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Propane Market Model Documentation Report

December 1993

**Energy Information Administration
Petroleum Marketing Division
Office of Oil and Gas
U.S. Department of Energy
Washington, DC 20585**

MASTER

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INTRODUCTION

Purpose of the Report

The purpose of this report is to define the objectives of the Propane Market Model (PMM), describe its basic approach, and to provide detail on model functions. This report is intended as a reference document for model analysts, users, and the general public. Documentation of the model is in accordance with EIA's legal obligation to provide adequate documentation in support of its models (Public Law 94-385, Section 57(b)(2)).

Model Summary

The PMM performs a short-term (6- to 9-month) forecast of demand and price for consumer-grade propane in the national U.S. market; it also calculates the end-of-month stock level during the term of the forecast. Another part of the model allows for short-term demand forecasts for certain individual Petroleum Administration for Defense (PAD) districts. The model is used to analyze market behavior assumptions or shocks and to determine the effect on market price, demand, and stock level.

Model Archival Citation

The Sectoral Propane Activity Market Model (PMM) is archived on IBM-compatible micro-floppy disks and is available through the sponsoring office. The model contact is:

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Report Organization

The remainder of this report is organized in the following manner: (1) model purpose, (2) model rationale, (3) model structure, (4) properties of mathematical solution, (5) calibration and sensitivity analysis, (6) documentation of technical detail on model data and equations, and (7) appendices.

MODEL PURPOSE

Model Objectives

The PMM is to be used for market analysis and general forecasting purposes and was developed for presentation at the State Heating Oil and Propane Program and the Winter Fuels conferences as well as for the annual Propane Outlook article published in the Petroleum Marketing Monthly. The model addresses very short-term, monthly U.S. market responses at the national level and also in PAD districts I & II. The model focuses on U.S. retail demand and market price and assesses market response to alternative scenarios and/or shocks by providing very short-term (up to 9-month) forecasts of propane demand and end-of-month stock levels, along with the market price at the national level. The model relies on the Short-Term Energy Outlook (STEO) mid-world oil price case to assist in defining a baseline (or most probable) case and then uses assumptions on different possible market disturbances to assess market response on a monthly basis; the PMM differs from STEO because of the provision for monthly PAD district level predictions. It has been used to forecast the effect of heating degree day and crude price changes on propane product supplied and market price. The PMM also provides a framework to calculate stock levels from the forecasted demand and price variables.

Model Input/Output

The PMM uses both DOE and non-DOE data input sources. The non-DOE data came from two sources. Data Resources, Inc. (DRI) databases provided values from the Bureau of Labor Statistics, for general macroeconomic variables (including the producer price index). The National Oceanic and Atmospheric Administration was the source for heating degree day information. The DOE historical data for crude oil prices, refinery variables, propane demand, stock levels, and retail price came from EIA publications: the Petroleum Marketing Annual/Monthly (various issues), the Petroleum Supply Annual/Monthly (various issues), the Weekly Petroleum Status Report (various issues) and the Winter Fuels Report (various issues). Forecasts for future values of the independent variables used in the PMM came from EIA's 3rd Quarter Short-Term

Integrated Forecasting System (Energy Information Administration, 1993) and Petroleum Marketing Division analysis of current market trends. Output from the PMM includes very short-term monthly forecasts of national U.S. demand, market price, and stock levels of consumer-grade propane, and also propane market demand in certain PAD districts.

Relationship to Other Models

The PMM does not directly interface with other models. However, the model directly utilizes forecasts of certain macroeconomic and energy price variables from the Short-Term Integrated Forecasting System (STIFS) as inputs.

MODEL OVERVIEW AND RATIONALE

Fundamental Assumptions

The PMM is to be used to judge the effect of shocks or alternative behavior assumptions on the demand, price, and end-of-month stock level for consumer-grade propane in the national economy. The theoretical basis for the model is the standard demand-supply approach used to determine the market effects of shifting demand and supply curves on a single product in an isolated market; it implicitly makes the assumption that all economic entities exhibit profit-maximizing behavior. The model indirectly allows for feedback effects between price and demand over a monthly time frame. Although the model functions at a monthly frequency, conclusions are normally drawn from the model on a quarterly or semi-annual basis. The PMM uses recent historical market behavior as a pattern for predicting near-term future market responses.

The PMM is concerned with very short-term (i.e., 6- to 9-month) projections into the future. In order to make the analysis more tractable, a number of simplifying assumptions were made concerning the behavior of the propane market; these include:

- Constant relative size of vehicle fleet using alternative fuels. It is assumed that there is no sudden demand surge due to the use of propane as an alternative vehicle fuel.
- The consumer propane market is isolated from disturbances to other petroleum product markets. It is assumed that any significant interaction between the propane market and other product markets would not occur within the timeframe of the forecast.
- Constant delivery infrastructure. It is assumed that there will be no significant changes in the consumer-grade propane distribution infrastructure during the duration of the forecast.

- The relative proportion of homes using propane for heating purposes remains constant. Additionally, furnace efficiency is assumed to be constant over the timeframe of the model projections.
- No dramatic changes in the macroeconomic or natural conditions. It is also assumed that the relative pricing structure of petrochemical inputs does not radically change.
- No changes in refinery economic conditions. All scenarios were conducted under the assumption that refinery and production conditions do not radically change during the duration of the forecast. Net imports are also assumed to be exogenously determined.

The model assumes that the data series identified as Propane/Propylene in the Petroleum Supply Monthly is entirely sold as consumer-grade propane and that the price of the product reflects that to the end user (or residential customer) in a retail market. The model also assumes that the data series "Propane (Consumer-grade), Sales to End Users" as published in the Petroleum Marketing Monthly does not measure the same market as the "Residential Propane Prices" reported in the Winter Fuels Report.

