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An Analysis of U.S. Propane Markets Winter 1996-97

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Executive Summary

In late summer 1996, in response to relatively low inventory levels and tight world oil markets, prices for crude oil, natural gas, and products derived from both began to increase rapidly ahead of the winter heating season. Various government and private sector forecasts indicated the potential for supply shortfalls and sharp price increases, especially in the event of unusually severe winter weather. Following a rapid runup in gasoline prices in the spring of 1996, public concerns were mounting about a possibly similar situation in heating fuels, with potentially more serious consequences.

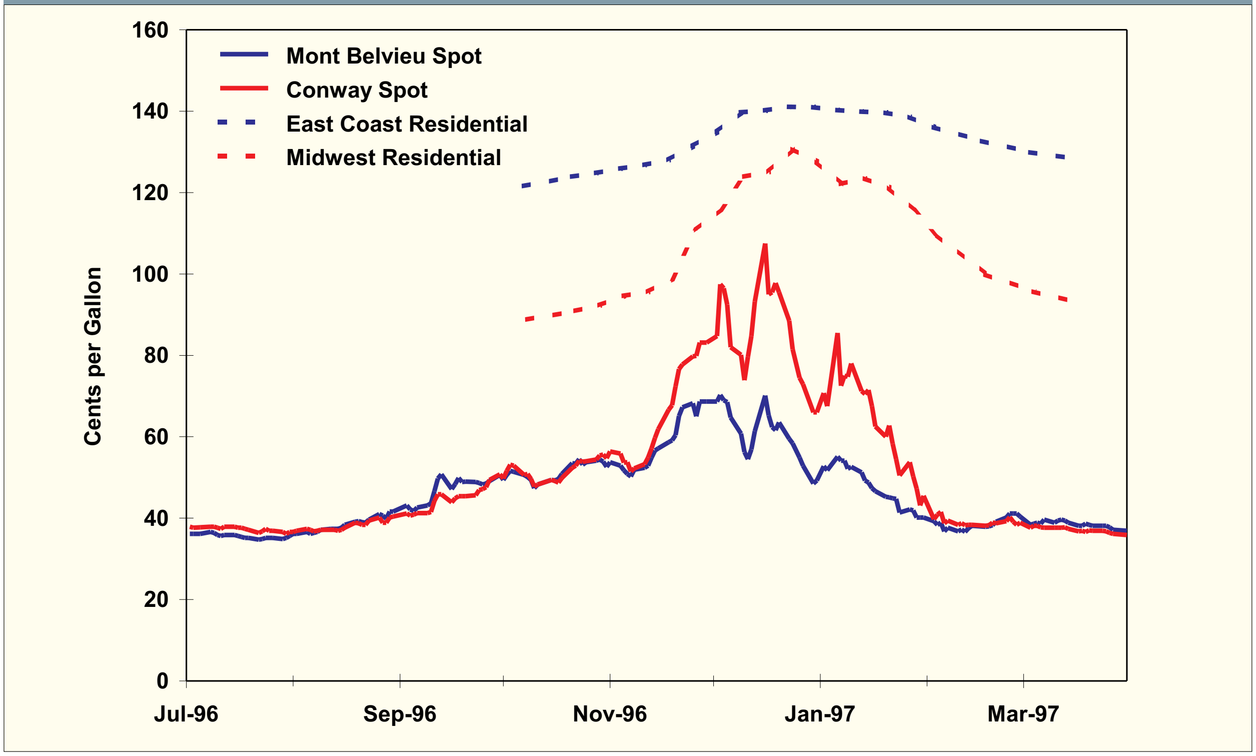
In response to these concerns, the Energy Information Administration (EIA) participated in numerous briefings and meetings with Executive Branch officials, Congressional committee members and staff, State Energy Offices, and consumers. EIA instituted a coordinated series of actions to closely monitor the situation and inform the public. This study constitutes one of those actions: an examination of propane supply, demand, and price developments and trends.

