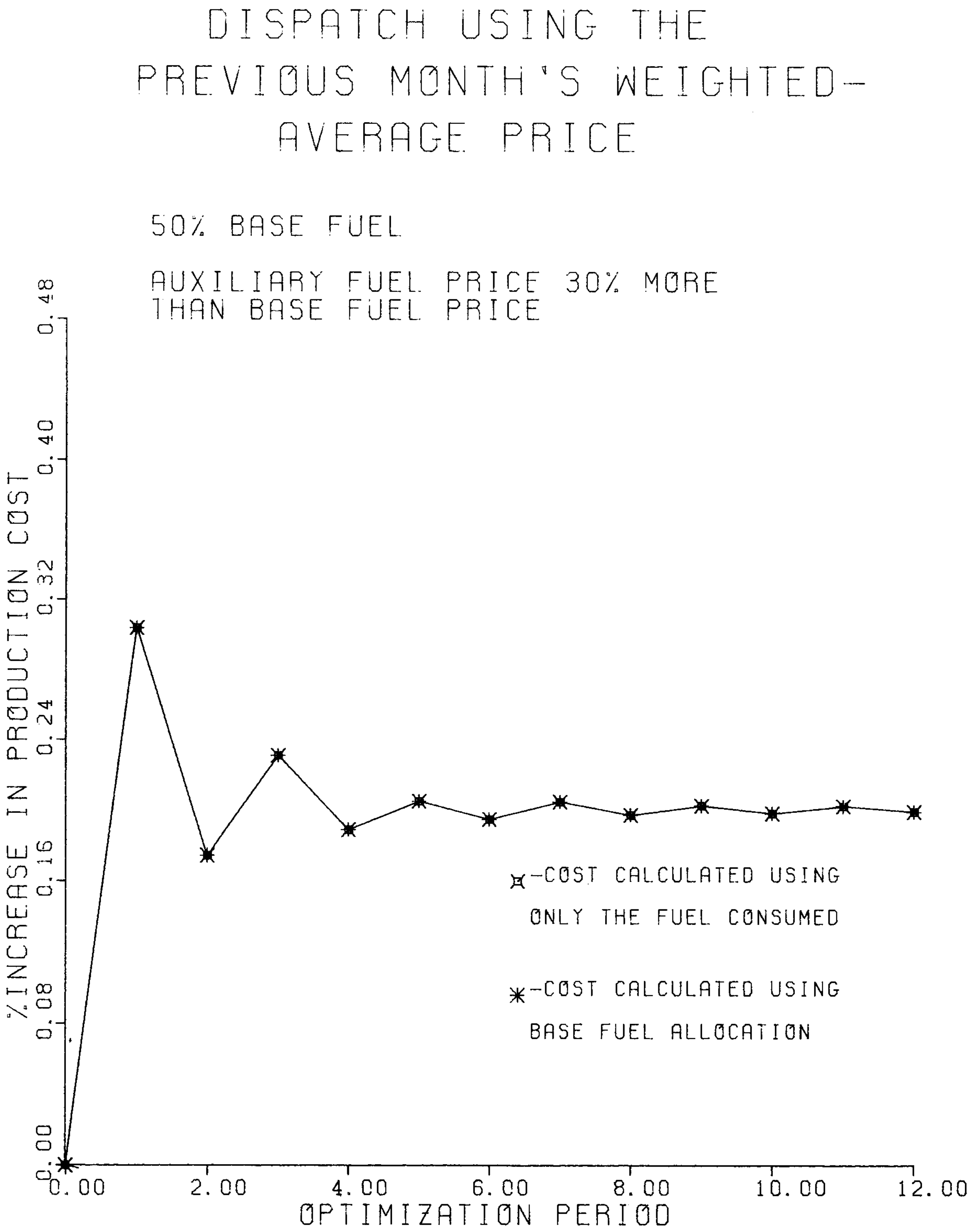
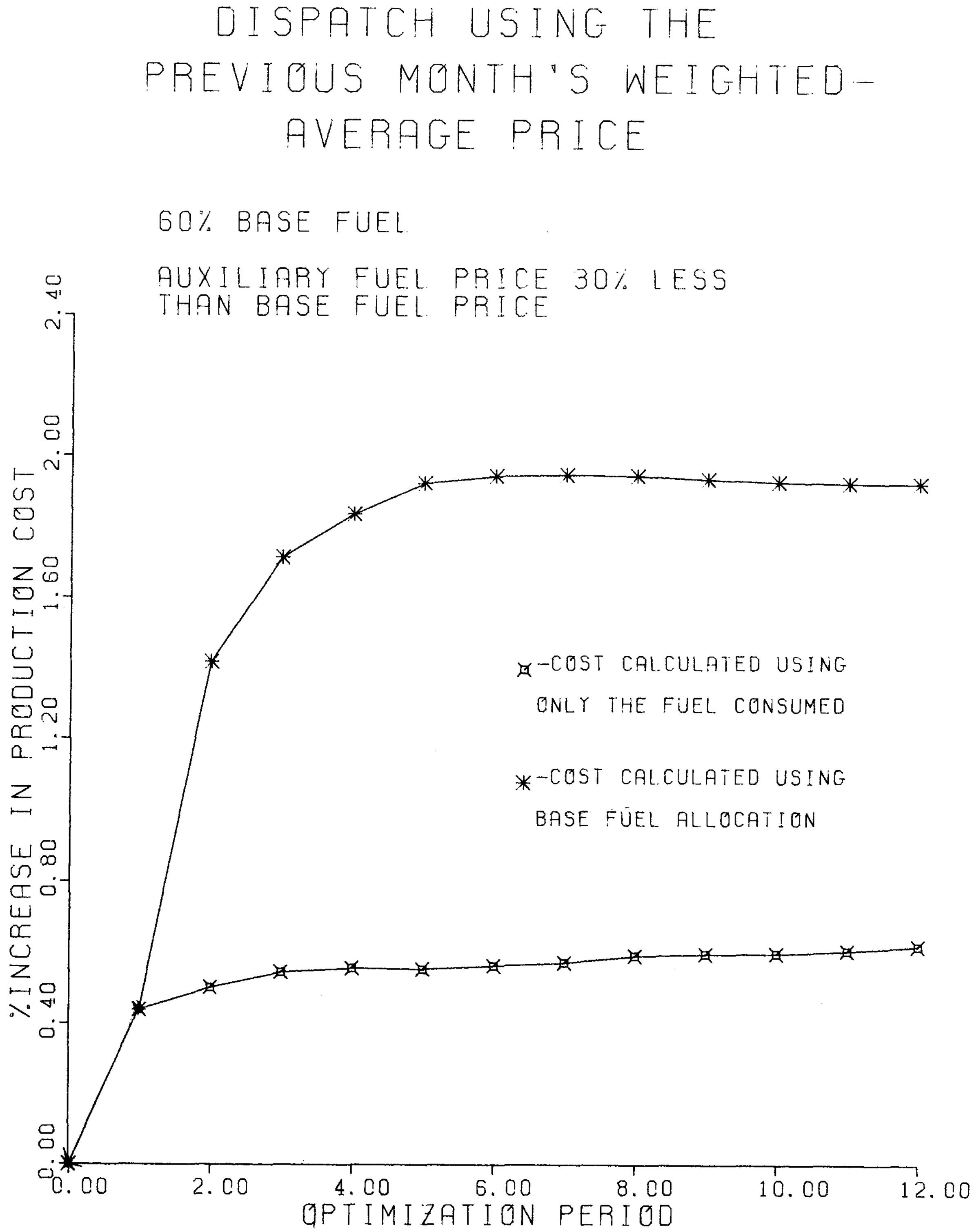