The PMM allows market players to make pricing decisions based on historical price, demand, and stock patterns. The model assumes that market players make decisions on a monthly basis; although this may be somewhat of a long reference time frame, any analysis utilizing a more rapid decisionmaking process would be hampered by the lack of data availability at higher frequencies.

Alternative Approaches

The PMM is a time series model typical of a form used for the estimation of propane demand (see, for example, Short-Term Integrated Forecasting System, 1993). Cross-sectional models of end user purchasing behavior were not considered because of the need to forecast market adjustments to possible shocks for longer than a single time period. The STIFS model was not used because of the desire to model the residential or end-use propane market as being distinct from the liquefied petroleum gas market; additionally, the retail price utilized by the STIFS model is at best an imperfect measure of the actual residential price for commercial grade propane.

MODEL STRUCTURE

Flow Diagram of National Model

PROPANE MARKET MODEL FLOW DIAGRAM

Solution of the PMM proceeds in a straight forward manner. The input variables are used as exogenous and predetermined variables for the independent estimation of demand and price. The model then algebraically calculates the projected stock level and other stock related variables used as inputs. The current period solution is printed and the model proceeds, if necessary, to the estimation for the next period.

List of Computations and Equations for National Model

The equation used by the model for the estimation of end-user price is of the form:

$$\text{PRICE} = \mathcal{F}(\text{current and lagged crude price, lags of STOCKDIF, current and lagged heating degree variable, monthly dummy variables}).$$

The actual estimated price equation is:

$$\begin{aligned} \text{PRICE}_t = & \alpha_0 + \alpha_{12} * \text{CRUDE}_t + \alpha_{13} * \text{CRUDE}_{t-1} + \alpha_{14} * \text{STOCKDIF}_{t-1} \\ & + \alpha_{15} * \text{STOCKDIF}_{t-2} + \alpha_{16} * \text{HDDSPSQ}_t + \alpha_{17} * \text{HDDSPSQ}_{t-1} \\ & + \sum_{i=1}^{11} \alpha_i * \text{DUMMY}_i \end{aligned}$$

The equation used to calculate the residential price is:

$$\text{RESPRICE}_t = \text{PRICE}_t * \text{PPI}_t + \gamma_t$$

The equation used to calculate the end-user price is:

$$\text{RETPRICE}_t = \text{PRICE}_t * \text{PPI}_t$$

The equation used by the model for the estimation of demand (product supplied) is of the form:

$$\text{DEMAND} = \mathcal{F}(\text{lagged STOCKDIF, current heating degree days, agricultural crop drying dummy variables, monthly dummy variables}).$$

The actual estimated demand equation is:

$$\begin{aligned} \text{DEMAND}_t = & \beta_0 + \beta_{12} * \text{STOCKDIF}_{t-2} + \beta_{13} * \text{HDD}_t + \sum_{i=1}^{11} \beta_i * \text{DUMMY}_i \\ & + \beta_{15} * \text{DONOV92} + \beta_{16} * \text{DODEC92} \end{aligned}$$

where

PRICE is the average (consumer-grade) propane refinery price to end-users deflated by the Producer Price Index, with outliers smoothed if necessary.

RESPRICE is the residential price of consumer-grade propane.

PPI is the producer price index.

RETPRICE is the average (consumer-grade) propane refinery price to end-users.

HDD is the mean deviation from the national norm of heating degree days¹.

$$HDDSPSQ = \begin{cases} HDD^{**2} & \text{if } HDD \geq 0 \\ 0 & \text{if } HDD < 0 \end{cases}$$

CRUDE is the average imported refiners acquisition cost of crude oil deflated by the Producer Price Index.

STOCKDIF is the deviation of the current stock level from the average of the previous 3 years.

DEMAND is the propane product supplied.

γ is an additive adjustment used to compensate for the difference between the end-user price and residential price. By definition:

$$\gamma_i = \begin{cases} \text{MEAN (RESPRICE}_i - \text{PRICE}_i) & \forall \text{ years, if } i=\text{OCT, NOV, DEC, JAN, FEB, MAR} \\ \gamma_{\text{OCT}} & \text{if } i=\text{SEP} \end{cases}$$

DUMMY_i are monthly dummy variables.

DONOV92 are dummy variables for November, 1992 and December, 1992, respectively.

DODEC92

t is the subscript variable for monthly time series observations.

The inputs to the above equations are exogenous (i.e. STEO estimated) or previously calculated values for the variables. Direct output from these equations consist of one month ahead forecasts of PRICE, RESPRICE and DEMAND for total consumer-grade propane. The determination of the one

¹HDD_t = (HDDA_t - HDDN_t) / DAYS, where HDDA_t is the actual population weighted heating degree days for time period t and HDDN_t is the estimated 30 year average (1951 - 1980 basis) for each period.

month ahead stock level from the forecasted level of demand is calculated by the following formulas:

$$\text{DELSTOCK}_t = (\text{PRIM_SUP}_t - \text{DEMAND}_t) * \text{DAYS}_t$$

$$\text{STOCK}_t = \text{STOCK}_{t-1} + \text{DELSTOCK}_t$$

$$\text{STOCKDIF}_t = \text{STOCK}_t - \text{STOCKAVG}_t$$

where PRIM_SUP is the sum of field production, refinery output and net imports of propane.