EIA's approach focused on identifying the underlying reasons for the tight supply/demand balance in the fall of 1996, and on examining the potential for a recurrence of these events next winter. Because of the relative lack of public knowledge regarding propane supply, demand, and markets, it was decided that a comprehensive review of background material should be presented along with the study to enhance understanding of the relevant causes and consequences examined. Chapters 2, 3, and 4 of this report comprise an explanation of the fundamentals of propane supply, demand, and markets, largely for those readers not overly familiar with the industry.

Propane has become an increasingly significant element in U.S. and world energy markets in recent years. It has long proven its versatility as a fuel for space heating and other residential uses, for industrial and agricultural applications, and for internal combustion engines. The single largest demand sector for propane is as a feedstock for petrochemical manufacturing.

The fall 1996 period was the fourth time in the past decade in which propane prices rose rapidly over a very short period of time. Spot propane prices at Mont Belvieu, Texas, and Conway, Kansas, the major propane storage and distribution centers in the United States, rose together from about 36 cents per gallon at the beginning of August to 50 cents by the end of September, the traditional beginning of the heating season (Figure E.1). Propane prices stood at the highest pre-season levels since 1990. They continued to rise through October, and in November, Conway prices soared, peaking at 107.5 cents per gallon on December 16. Mont Belvieu prices stayed high, but did not follow Conway's rapid ascent, peaking at 70.3 cents on December 3. Both Conway and Mont Belvieu prices fell in mid-December, with Conway falling faster and reaching parity with Mont Belvieu by mid-February. Retail prices downstream from Conway and Mont Belvieu lagged behind changes in spot markets with significant regional differences, but all propane prices returned to more seasonal levels by March.

Figure E.1 Spot and Residential Propane Prices



Sources: Spot - Standard and Poor's Platt's; Residential - Energy Information Administration.

EIA's analysis concluded that winter 1996-97 propane market behavior can be explained by a combination of fundamental market factors, as follows:

- **The propane price increase from August through early November appeared to be due to price increases in crude oil, low stocks at the beginning of the heating season, and diminished prospects for late stock recovery, mainly as a result of strong demand in the Midwest.**
  - Since crude oil is a major propane feedstock, propane prices generally follow significant crude price movements. Crude oil prices increased over $5 per barrel from late July to mid-October, with propane keeping pace.
  - Propane prices are also sensitive to early-winter stock levels, because stocks are an important supply source during the peak heating season. U.S. propane stocks normally supply about 20 percent of demand during the high-demand months of December, January and February, compared to distillate stocks, which supply about 12 percent of demand during these same months. Nationally, propane inventories at the end of September were at their third lowest level for the start of the winter heating season. Most of the shortfall was on the Gulf Coast, and was the result of a slightly below-average summer stock build and a low starting level at the

end of winter 1995-96. Cold weather and late crop-drying needs boosted demand in the Midwest (PADD 2) in October, dashing any hopes of a late stock recovery.

– Domestic propane supply is relatively inflexible, compared to other heating fuels, because propane is produced as a by-product of both petroleum refining and natural gas processing. Increased import/export flows can require weeks to meet resupply needs, and may only come at high prices, based on world market conditions.

– Demand is also relatively inflexible. Residential/commercial and agricultural demands are largely determined by weather, and little fuel-switching capability exists. The petrochemical sector, however, generally acts to moderate market stress. Financial incentives stimulate this sector to reduce propane use when propane prices rise relative to other petrochemical feedstock prices. From August through December 1996, petrochemical use of propane dropped by over 130 thousand barrels per day in response to price increases.

- **Continued high crude oil prices supported both Mont Belvieu and Conway prices through the remainder of the winter. However, Conway prices rose much more rapidly than those at Mont Belvieu, due to colder-than-normal weather in the Midwest through December, following extraordinarily strong Midwest demand in October and November that depleted Midwest stocks prior to the peak demand months.**

– Crude oil prices remained high through December, providing no relief to propane prices. Crude prices alone probably would have kept propane prices through December higher than those of the previous year, but other factors caused propane prices to rise well above the crude oil influence.