Figure I-48. Use of the Unit's Weighted-Average Fuel Price for Dispatch



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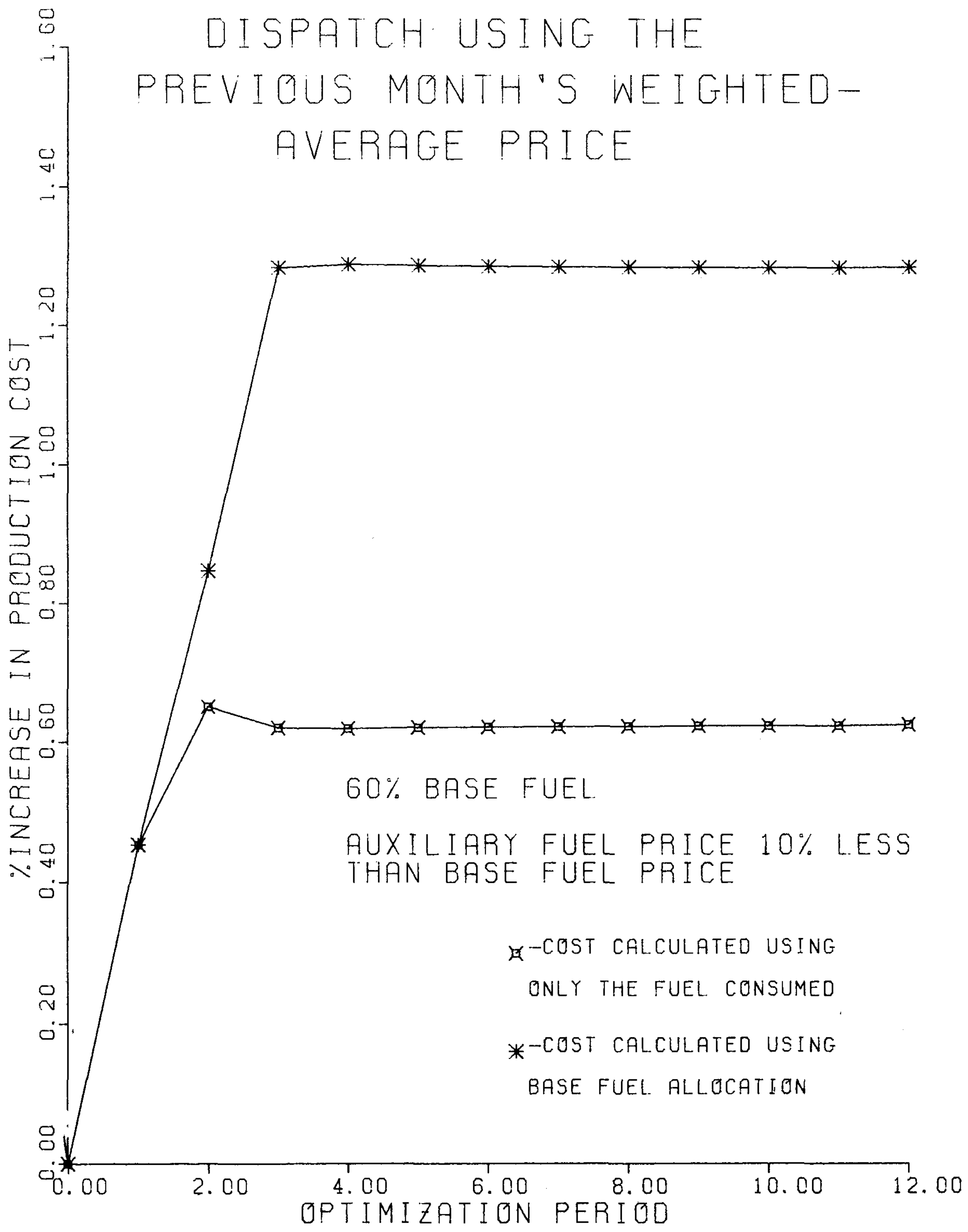