DAYS is the number of days in month t

STOCKAVG is $(\text{STOCK}_{t-12} + \text{STOCK}_{t-24} + \text{STOCK}_{t-36}) / 3$

Flow Diagram of PAD District Models

PROPANE PAD DISTRICT I MODEL FLOW DIAGRAM

PROPANE PAD DISTRICT II MODEL FLOW DIAGRAM

List of Computations and Equations for PAD District Models

The equation used by the model for the estimation of demand in PAD district I is of the form:

$$\text{DEMAND} = f(\text{current heating degree days, agricultural crop drying dummy variables, monthly dummy variables}).$$

The actual estimated demand equation is:

$$\text{DEMAND1}_t = \beta_0 + \beta_{12} * \text{HDD1}_t + \sum_{i=1}^{11} \beta_i * \text{DUMMY}_i + \beta_{13} * \text{DONOV92} + \beta_{14} * \text{DODEC92}$$

The equation used by the model for the estimation of end-user price in PAD district II is of the form:

$$\text{PRICE} = f(\text{crude price, lagged stock variable, lagged heating degree variable, 12-month lag on price, monthly dummy variables}).$$

The actual estimated price equation is:

$$\begin{aligned} \text{PRICE2}_t = & \alpha_0 + \alpha_{12} * \text{CRUDE}_t + \alpha_{13} * \text{STKDIF2}_{t-2} + \alpha_{14} * \text{HDDSPSQ2}_{t-1} + \alpha_{15} * \text{PRICE2}_{t-12} \\ & + \sum_{i=1}^{11} \alpha_i * \text{DUMMY}_i \end{aligned}$$

The equation used by the model for the estimation of demand in PAD district II is of the form:

$$\text{DEMAND} = f(\text{heating degree days, price, agricultural crop drying dummy variables, monthly dummy variables}).$$

The actual estimated demand equation is:

$$\begin{aligned} \text{DEMAND2}_t = & \beta_0 + \beta_{12} * \text{HDD2}_t + \beta_{13} * \text{PRICE2}_t + \sum_{i=1}^{11} \beta_i * \text{DUMMY}_i \\ & + \beta_{14} * \text{DONOV92} + \beta_{15} * \text{DODEC92} \end{aligned}$$

where PRICE2 is the average (consumer-grade) propane refinery price to end-users in PAD district II deflated by the Producer Price Index.

HDD1 is the mean deviation from normal heating degree days in PAD district 1.

HDD2 is the mean deviation from normal heating degree days in PAD district 2.

$$\text{HDDSPSQ2} = \begin{cases} \text{HDD2}^2 & \text{if HDD2} \geq 0 \\ 0 & \text{if HDD2} < 0 \end{cases}$$

STKDIF2 is the deviation of the current stock level in PAD district 2 from the average of the previous 3 years.

DEMAND1 is the propane product supplied in PAD district 1.

DEMAND2 is the propane product supplied in PAD district 2.

where the remaining variables having been previously defined.

The inputs to the above equations are exogenous (i.e., STEO estimated) or previously calculated values for the variables. Direct output from these equations consists of 1-month-ahead forecasts of DEMAND (and PRICE) for consumer-grade propane in the individual PAD districts. The determination of the 1-month-ahead stock level from the forecasted level of demand is calculated by using the following formulas:

for PAD district I,

$$\text{DELSTK1}_t = (\text{PRIMSUP1}_t - \text{DEMAND1}_t) * \text{DAYS}_t$$

$$\text{STOCK1}_t = \text{STOCK1}_{t-1} + \text{DELSTK1}_t$$

$$\text{STKDIF1}_t = \text{STOCK1}_t - \text{STKAVG1}_t$$

and for PAD district II,

$$\text{DELSTK2}_t = (\text{PRIMSUP2}_t - \text{DEMAND2}_t) * \text{DAYS}_t$$

$$\text{STOCK2}_t = \text{STOCK2}_{t-1} + \text{DELSTK2}_t$$

$$\text{STKDIF2}_t = \text{STOCK2}_t - \text{STKAVG2}_t$$

where PRIMSUP x is the sum of field production, refinery output, net imports and net receipts of propane for PAD district I (when $x=1$) and PAD district II (when $x=2$).

STKAVG x is calculated by the following formula for PAD district I (when $x=1$) and PAD district II (when $x=2$):

$$\text{STKAVG}_x_t = (\text{STOCK}_x_{t-12} + \text{STOCK}_x_{t-24} + \text{STOCK}_x_{t-36}) / 3$$

PROPERTIES OF MATHEMATICAL SOLUTION

Theoretical Considerations

The U.S. model is a standard demand-supply set of equations with no contemporaneous direct dependence between the demand and price equations. Any possible problem of simultaneous equations bias was addressed by formulating the model as a set of equations with no direct dependency among the dependent variables. Both dependent variables, viz. price and demand, are independently determined only by exogenous and predetermined variables. The predetermined stock variable is determined directly from the demand equation and from exogenous refinery and economic variables; in its lagged form, the stock variable implicitly acts (with a lag) as a price variable in the demand regression equation. There is indirect feedback from the demand equation to the price equation through the lagged stock variable; the lack of a direct feedback from demand to price implies that a disturbance to the demand equation will not greatly affect the price equation. Thus, there is probably no contemporaneous correlation between the demand equation and price, so that Ordinary Least Square (OLS) estimate is unbiased (P. Kennedy, 1985).

The demand equation for PAD district II includes the current price as an explanatory variable; thus, simultaneous equation bias will exist. However, the size of any contemporaneous correlation is expected to be small in the inelastic demand range in which the model is designed to work and because heating degree days capture a very large portion of the fluctuation in demand.

Certain a priori restrictions were placed on the domain of a number of variables. These include:

- The lag-one autocorrelation parameter of the model has a domain between -1 and +1
- The elasticity of demand is between 0 and -1; the elasticity of supply is greater than zero
- The price, demand, and stock level are finite and greater than zero.