– The Midwest started the heating season with stocks only slightly lower than normal, but high demand in October and extraordinarily high demand in November from crop drying and unusually cold weather drew PADD 2 stocks down to 22 percent below their 5-year average by the end of November. A similar situation, though with some differences in timing, occurred in late 1992 and early 1993. In the Midwest, stocks supply about 25 percent of demand during the months of December through February, and the upper Midwest is relatively isolated from Mont Belvieu supplies. End-of-November stock levels in the Midwest were not high enough to sustain even normal stock draws during the next three months without dipping below minimum working stock levels.

– With forecasts for very cold weather to continue, and the inherent inflexibility of the supply system to provide additional stocks quickly, marketers rushed to obtain available supplies, bidding up Conway prices well above Mont Belvieu in November and December. The price difference rose high enough to attract some rail and truck transportation from Mont Belvieu. Mont Belvieu prices were pulled higher in response to Conway, despite the fact that areas served by Mont Belvieu had experienced a mild December, which allowed Mont Belvieu stocks to recover toward normal levels.

– Finally, in December, as temperatures in the Midwest returned to more seasonal levels, and those in the rest of the country were warmer than normal, prices began to fall. By January, even though major areas in the Midwest were still colder than normal, the mild weather in areas outside the Midwest, coupled with falling crude oil prices, caused both Mont Belvieu and Conway prices to tumble rapidly back to more normal levels.

This examination of propane supply, demand, and market conditions during the winter 1996-97 contains implications for future heating seasons. Without significant and unexpected improvements in industry infrastructure (e.g., increasing pipeline capacity between major storage hubs or secondary storage capacity), U.S. propane markets, particularly in PADD 2, will likely continue for the foreseeable future to be susceptible to the type of regional supply squeeze that was seen during the past winter. Propane demand is expected to continue to grow at a slow but steady pace, while domestic propane production is limited by refinery capacity and natural gas production. Infrastructure improvements are very expensive, particularly for gas liquids, which must be stored in pressurized tankage. Finally, options available to consumers are limited, as home storage tanks are most often owned and controlled by suppliers.

The outlook for propane supply and prices during the 1997-98 heating season, based on limited indicators available at this time, appears to be significantly more favorable for consumers than that of the past winter. Several factors drive this assessment:

- **World crude oil price levels, underlying all petroleum product markets, are widely expected to be significantly lower in the fall of 1997 than in 1996.** While average fourth quarter 1996 world crude oil prices were more than $6 per barrel above those the previous year, EIA forecasts fall 1997 prices to reflect a decline of more than $3.50 per barrel from 1996. A building surplus in world crude oil supplies, as rising production outstrips demand, has resulted in a drop of over $6 per barrel since the beginning of the year, with prices expected to stabilize somewhat over the remainder of 1997.
- **Assuming the return of both heating demand and the size of the corn crop to average levels, fall propane demand in PADD 2 should be well below the record levels seen in 1996; however, PADD 2's demand declines could be tempered by demand increases in PADDs 1 and 3, which experienced warmer-than-normal temperatures this past winter.** PADD 2 demand in October and November 1996 was 23 percent greater than the 5-year average, fueling the strong stock draw that pushed regional prices to historical highs. A presumed return to normal seasonal demand levels would remove a major potential source of regional price pressure. In spite of PADD 2's colder-than-average weather, the U.S. in total experienced a warmer-than-normal winter. Normal weather next winter could result in higher total propane demand than that seen in winter 1996/97, which would keep U.S. average prices from declining as much as the other factors discussed on this page might imply.
- **The significantly higher season-ending propane stock levels in March 1997, compared to the previous spring, should allow for higher beginning stocks this fall than in 1996.** Despite a relatively normal 1996 off-season stockbuild, the low spring stocks carried over to similarly diminished starting inventories for winter 1996/97. Propane stocks ended this winter about 4.4 million barrels higher than the previous year overall, including a 3.3-million-barrel surplus in PADD 2 alone. Assuming a typical summer build, propane inventories could enter the 1997-98 heating season above the 5-year average level both nationally and in the vulnerable PADD 2 region. Thus, even though a return to normal temperatures nationwide may mean higher demand in PADDs 1 and 3 next winter than winter 1996/97, stocks in all areas are likely to be at or above normal levels, and thus able to serve the higher demand adequately.
- **High levels of refinery inputs expected through this spring and summer, in order to meet gasoline demand, will also result in higher domestic propane production.** If refinery runs reach expected levels, as much as 6 thousand barrels per day of additional propane will be produced, further facilitating the summer stockbuild.