Figure I-50. Use of the Unit's Weighted-Average Fuel Price for Dispatch

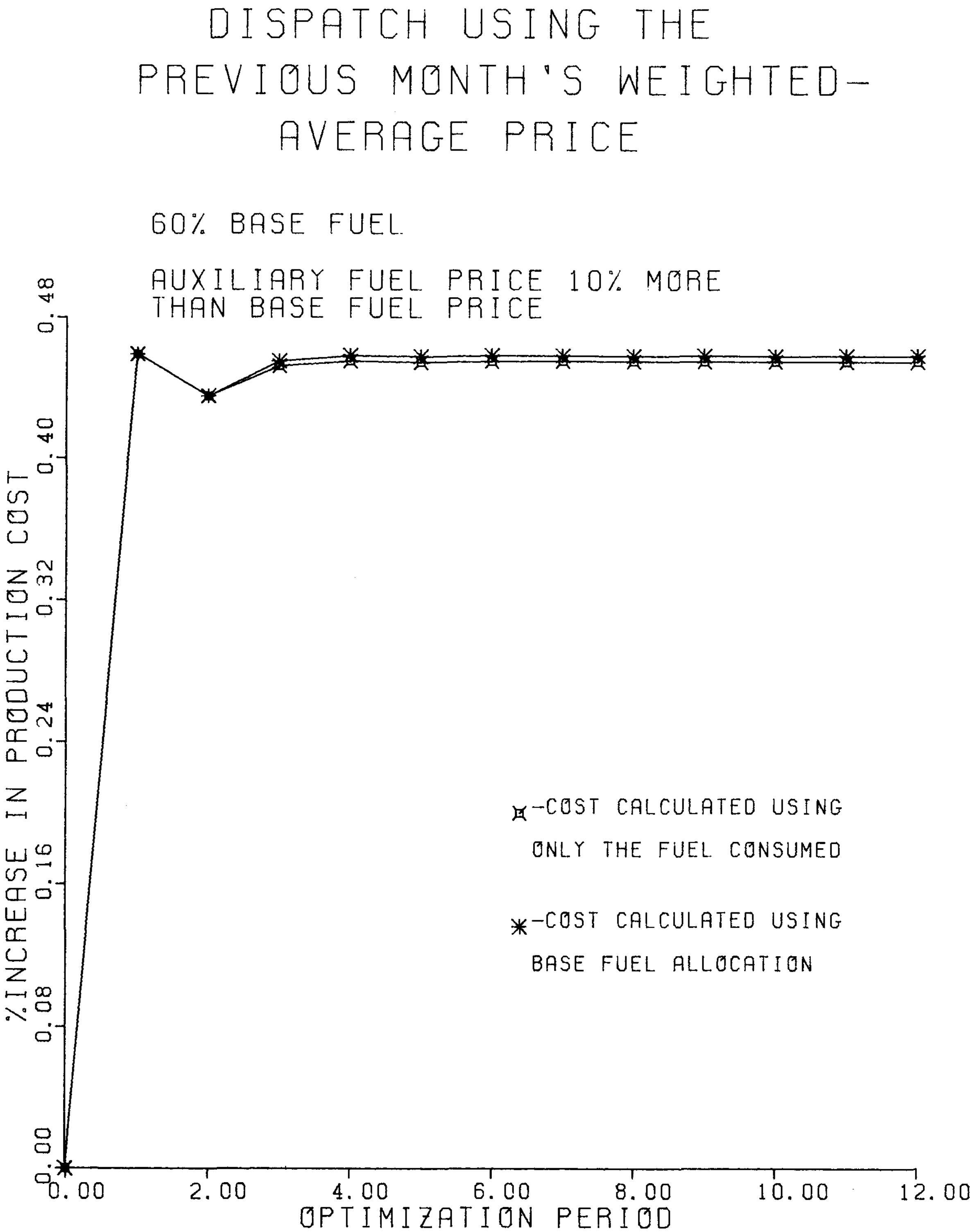

Figure I-51. Use of the Unit's Weighted-Average Fuel Price for Dispatch

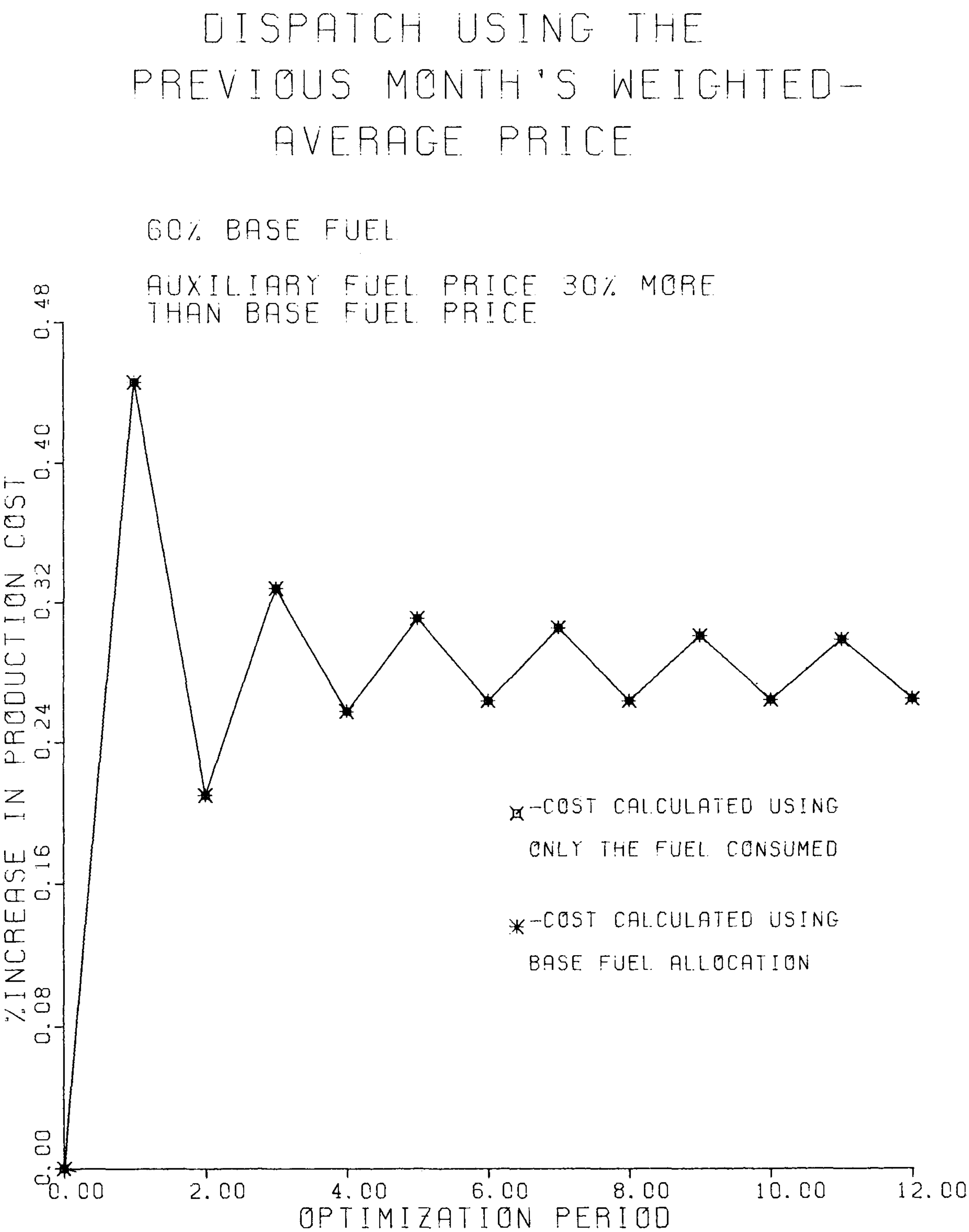

Figure I-52. Use of the Unit's Weighted-Average Fuel Price for Dispatch

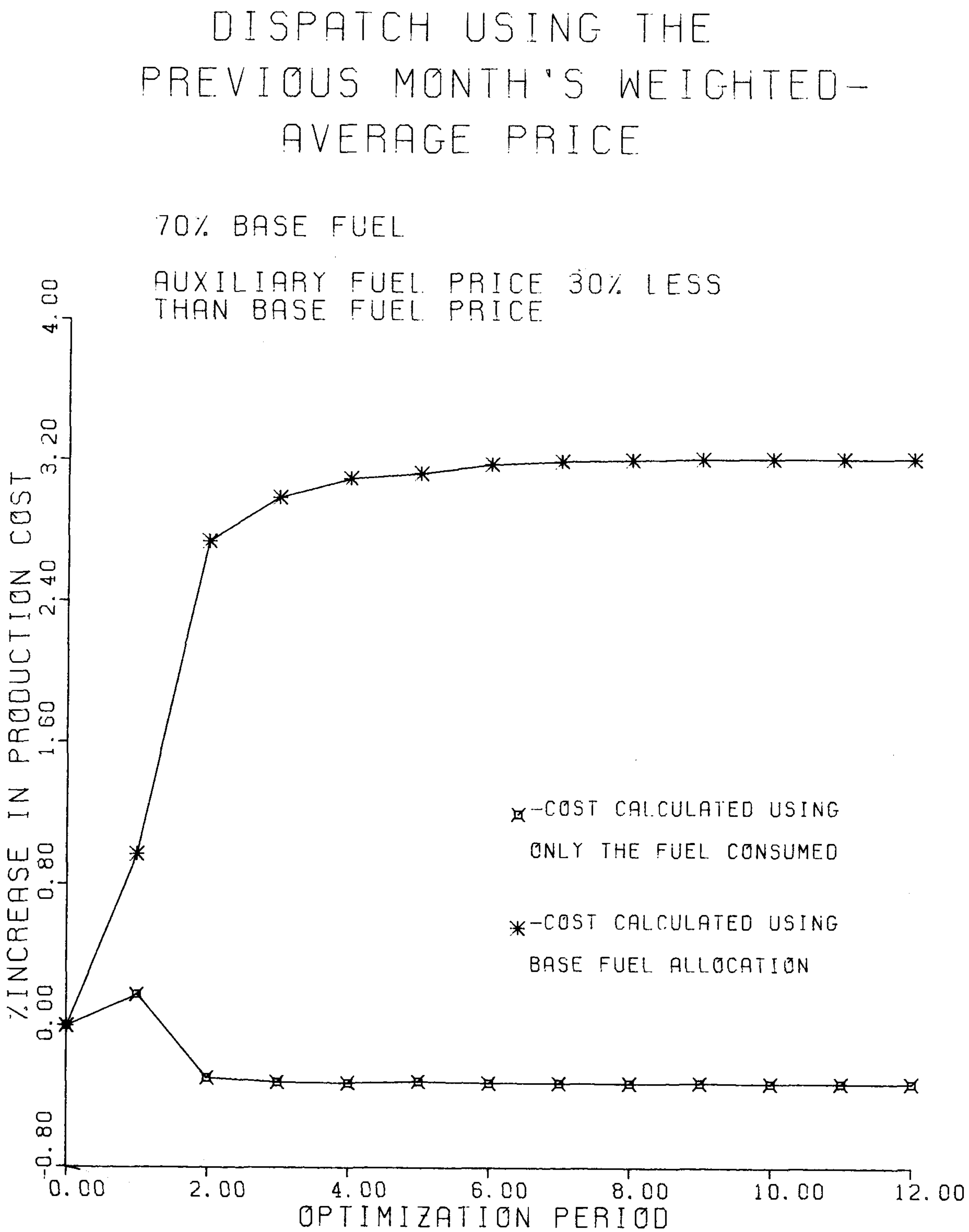

Figure I-53. Use of the Unit's Weighted-Average Fuel Price for Dispatch

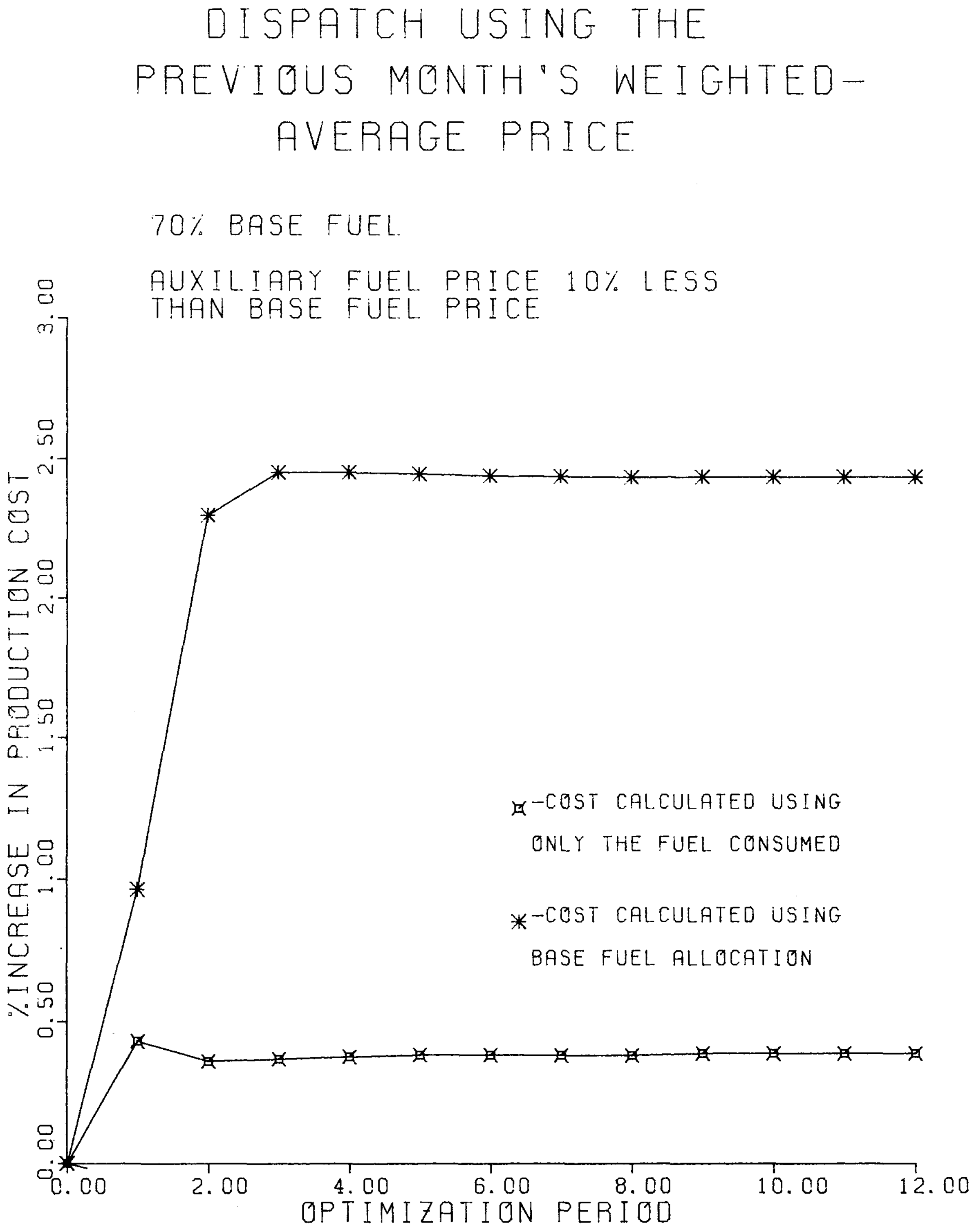

Figure I-54. Use of the Unit's Weighted-Average Fuel Price for Dispatch

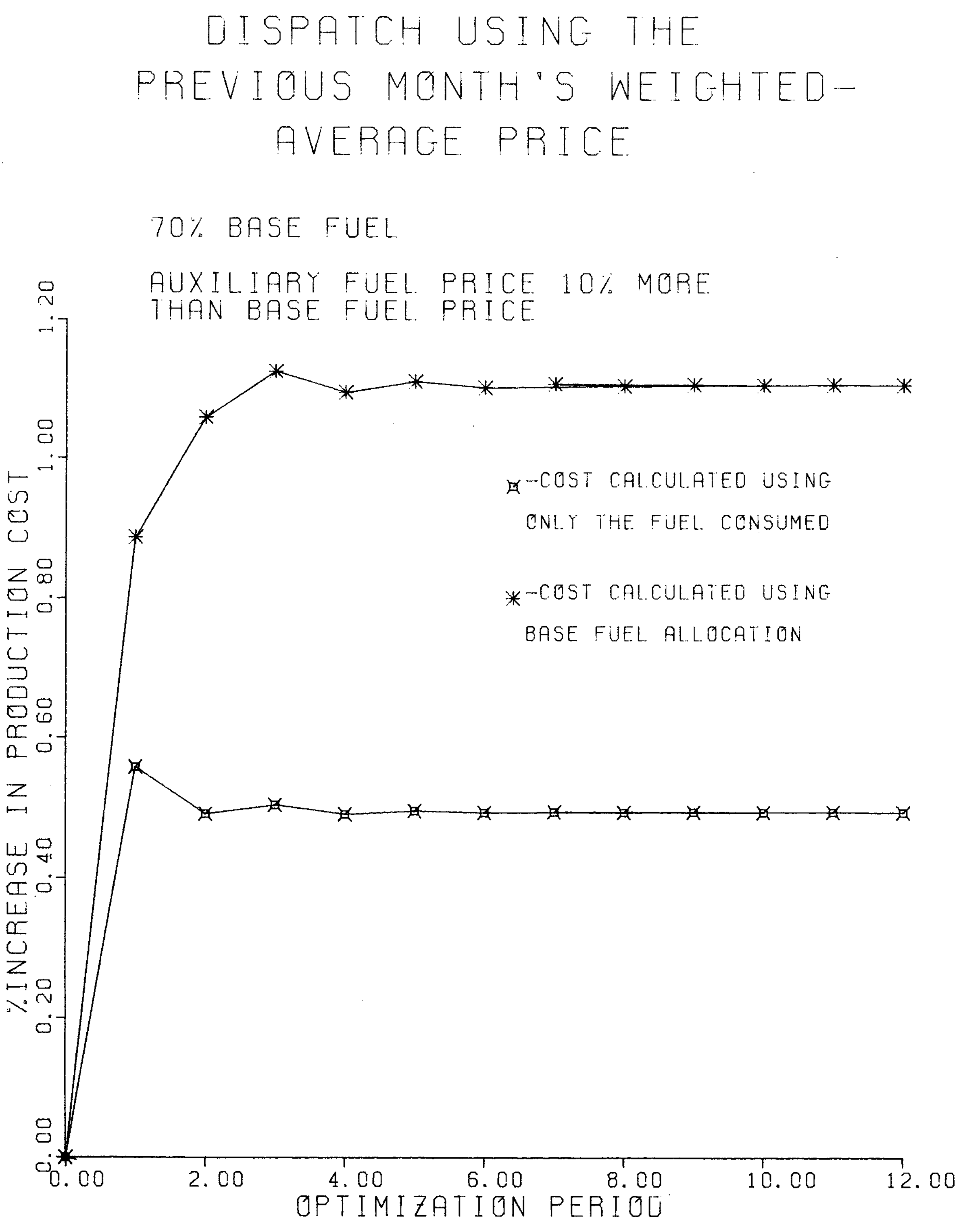

Figure I-55. Use of the Unit's Weighted-Average Fuel Price for Dispatch

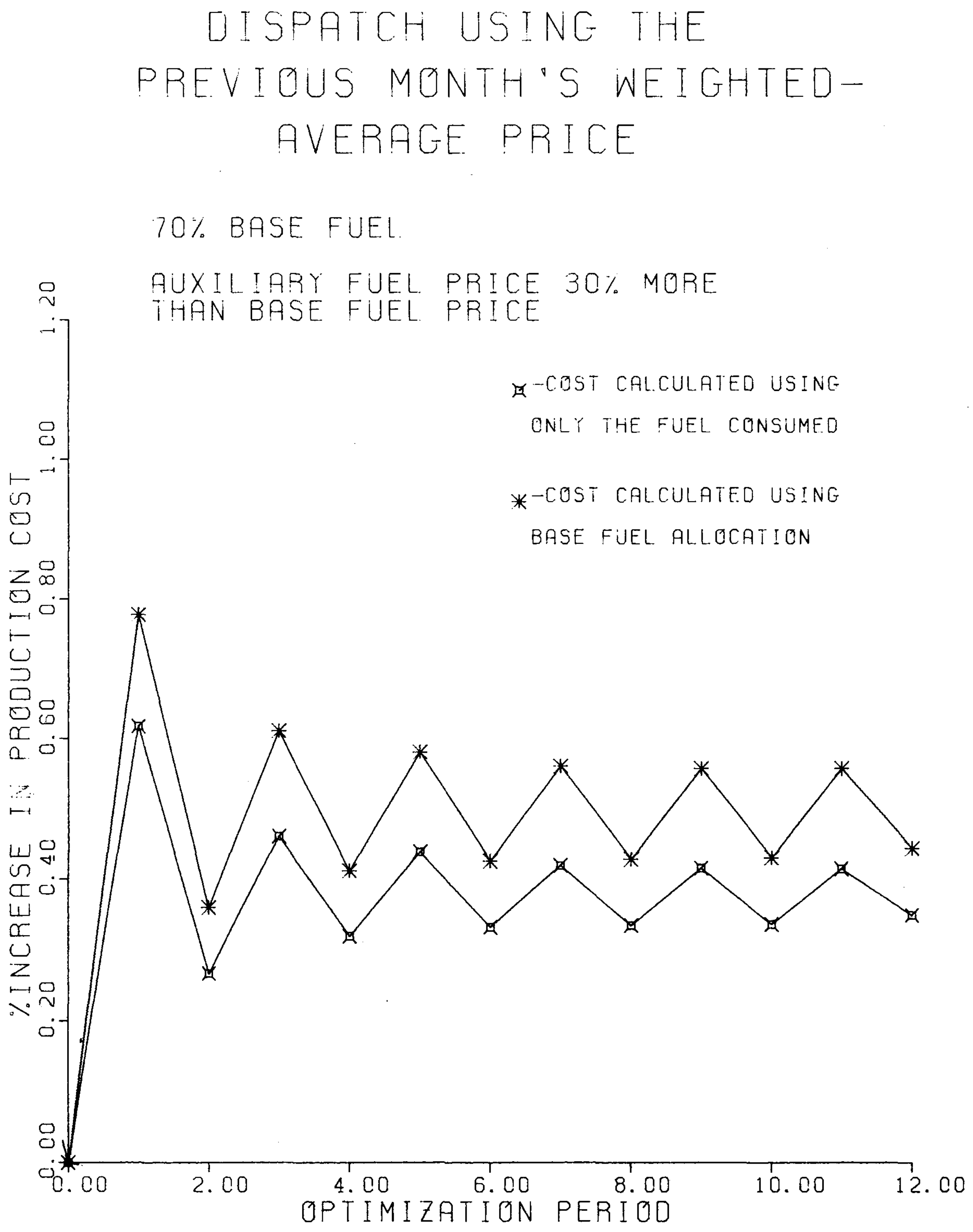

Figure I-56. Use of the Unit's Weighted-Average Fuel Price for Dispatch