Subject-Matter Considerations

The original purpose of the PMM was to model the residential (as being different from the retail) consumer-grade propane market at the national level, and to a more limited extent, at certain PAD district levels. Data limitations required expanding the focus of the analysis so as to model the retail market as opposed to the residential market for propane. The definitions used in this document are:

END-USER PRICE: This is the average price for the sale of consumer-grade propane by refiners to end-users as is reported in the Petroleum Marketing Monthly. These monthly data include sales to industrial users and resellers to the residential market; the data are available at the national level for all months and at the PAD district level for most months.

RESIDENTIAL PRICE: This is the average price for the sale of consumer-grade propane directly to residential customers as is reported in the Winter Fuels Report. The data are available for a 6-month period beginning in October and include values for PAD districts 1 through 3 and an average.

From the above distinction between end-user and residential prices, a number of observations can be easily inferred:

- The residential price is higher than the retail price.
- The residential price is a more reliable indicator of the price paid by actual residential consumers. This is the value of most interest to State Energy Offices and congressional staffs.
- The average (end-user) price quoted by individual refiners varies by a factor of 3 (eg. 20 to 60 cents per gallon) depending on the principal customer of the refiner.

The PMM assumes that market reactions are based on recent historical patterns. While the annual incorporation of current data with historical trends may affect the PMM's responsiveness, minor structural changes in the market can be accommodated with modifications to the equations. The domain of the input variables is assumed to be that of the recent historical time series for the individual variables.

CALIBRATION AND SENSITIVITY ANALYSIS

Results of Calibration

Calibration of the model was performed using a comparison of the forecasts for demand, retail price, and end-of-month stock level forecasted by the PMM with the STIFS values for the period June, 1993, through March, 1994. The following three tables illustrate the comparison values. It should be noted that the PMM end-of-month stock

values for the first 2-months (i.e., June and July) reported in the tables were estimated from actual data².

PROPANE OUTLOOK: DEMAND
Comparison of STEO and PMM Forecasts

DATE	STEO (MMbbl/d)	PMM (MMbbl/d)
Jun-93	754	720
Jul-93	775	793
Aug-93	818	855
Sep-93	899	945
Oct-93	1005	1076
Nov-93	1037	1098
Dec-93	1159	1233
Jan-94	1303	1353
Feb-94	1182	1282
Mar-94	1037	1106

²The tabulated values were estimated from a linear interpolation of weekly data published in the Weekly Petroleum Status Report, DOE/EIA-0208, various issues.

PROPANE OUTLOOK: STOCKS
Comparison of STEO and PMM Forecasts

DATE	STEO (MMbbl)	PMM (MMbbl)
Jun-93	46.652	44.900
Jul-93	52.705	51.700
Aug-93	57.425	57.140
Sep-93	58.886	59.697
Oct-93	56.391	58.570
Nov-93	50.951	56.674
Dec-93	44.922	50.539
Jan-94	35.818	40.682
Feb-94	30.575	33.916
Mar-94	30.338	31.876

PROPANE OUTLOOK: END-USER PRICE
Comparison of STEO and PMM Forecasts

DATE	STEO (cents/gal)	PMM (cents/gal)
Jun-93	65.4	61.2
Jul-93	64.0	61.5
Aug-93	65.1	63.7
Sep-93	67.4	63.2
Oct-93	68.2	62.3
Nov-93	70.6	66.5
Dec-93	74.0	73.5
Jan-94	77.4	75.2
Feb-94	76.5	74.7
Mar-94	72.8	71.0

Another calibration was done by using the PMM to perform a dynamic ex post forecast of propane end-user price and demand for the first two quarters in calendar year 1993. The results are shown in the next two tables, along with the actual values and the STIFS projections for the same time period³. It can be seen that the accuracy of the PMM values compare favorably to those generated by STIFS.

U.S. NATIONAL PROPANE EX POST FORECAST: END-USER PRICE
Comparison of Model Predictions with Actual Values
(Cents per Gallon)

DATE	SERIES	ACTUAL	PMM	STEO
1st Quarter, 1993	Value	74.7	71.6	71.4
	Deviation from Actual		-3.1	-3.3
2nd Quarter, 1993	Value	67.0	64.6	64.6
	Deviation from Actual		-2.4	-2.4

³The STIFS values were taken from a computer run generated on 30MAR93, and include some published values for the first quarter.

U.S. NATIONAL PROPANE EX POST FORECAST: DEMAND
Comparison of Model Predictions with Actual Values
(Thousands Barrels per Day)

DATE	SERIES	ACTUAL	PMM	STEO
1st Quarter, 1993	Value	1200	1213	1231
	Deviation from Actual		+13	+31
2nd Quarter, 1993	Value	767	755	866
	Deviation from Actual		-12	+99

Another calibration was done by using the PMM(PADD1) to perform a dynamic ex post forecast of propane demand in PAD district I for the first two quarters in calendar year 1993. The results are shown in the next table. (Values from the STIFS model are not available at the PAD district level.)

PAD DISTRICT 1 PROPANE EX POST FORECAST: DEMAND
Comparison of Model Predictions with Actual Values
(Thousands Barrels per Day)

DATE	SERIES	ACTUAL	PMM
1st Quarter, 1993	Value	225	228
	Deviation from Actual		+3
2nd Quarter, 1993	Value	116	116
	Deviation from Actual		0

Another calibration was done by using the PMM(PADD2) to perform a dynamic ex post forecast of propane demand and end-user price in PAD district II ~~from the first previous version of the model used to this analysis~~ Propane Market in PAD district 2 during the 1992-93 heating season (see Burdette, et al., 1993). The results are shown in the next two tables. (Values from the STIFS model are not available at the PAD district level.)