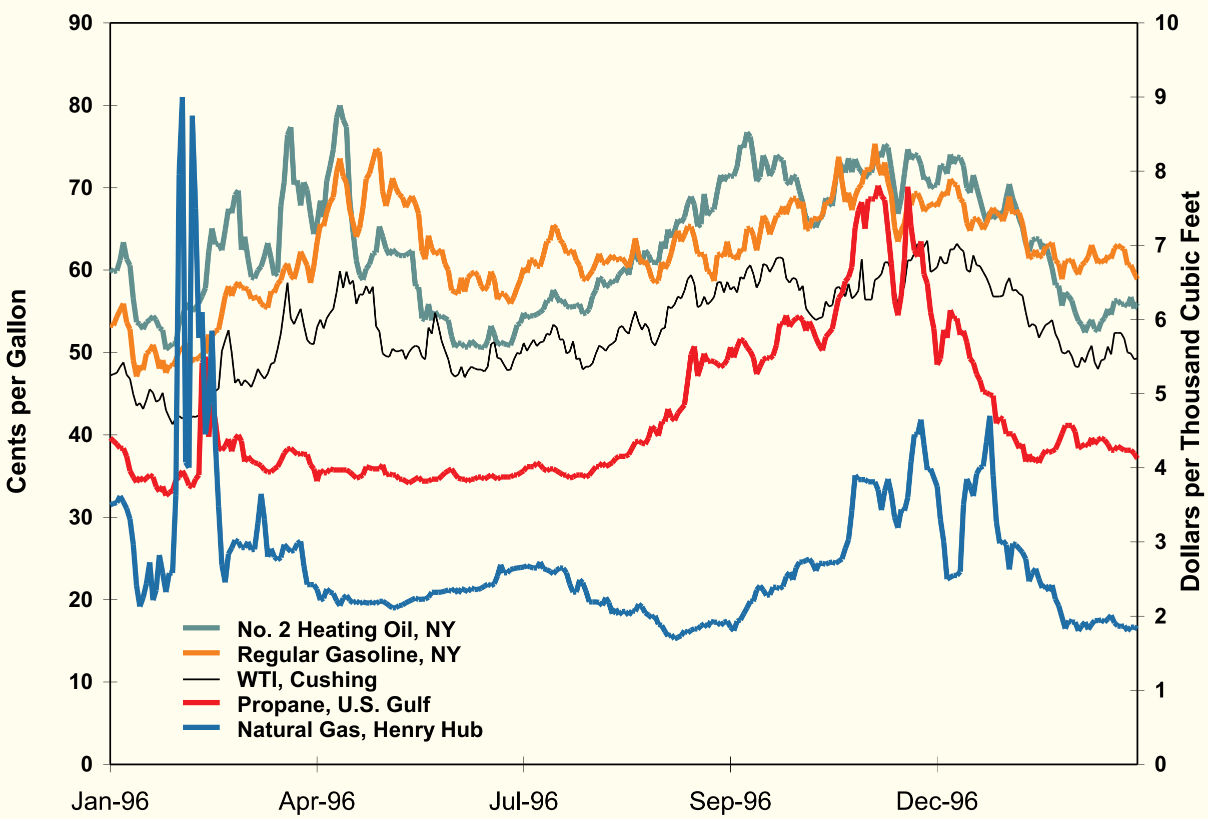
In short, with pre-season stocks expected to be above average relative to recent history, and Midwest demand not likely to repeat last winter's early surge, propane markets may be well-supplied during the peak portion of next winter's heating season.