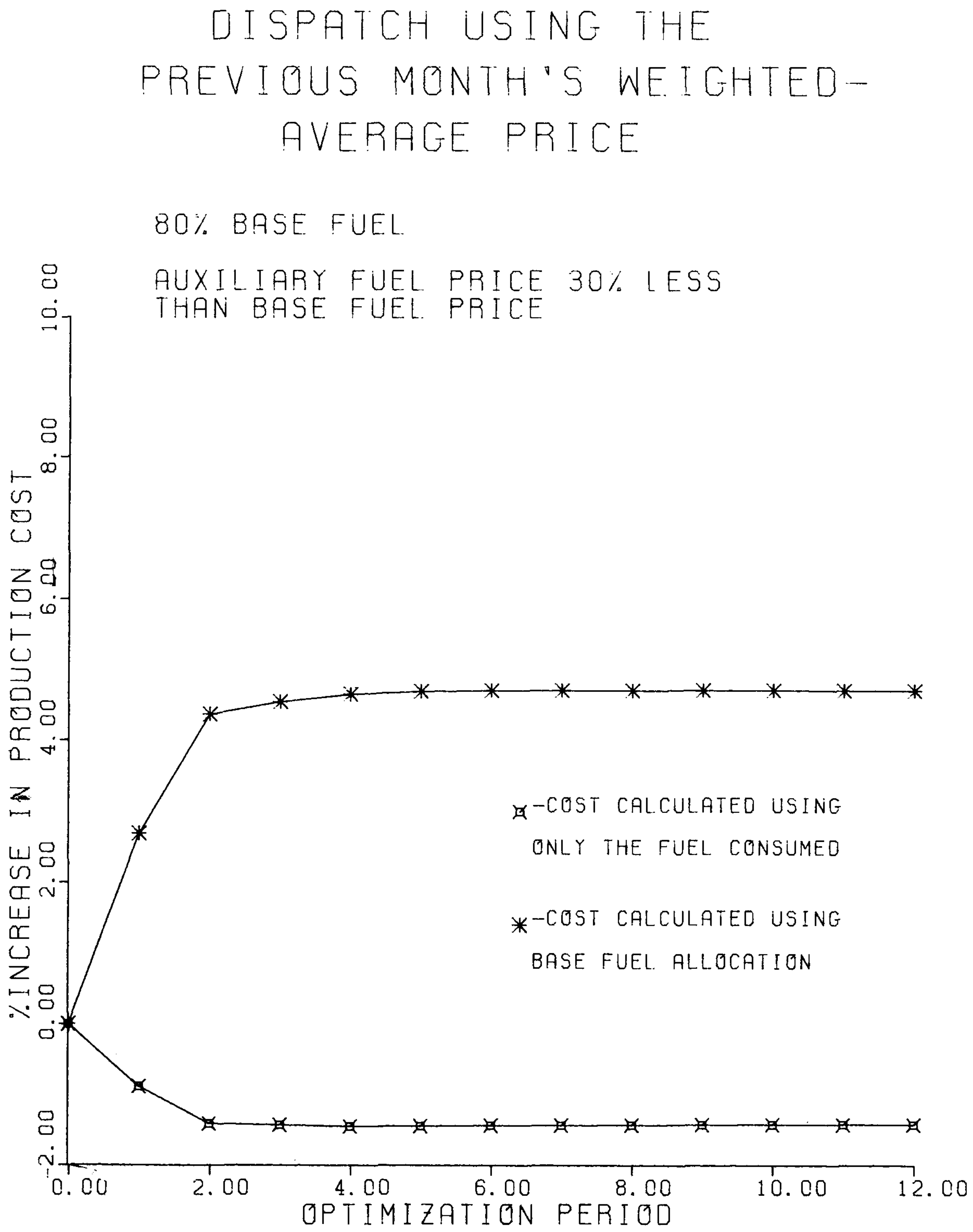

Figure I-57. Use of the Unit's Weighted-Average Fuel Price for Dispatch

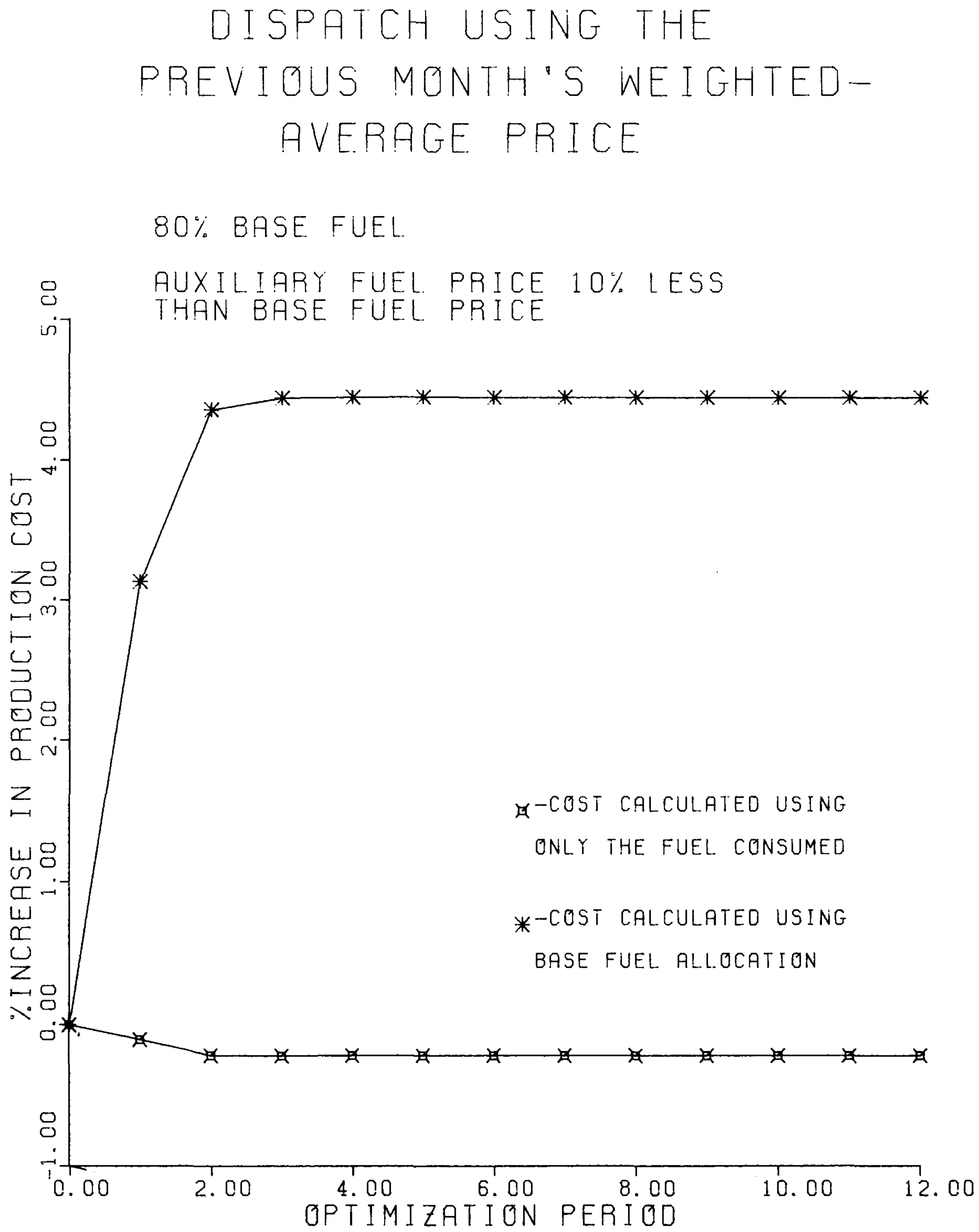

Figure I-58. Use of the Unit's Weighted-Average Fuel Price for Dispatch

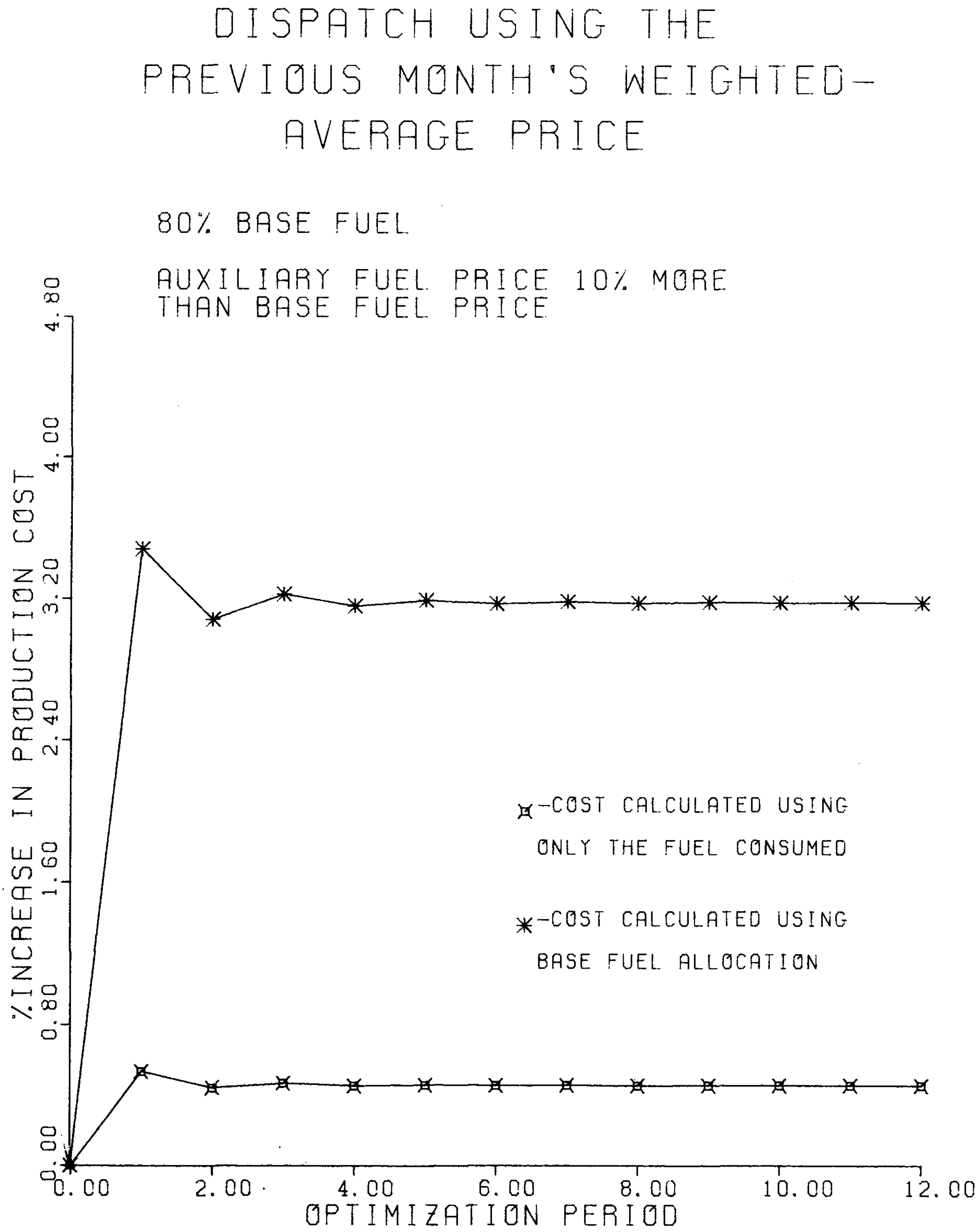

Figure I-59. Use of the Unit's Weighted-Average Fuel Price for Dispatch

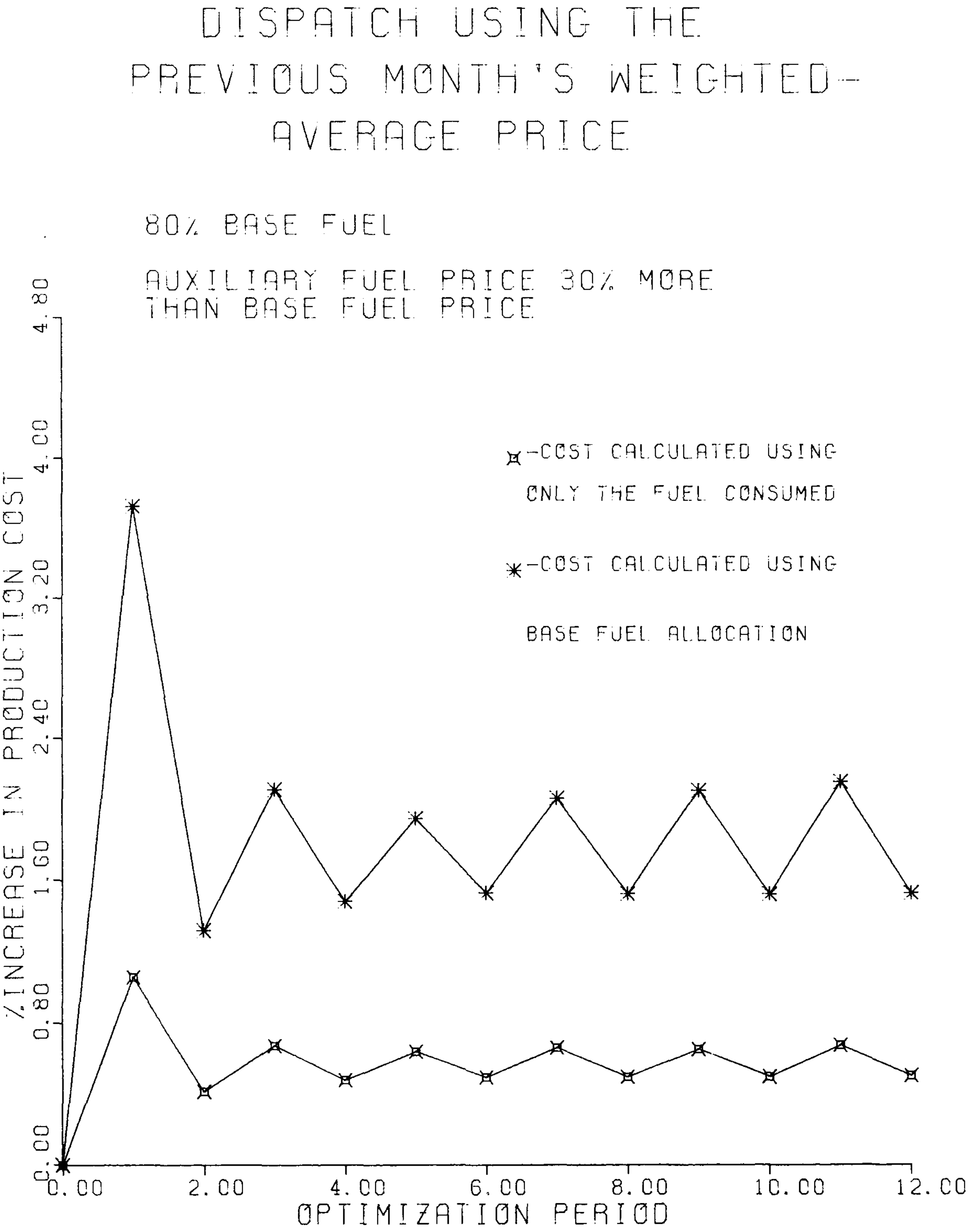

Figure I-60. Use of the Unit's Weighted-Average Fuel Price for Dispatch

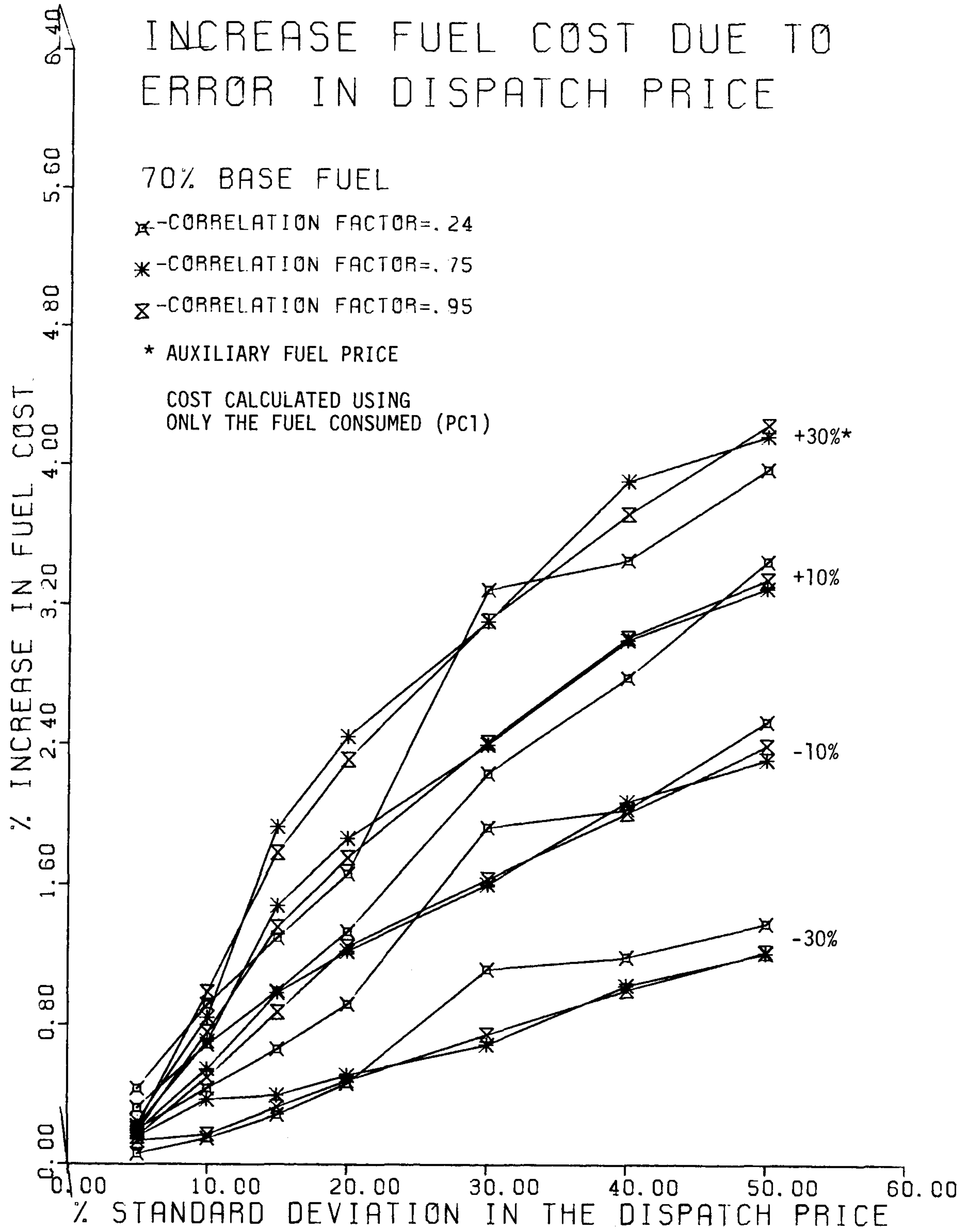

Figure I-61. Increased Fuel Cost Due to Random Dispatch Error

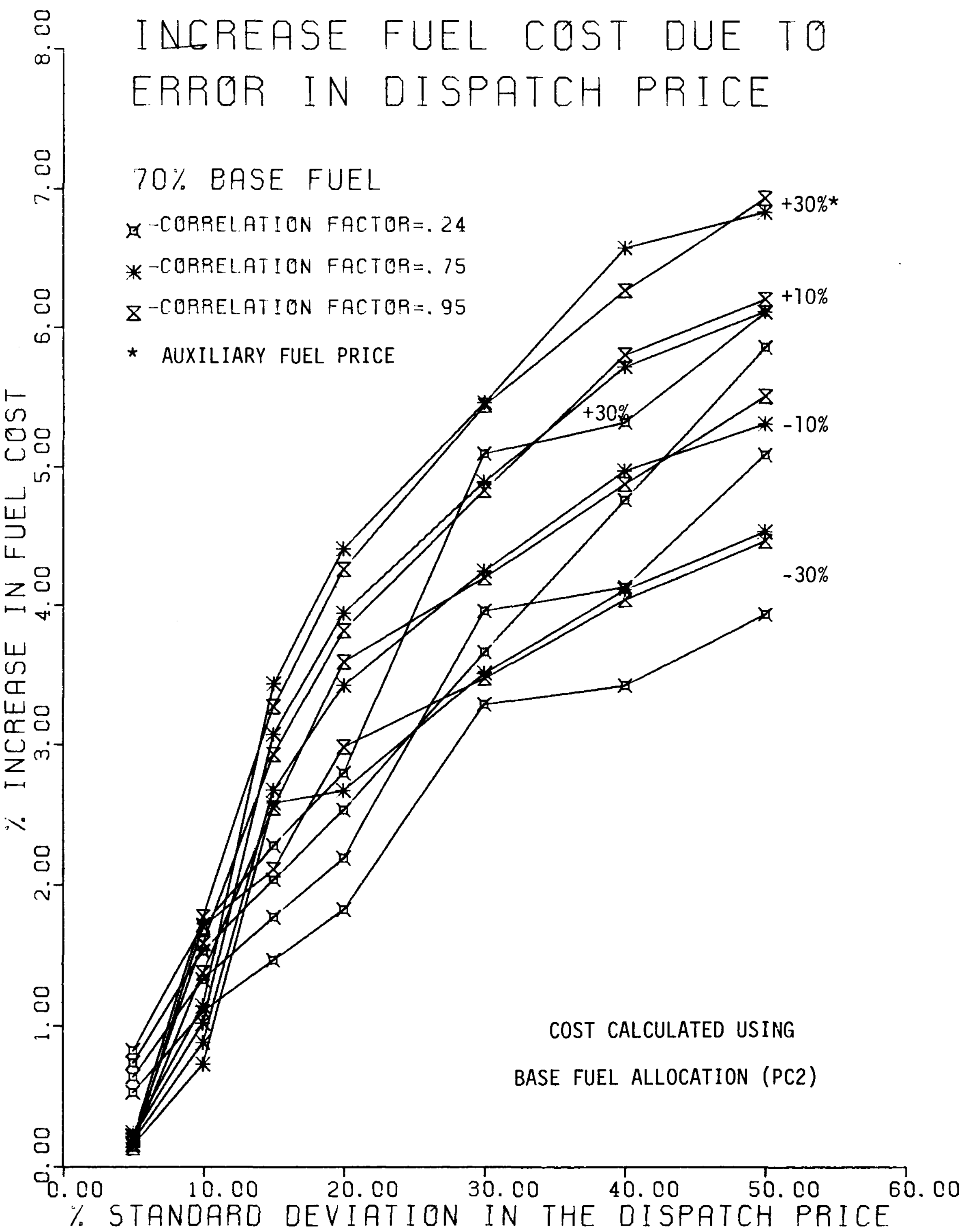

Figure I-62. Increased Fuel Cost Due to Random Dispatch Error

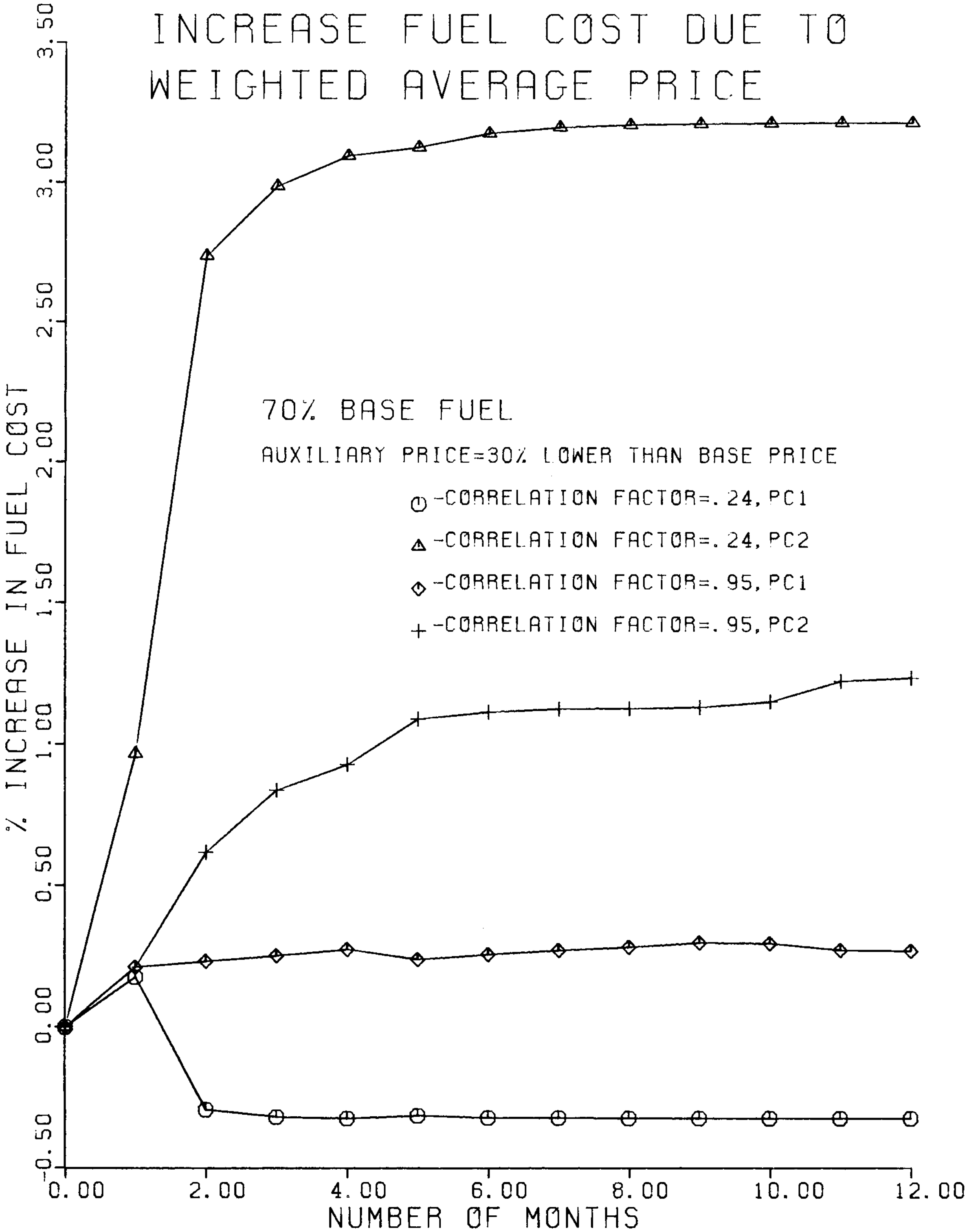

Figure I-63. Use of the Unit's Weighted-Average Fuel Price for Dispatch