PAD DISTRICT II PROPANE EX POST FORECAST: END-USER PRICE
Comparison of Model Predictions with Actual Values
(Cents per Gallon)

DATE	SERIES	ACTUAL	PMM
1st Quarter, 1993	Value	82.8	78.5
	Deviation from Actual		-4.3
2nd Quarter, 1993	Value	79.9	71.5
	Deviation from Actual		-8.4

PAD DISTRICT II PROPANE EX POST FORECAST: DEMAND
Comparison of Model Predictions with Actual Values
(Thousands Barrels per Day)

DATE	SERIES	ACTUAL	PMM
1st Quarter, 1993	Value	370	404
	Deviation from Actual		+34
2nd Quarter, 1993	Value	193	184
	Deviation from Actual		-9

The PAD district 2 retail propane market underwent a severe disruption during the 1992-93 heating season due to unseasonable cold weather and late crop drying during the 4th quarter of 1992. The effects of this market stress were still being felt during the first part of the following year (see Burdette, et al., 1993) for a more extensive discussion of the causes and effects of this market disturbance.) One of the effects that the PMM(PADD2) was not able to fully capture was the large run-up of end-user prices. In order to verify the adequacy of the model in more normal market circumstances, another dynamic ex post simulation of the model was done for the first three quarters in the 1993 calendar year. Even though the regression model was based on data time series of only 36 months, the results, as presented in the next two tables, show deviations from actual values of less than 10 percent.

PAD DISTRICT II PROPANE EX POST FORECAST: END-USER PRICE
Comparison of Model Predictions with Actual Values
(Cents per Gallon)

DATE	SERIES	ACTUAL	PMM
1st Quarter, 1992	Value	72.5	75.3
	Deviation from Actual		+2.8
2nd Quarter, 1992	Value	67.4	70.1
	Deviation from Actual		+2.7
3rd Quarter, 1992	Value	64.6	70.1
	Deviation from Actual		+5.5

PAD DISTRICT II PROPANE EX POST FORECAST: DEMAND
Comparison of Model Predictions with Actual Values
(Thousands Barrels per Day)

DATE	SERIES	ACTUAL	PMM
1st Quarter, 1992	Value	341	363
	Deviation from Actual		+22
2nd Quarter, 1992	Value	179	194
	Deviation from Actual		+15
3rd Quarter, 1992	Value	237	232
	Deviation from Actual		-5

Model Runs to Test Concordance with Intuition

The PMM underwent two tests to determine its correspondence with intuition and economic theory. This test was performed by increasing the severity of a prolonged cold snap during the heating season and was done in two parts: (1) the Cold Heating Season case, which increases the total mean heating degree days during the October through March season by 10 percent over the normal amount and (2) the Cold Winter case, which takes the same number of increased mean heating degree days and apportions this amount just over the winter months (i.e., January through March). Since one of the principal uses of consumer-grade propane is for residential and industrial heating, the results of this test should show that during the period of colder temperatures, demand for propane will increase over and above that in the base case. The increased demand would create a larger demand/supply imbalance, thus putting additional upward pressure on prices, and would also result in larger stock drawdowns. This expected pattern of market behavior emulates that described in the EIA service report entitled "An Analysis of Heating Fuel Market Behavior, 1989-90", which provides an ex post analysis of a severe 1-month cold snap.

The following tables show the PMM's behavior under these scenarios and demonstrates the models concordance with intuition. The model predicts that both the demand and retail price of distillate will rise, beginning in the first month of the appearance of the cold snap.

PROPANE SCENARIOS: DEMAND
Impact of Alternative Scenario Assumptions
(Thousand Barrels per Day)

DATE	BASE CASE	COLD HEATING SEASON	COLD WINTER
Aug-93	855	855	854
Sep-93	945	945	945
Oct-93	1076	1102	1076
Nov-93	1098	1153	1098
Dec-93	1233	1310	1233
Jan-94	1353	1433	1510
Feb-94	1282	1339	1422
Mar-94	1106	1129	1185

PROPANE SCENARIOS: END-USER PRICE
Impact of Alternative Scenario Assumptions
(Cents per Gallon)

DATE	BASE CASE	COLD HEATING SEASON	COLD WINTER
Aug-93	63.7	63.7	63.7
Sep-93	63.2	63.2	63.2
Oct-93	62.3	62.4	62.3
Nov-93	66.5	66.7	66.5
Dec-93	73.5	74.7	73.5
Jan-94	75.2	77.9	75.9
Feb-94	74.7	78.7	80.4
Mar-94	71.0	75.6	77.5

PROPANE SCENARIOS: STOCK LEVEL
Impact of Alternative Scenario Assumptions
(Millions of Barrels)

DATE	BASE CASE	COLD HEATING SEASON	COLD WINTER
Aug-93	57.140	57.140	57.140
Sep-93	59.697	59.697	59.697
Oct-93	58.570	57.765	58.570
Nov-93	56.674	54.212	56.674
Dec-93	50.539	45.681	50.539
Jan-94	40.682	33.346	35.826
Feb-94	33.916	24.970	25.119
Mar-94	31.876	22.221	20.935

DOCUMENTATION OF TECHNICAL DETAIL ON MODEL DATA AND EQUATIONS

Validation of Input Data

Input variables which the PMM has in common with the STIFS were used with identical values.

Non-DOE Input Sources:

- Data Resources, Inc. (DRI) database, data from Bureau of Labor Statistics
 - Producer price index data
- U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Data Source DRD 964X
 - Actual and normal statewide monthly heating degree day values.