1. Introduction

In the fall of 1996, prices for crude oil, natural gas, and most petroleum products began to rise rapidly in advance of the winter heating season (Figure 1.1). Inventories for all heating fuels were low, in relation to both the previous year and recent-year averages. Outlooks from the Energy Information Administration (EIA) and other sources indicated the potential for supply shortfalls and sharp price increases, especially in the event of unusually severe winter weather. U.S. consumers had already experienced a rapid runup in gasoline prices in the spring of 1996, and public concerns were mounting about a possibly similar situation in heating fuels, with potentially more serious consequences.

In response to these concerns, the Energy Information Administration (EIA) participated in numerous briefings and meetings with Executive Branch officials, Congressional committee members and staff, State Energy Offices, and consumers. EIA instituted a coordinated series of

Figure 1.1 Crude Oil, Natural Gas, and Petroleum Product Prices, 1996-97



Source: Reuters.

What is Propane?

Propane, also known as “bottled gas” or “LP-gas” (liquefied petroleum gas) is a colorless paraffinic hydrocarbon with a chemical formula of C_3H_8 and a molecular weight of 44.094. Although propane is nontoxic and odorless, a foul-smelling sulfur-containing compound known as ethyl mercaptan is added to propane so that leaks can be easily detected. At normal atmospheric pressure and temperatures propane is a gas. However, under moderately higher pressure and/or lower temperature it becomes a liquid, which vaporizes to a clean-burning gas when released from its storage container. The vapor pressure of propane at 70° F is 127 psig. Total heating values of propane are 91,502 BTU per liquid gallon, and 2,488 BTU per cubic foot after vaporization.[1] This compares with 1,027 BTU per cubic foot of natural gas.[2] Because propane is 270 times more compact as a liquid than as a gas, it is transported and stored in its liquid state.

The LP-gas industry began sometime after the development of natural gas and shortly before the First World War. At that time, there was an operating problem in the natural gas distribution process. Part of the gathering line from natural gas fields ran under a cold stream, and the cold water caused the heavier hydrocarbons in the natural gas to condense, thus blocking the natural gas line. As a result of this discovery, experimental facilities were built to cool natural gas after it was compressed, in order to separate the liquefiable hydrocarbons (including propane and butane).

During the period between 1910 and 1920, LP-gas applications were under development. The first residential cooking installation was made in 1912, and the first propane-powered automobile was developed in 1913. By 1920, propane was marketed for flame cutting and cooking applications. By 1927, total sales of propane had surpassed one million gallons per year.

Technical innovations in organic chemistry during the 1920's led to the development of ethylene, one of the building blocks of the petrochemical industry and a major new application for propane. The petrochemical industry boomed, and by 1947, about 20 percent of the propane consumed was being used as petrochemical feedstock.

During the 1950's and 1960's, the LP-gas industry expanded the infrastructure to include several interstate pipelines, construction of large underground storage facilities, and a fleet of pressurized jumbo rail tank cars. These measures enabled the LP-gas industry to reach new markets in the Northeast and upper Midwest regions. Even today, most propane consumption lies in regions served by the major pipeline systems. By the 1970's, the LP-gas industry had reached maturity, with slow to moderate growth rates that are still present today.

1 National Propane Gas Association, *Facts About Propane*, Lisle, Illinois.

2 Energy Information Administration, *Monthly Energy Review, January 1997*, DOE/EIA-0035(97/01), Table A4, p.147.

actions to closely monitor the situation and inform the public. This study constitutes one of those actions: an examination of propane supply, demand, and price developments and trends.

Propane is in some ways unique among the major petroleum products produced and consumed in the United States (see box). Because propane is produced as a by-product of both petroleum refining and natural gas processing, its availability and prices are affected by the operations of both of those industries, but its volume is too small to significantly affect refinery or gas plant operating rates. Additionally, although it is used as a heating or motor fuel in a wide variety of applications, the single largest use of propane is for petrochemical feedstocks, which are subject to a very different set of economic conditions than those for competing fuels. Finally, the regional nature of propane production and demand, and the limited size of available distribution infrastructure, place difficult constraints on propane supply during periods of high consumption.