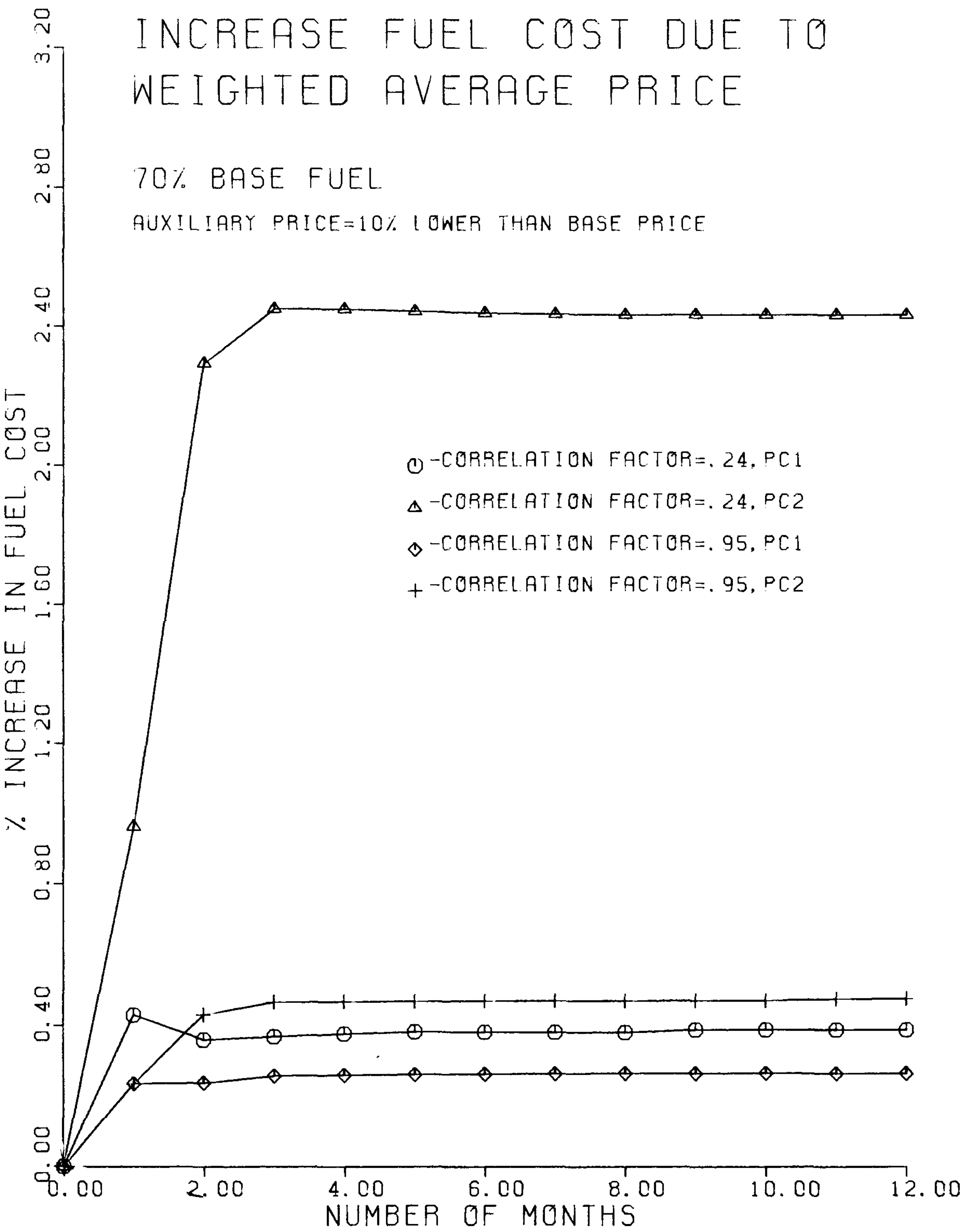

Figure I-64. Use of the Unit's Weighted-Average Fuel Price for Dispatch

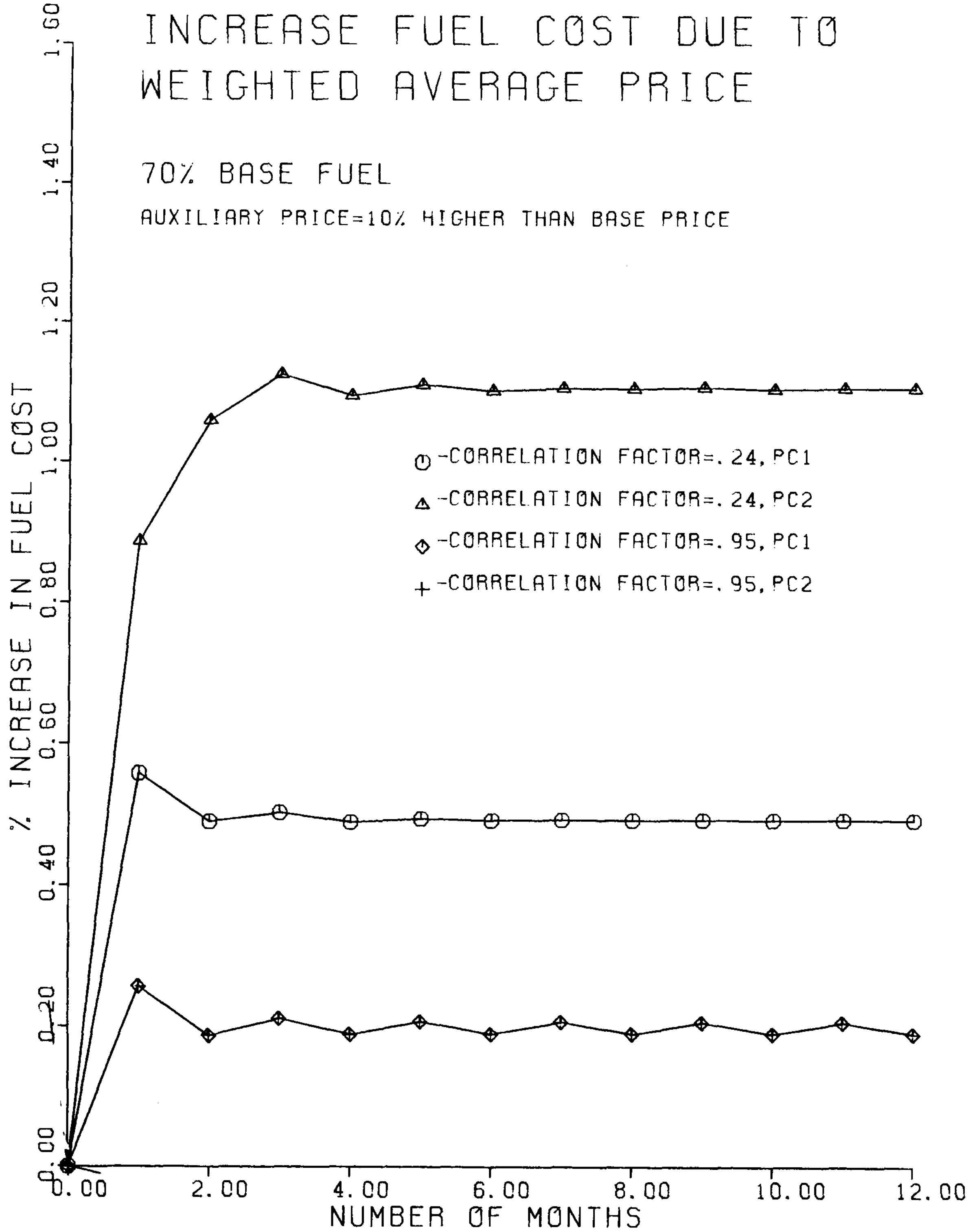

Figure I-65. Use of the Unit's Weighted-Average Fuel Price for Dispatch

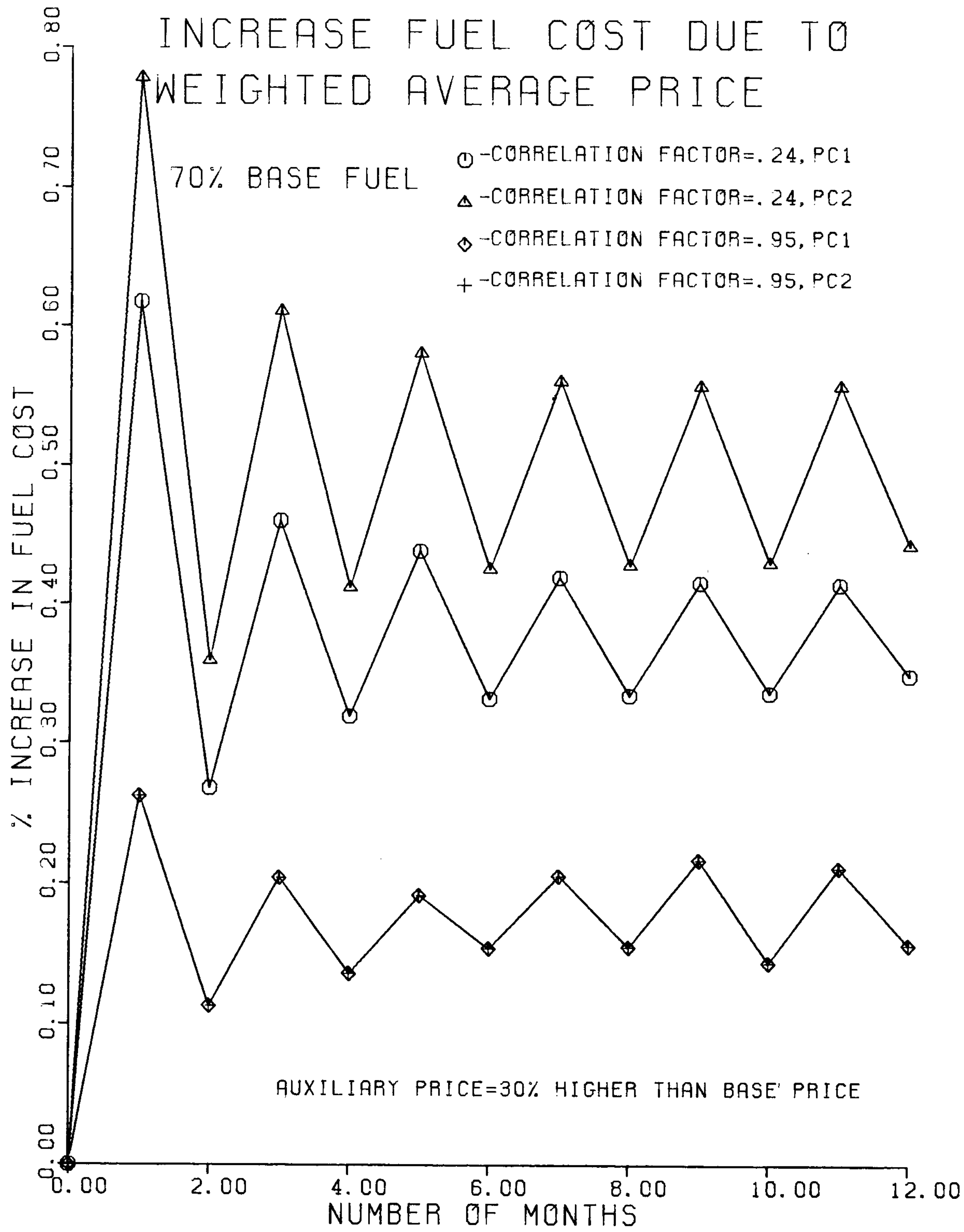

Figure I-66. Use of the Unit's Weighted-Average Fuel Price for Dispatch

Appendix J

GLOSSARY

Much of the material dealt with in this three-volume report is not frequently dealt with in the published technical literature, and many readers may encounter terms or phrases that are unfamiliar. This appendix provides definitions for many such terms. For completeness, some more commonlv encountered items are included as well.

Commit — To put, or schedule to put, a unit into operation.