DOE Data Input Sources:

Forms and Publications:

- Energy Information Administration, Petroleum Supply Annual, DOE/EIA-0340 and Petroleum Supply Monthly, DOE/EIA-0109, various issues
 - Propane/propylene stocks and product supplied
- Energy Information Administration, Petroleum Marketing Annual, DOE/EIA-0487 and Petroleum Marketing Monthly, DOE/EIA-0380, various issues
 - Average imported crude oil refiner acquisition costs, propane (consumer-grade) refiner's price of sales to end users
- Energy Information Administration, Winter Fuels Report, DOE/EIA-0538, various issues
 - Residential propane prices.

Models and Other:

- Energy Information Administration, Short-Term Integrated Forecasting System
 - Forecasts of economic and refinery variables.

Validation, Goodness-of-Fit of Equations Providing Parameter Estimates

The next table details the parameter estimates and a number of statistics related to the goodness-of-fit of the equations estimated by the PMM.

REGRESSION RESULTS

Total U.S. Market

Dependent Variable is PRICE

SAMPLE RANGE: 1989.01 - 1993.05

Number of Observations: 53

Convergence achieved after 12 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT	Prob> T
C	35.105689	4.0744392	8.6161	0.0000
CRUDE	0.0505421	0.3870722	0.1306	0.8969
CRUDE(-1)	0.8342886	0.3890691	2.2728	0.0297
HDDSPSQ	0.0230637	0.0478658	0.4818	0.6331
HDDSPSQ(-1)	0.1566631	0.0565233	2.7717	0.0091
STOCKDIF(-1)	-3.668E-05	0.0001399	-0.2623	0.7947
STOCKDIF(-2)	-0.0002949	0.0001147	-2.5700	0.0149
JAN	13.992946	2.1322355	6.5626	0.0000
FEB	13.980733	1.9757258	7.0763	0.0000
MAR	11.007546	1.9002432	5.7927	0.0000
APR	6.1733109	1.8462860	3.3436	0.0021
MAY	1.9958117	1.7360921	1.1496	0.2586
JUN	-0.6788844	1.4855722	-0.4570	0.6507
AUG	2.6078367	1.5583210	1.6735	0.1037
SEP	3.1058165	1.9188319	1.6186	0.1151
OCT	2.9453507	2.0903998	1.4090	0.1682
NOV	6.4997304	2.1778258	2.9845	0.0053
DEC	12.127239	2.3635989	5.1308	0.0000
MA(2)	0.5654844	0.1388481	4.0727	0.0003
AR(1)	0.4776522	0.1166382	4.0952	0.0003
R-squared	0.92816	Mean of dependent var	58.2556	
Adjusted R-squared	0.88679	Sum of squared resid	211.908	
S.E. of regression	2.53406	F-statistic	22.4382	
Durbin-Watson stat	1.74061	Prob(F-statistic)	0.00000	

Dependent Variable is DEMAND
SAMPLE RANGE: 1989.01 - 1993.05
Number of Observations: 53

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT	Prob> T
C	812.96815	32.047652	25.3675	0.0000
STOCKDIF(-2)	0.0054174	0.0017907	3.0253	0.0045
HDD	30.784476	4.9323717	6.2413	0.0000
DONOV92	138.57655	75.648570	1.8318	0.0750
DODEC92	209.80561	75.528859	2.7778	0.0085
JAN	515.09537	45.920129	11.2172	0.0000
FEB	439.46719	43.103537	10.1956	0.0000
MAR	266.36025	42.874757	6.2125	0.0000
APR	68.205195	42.431812	1.6074	0.1165
MAY	-18.904094	42.475149	-0.4451	0.6589
JUN	-70.408909	44.722913	-1.5743	0.1239
AUG	57.971231	44.727338	1.2961	0.2030
SEP	135.02976	44.724093	3.0192	0.0046
OCT	253.28219	44.758127	5.6589	0.0000
NOV	268.33701	48.627089	5.5183	0.0000
DEC	401.59385	49.104785	8.1783	0.0000
R-squared		0.93019	Mean of dependent var	985.830
Adjusted R-squared		0.90189	Sum of squared resid	148008.
S.E. of regression		63.2473	F-statistic	32.8668
Durbin-Watson stat		1.87089	Prob(F-statistic)	0.00000

REGRESSION RESULTS

PAD District I

Dependent Variable is DEMAND1
 SAMPLE RANGE: 1989.01 - 1993.05
 Number of Observations: 53

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT	Prob> T
C	125.85009	5.6615382	22.2290	0.0000
HDD1	6.9747733	0.7138366	9.7708	0.0000
D0NOV92	8.5687056	13.083805	0.6549	0.5165
D0DEC92	38.097082	13.115489	2.9047	0.0061
JAN	135.55630	8.1683493	16.5953	0.0000
FEB	109.98476	7.7742387	14.1473	0.0000
MAR	57.990841	7.6066964	7.6237	0.0000
APR	2.8277032	7.6010201	0.3720	0.7119
MAY	-12.720721	7.5993039	-1.6739	0.1024
JUN	-16.189252	8.0066579	-2.0220	0.0503
AUG	14.155164	8.0066006	1.7679	0.0851
SEP	24.153045	8.0070639	3.0165	0.0045
OCT	46.651384	8.0074618	5.8260	0.0000
NOV	48.856692	8.6510148	5.6475	0.0000
DEC	97.982574	8.6633430	11.3100	0.0000
R-squared		0.95909	Mean of dependent var	166.309
Adjusted R-squared		0.94401	Sum of squared resid	4872.02
S.E. of regression		11.3230	F-statistic	63.6256
Durbin-Watson stat		1.80266	Prob(F-statistic)	0.00000

REGRESSION RESULTS

PAD District II

Dependent Variable is DEMAND2

SAMPLE RANGE: 1989.01 - 1993.04

Number of Observations: 52

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT	Prob> T
C	266.29286	42.023750	6.3367	0.0000
HDD2	9.2404841	1.5095011	6.1215	0.0000
PRICE2	-1.5127742	0.7302314	-2.0716	0.0455
D0NOV92	158.97165	34.935537	4.5504	0.0001
D0DEC92	133.84972	35.079771	3.8156	0.0005
JAN	300.42466	23.729096	12.6606	0.0000
FEB	243.16349	21.634953	11.2394	0.0000
MAR	140.60105	20.882076	6.7331	0.0000
APR	23.711039	20.598186	1.1511	0.2573
MAY	-9.8991194	20.905625	-0.4735	0.6387
JUN	-12.562579	20.869736	-0.6020	0.5510
AUG	50.068838	20.895836	2.3961	0.0219
SEP	88.179150	20.924472	4.2142	0.0002
OCT	178.65841	20.969536	8.5199	0.0000
NOV	154.97171	23.442471	6.6107	0.0000
DEC	228.61644	25.256732	9.0517	0.0000
R-squared	0.94643	Mean of dependent var		296.885
Adjusted R-squared	0.92411	Sum of squared resid		31335.2
S.E. of regression	29.5029	F-statistic		42.4014
Durbin-Watson stat	1.52868	Prob(F-statistic)		0.00000

Dependent Variable is PRICE2
SAMPLE RANGE: 1989.01 - 1993.04
Number of Observations: 51
Convergence achieved after 5 iterations

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT	Prob> T
C	44.693625	6.7456910	6.6255	0.0000
STKDIF2(-2)	-0.0002792	0.0002276	-1.2267	0.2286
HDDSPSQ2(-1)	0.1237428	0.0143155	8.6440	0.0000
CRUDE	1.2415074	0.2361146	5.2581	0.0000
PRICE2(-12)	-0.1376497	0.0686892	-2.0040	0.0533
JAN	16.462349	2.2834532	7.2094	0.0000
FEB	14.754723	1.9942275	7.3987	0.0000
MAR	10.097754	1.8480355	5.4640	0.0000
APR	8.0729644	1.6721608	4.8279	0.0000
MAY	2.6619221	1.4046996	1.8950	0.0669
JUN	-0.5510460	1.0439594	-0.5278	0.6011
AUG	-0.3606424	1.0970808	-0.3287	0.7444
SEP	-1.2874428	1.5511660	-0.8300	0.4125
OCT	-2.3011433	1.8292416	-1.2580	0.2172
NOV	2.7084960	1.9251698	1.4069	0.1688
DEC	9.8219131	1.9944100	4.9247	0.0000
AR(1)	0.9076276	0.0870725	10.4238	0.0000
MA(2)	-0.7576949	0.1302063	-5.8192	0.0000
R-squared		0.95927	Mean of dependent var	60.1629
Adjusted R-squared		0.93828	Sum of squared resid	140.727
S.E. of regression		2.06505	F-statistic	45.7156
Durbin-Watson stat		2.06118	Prob(F-statistic)	0.00000

BIBLIOGRAPHY

- M. Burdette, J. Cook, D. Hinton, & J. Zyren, "Midwest Propane Markets, 1992-1993: A Mid-Season Assessment," Winter Fuels Report, DOE/EIA-0538(92/93-18), February 1993, pp. xi-xvii.
- Energy Information Administration, Short-Term Integrated Forecasting System, 1993 Model Documentation Report, DOE/EIA-M041(93), 1993, Washington, DC.
- Energy Information Administration, An Analysis of Heating Fuel Market Behavior in 1989-90, Service Report, SR/OG/90-01, 1990, Washington, DC.
- P. Kennedy, A Guide To Econometrics, 2nd Edition, MIT Press, Cambridge, Massachusetts, 1985.

Model Abstract

Model Name: Propane Market Model

Model Acronym: PMM

Model Description: The PMM performs a short-term (6- to 9-month) forecast of demand and price in the residential U.S. propane market; the model also calculates the end-of-month stock level. The model can also be used to calculate the demand and end-of-month stock level in several PAD districts. The model is used to analyze certain market behavior assumptions or market shocks and to determine their effect on market price, demand, and stocks.

Last Model Update: October, 1993.

Part of Another Model: None.

Model Interfaces: None. The PMM uses inputs from STIFS, from which it obtains Economic and Refinery Data.

Sponsor:

- **Office:** Office of Oil and Gas
- **Division:** Petroleum Marketing Division
- **Branch:** Publications and Analysis, EI-432
- **Model Contact:** Charles Dale
- **Telephone:** (202) 586-1805.

Documentation: Energy Information Administration, Model Documentation of the Propane Market Model, DOE/EIA-M055, (Washington, DC, October, 1993).

Archive Media and Installation Guides: Archived on micro-floppy disks, with internal documentation. Available from sponsoring office. Archive packages describing the use of the model in published applications may be obtained from:

National Technical Information Service
5285 Port Royal Road

Purpose: The Propane Market Model was developed to provide support for the annual "Propane Outlook" article published in the Petroleum Marketing Monthly. The PMM assesses the market response to alternative market scenarios and/or shocks. The model uses the STIFS mid-world oil price case for values of economic and refinery behavior variables to assist in defining a base-line case and then uses assumptions on different possible market disturbances to assess their effects on a monthly basis. The PMM provides a framework to calculate stock levels from the estimated demand and price variables.

Energy System Described by Model: The residential propane demand, end-user prices, and end-of-month stock levels.