Compliance fuel — A fuel, typically having low content of sulfur and other pollutants, burned to comply with clean-air standards.

Commitment schedule period — The time period for which an hourly unit commitment schedule is to be generated.

Decommit — To remove, or schedule to remove, a unit from operation.

Dispatchable generation — Generation capability that is available for discretionary scheduling and dispatch. This excludes fixed-output peaking units, base- or block-loaded units, and those on must-down or must-run status.

Draw — To take fuel from a source or inventory; used in the sense of drawing water from a well, and generally in connection with long-term fuel contracts as the source. May be used as a noun to indicate an amount drawn from a contract (i.e., "an awfully large draw last month").

Economic down status — In the unit commitment process, a unit is on economic down status if the unit is off-line for economic reasons.

Economic run status — A unit that is on-line and dispatchable, and cannot be shut down because of minimum up-time requirements, is in economic run status.

LTFS — Abbreviation for Long-Term Fuel Scheduling program.

MTFGS — Abbreviation for Mid-Term Fuel and Generation Scheduling program.

Must-down status — In the unit commitment process, a unit that is prescheduled to be out of operation for a period of time is put on must-down status for each hour during that period.

Must-run status	Similarly, a unit that is prescheduled to be in operation during a given period is put on must-run status, thus removing the option of decommitting the unit at any hour during the period.
Out-of-kilter algorithm	A mathematical procedure for solving a particular class of optimization problems dealing with flaws in linear capacitated networks. The yearly fuel scheduling problem is solved as a linear network optimization problem using the out-of-kilter algorithm.
Pilot and stabilizer fuel	Fuel, usually oil or gas, that is used to stabilize the inherent irregularities of coal combustion, and to serve as a pilot and starting fuel.
Take-or-pay	A type of long-term fuel contract characterized by a lower limit on the quantity of fuel to be shipped during some period of time, where the user must pay for this minimum quantity whether or not he takes delivery.
Transshipment	The shipping of fuel from one generating plant to another.