Coverage:

- **Geographic:** National, PAD districts 1 and 2
- **Time Unit/Frequency:** Monthly
- **Products:** Consumer-grade propane
- **Economic Sector:** Residential propane market.

Modeling Features:

- **Model Structure:** Multi-equation model
- **Modeling Technique:** Ordinary least squares, with correction for autocorrelation
- **Special Features:** None.

Non-DOE Input Sources:

- Data Resources, Inc. (DRI) database, data from the Bureau of Labor Statistics
 - Producer price index data
- U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Data Source DRD 964X
 - Actual and normal statewide monthly heating degree day values.

DOE Data Input Sources:

Forms and Publications:

- Energy Information Administration, Petroleum Supply Annual, DOE/EIA-0340 and Petroleum Supply Monthly, DOE/EIA-0109
 - Propane/propylene stocks and product supplied
- Energy Information Administration, Petroleum Marketing Annual, DOE/EIA-0487 and Petroleum Marketing Monthly, DOE/EIA-0380
 - Average imported crude oil refiner acquisition costs, refiner price of propane (consumer-grade) sales to end users
- Energy Information Administration, Winter Fuels Report, DOE/EIA-0538, various issues
 - Residential propane prices.

Models and Other:

- Energy Information Administration, Short-Term Integrated Forecasting System
 - Forecasts of economic and refinery variables.

General Output Descriptions: PMM is used to generate very short-term (up to 9 months), monthly forecasts of U.S. demand, price, and stock levels of residential (consumer-grade) propane. There is also provision for demand forecasts in certain PAD districts.

Computing Environment:

- **Hardware Used:** IBM-compatible personal computer
- **Operating System:** MS DOS
- **Software Used:** Micro-TSP, Version 7.01 or higher
- **Memory Requirements:** 640K
- **Storage Requirements:** 640K
- **Estimated Run Time:** 30 seconds calculation time on an 80386 PC operating under DOS 5
- **Special Features:** None

Independent Expert Reviews: None.

Status of Evaluations by Sponsor: On-going.

References

M. Burdette, J. Cook, D. Hinton, & J. Zyren, "Midwest Propane Markets, 1992-1993: A Mid-Season Assessment," Winter Fuels Report, DOE/EIA-0538(92/93-18), February 1993, pp. xi-xvii.

Energy Information Administration, Short-Term Integrated Forecasting System, 1993 Model Documentation Report, DOE/EIA-M041(93), 1993, Washington, DC.

Energy Information Administration, An Analysis of Heating Fuel Market Behavior in 1989-90, Service Report, SR/OG/90-01, 1990, Washington, DC.

P. Kennedy, A Guide To Econometrics, 2nd Edition, MIT Press, Cambridge, Massachusetts, 1985.

Model Cross Reference

Total U.S. Market

<u>Equations</u> <u>(Pages 6-8)</u>	<u>Location in Code</u> <u>(Line Numbers)</u>
DEMAND	1-3
PRICE	7-11
DELSTOCK	4
STOCK	5
STOCKDIF	6
RETPRICE	12
RESPRICE	13

<u>Variable Name</u>	<u>Name in Code</u>	<u>Location in Code</u>
PRICE	PRICE	7, 12
CRUDE	CRUDE	7
DEMAND	DEMAND	1, 4
HDD	HDD	1
HDDSPSQ	HDDSPSQ	7, 8
PPI	PPI	12
DUMMY	JAN, FEB, etc.	2-3, 8-10
DONOV92	DONOV92	1
DODEC92	DODEC92	2
DELSTOCK	DELSTOCK	4, 5
STOCK	STOCK	5, 6
PRIM_SUP	PRIM_SUP	4
DAYS	DAYS	4
STOCKDIF	STOCKDIF	1, 6, 8

Model Cross Reference

Total U.S. Market

(continued)

<u>Variable Name</u>	<u>Name in Code</u>	<u>Location in Code</u>
STOCKAVG	STOCKAVG	6
RESPRICE	RESPRICE	13
γ	GAMMA	13
RETPRICE	RETPRICE	12, 13

Model Cross Reference

PAD District I

<u>Equations</u> <u>(Pages 11-12)</u>	<u>Location in Code</u> <u>(Line Numbers)</u>
DEMAND1	1-3
DELSTK1	4
STOCK1	5

<u>Variable Name</u>	<u>Name in Code</u>	<u>Location in Code</u>
DEMAND1	DEMAND1	1, 4
HDD1	HDD1	1
DUMMY	JAN, FEB, etc.	1-3
D0NOV92	D0NOV92	1
D0DEC92	D0DEC92	2
DELSTK1	DELSTK1	4, 5
STOCK1	STOCK1	5
PRIMSUP1	PRIMSUP1	4
DAYS	DAYS	4

Model Cross Reference

PAD District II

Equations (Pages 11-12)

Location in Code (Line Numbers)

DEMAND2	1-4
PRICE2	5-7
DELSTK2	8
STOCK2	9
STKDIF2	10

Variable Name

Name in Code

Location in Code

PRICE2	PRICE2	1, 2, 5
CRUDE	CRUDE	1
DEMAND2	DEMAND2	5, 8
HDD2	HDD2	5
HDDSPSQ2	HDDSPSQ2	1
DUMMY	JAN, FEB, etc.	2-4, 6-7
D0NOV92	D0NOV92	5
D0DEC92	D0DEC9	5
DELSTK2	DELSTK2	8, 9
STOCK2	STOCK2	9, 10
PRIMSUP2	PRIMSUP2	8
DAYS	DAYS	8
STOCKDIF	STOCKDIF	1, 10
STKAVG2	STKAVG2	10

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