Because of the unusual characteristics of propane, in comparison to more widely discussed and analyzed fuels such as gasoline, distillates, and natural gas, this report was developed in two major parts. The first part, including Chapters 2, 3, and 4, comprises an explanation of the fundamentals of propane demand, supply, and markets, largely for those readers not overly familiar with the industry. The second part, including Chapters 5 and 6, presents an examination of the particular propane supply and market conditions that evolved this past winter, and a look at the implications for the future.

Chapter 2, *Propane Demand*, explains the primary uses and demand sectors for propane in the United States, with particular attention to petrochemical feedstocks and residential consumption. Seasonal variation and regional distribution characteristics of propane demand are described.

Chapter 3, *Propane Supply and Logistics*, describes propane production, imports, and distribution in the United States. Domestic production from refining and natural gas processing is described. Propane distribution by pipeline is examined, along with storage in both producing and consuming areas. The need for imports, their source, and typical seasonal patterns are explained.

Chapter 4, *Propane Markets*, outlines the major factors that influence propane prices, including the supply/demand balance, weather, inventory levels, and crude oil prices, among others. The various market levels at which propane is sold are delineated, from spot and futures markets down to retail sales. The phenomenon of price spikes in propane markets is also discussed.

Chapter 5, *Propane Supply, Demand, and Prices in the 1996-97 Heating Season*, explores the events of the past fall and winter with regard to propane prices and supply adequacy. The various factors that drove the major market trends during the heating season are examined. Actions undertaken by Federal and State government agencies to prevent or alleviate consumer hardships are listed.

Chapter 6, *Conclusion and Outlook*, presents the overall findings of this report, and the implications seen for U.S. propane markets in future years.

Appendices A and B provide further details on the production capacity and feedstock mix of U.S. ethylene plants, and the analysis performed to investigate the speed of price movement from spot to residential propane markets.

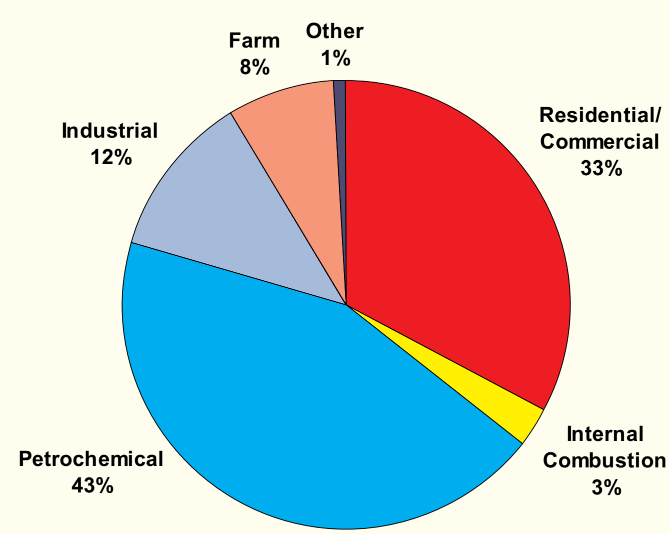
2. Propane Demand

Propane demand in the United States comes from several different sectors, including residential/commercial, petrochemical, industrial, and agricultural (Figure 2.1). Other applications, which account for the remainder of propane demand, include use as a fuel in internal combustion engines (generators, pumps, and fork lifts) and in gas utility peak-shaving operations.[1] Each of the major consuming sectors exhibits a distinct pattern in response to seasonal and other influences. These consumption patterns generally follow cycles that are counterbalancing, limiting the maximum aggregate demand at any one time.

Because of the influence of the highly weather-dependent residential sector, total propane demand generally mirrors the same seasonal patterns as the residential sector, rising during the winter months but falling during the spring and summer. Limited offsetting variations in petrochemical demand for propane, which tends to decline when heating demand is the greatest, have relatively little impact on this seasonal pattern. While total demand for propane averaged about 1.1 million barrels per day during 1996 (3.6 percent higher than in 1995), monthly levels varied significantly, from a seasonal low of 0.8 million barrels per day during June to a seasonal high of nearly 1.5 million barrels per day during January.

The largest demand sectors, with the exception of industrial use, tend to be centered in specific regions. Petrochemical feedstock demand for propane is concentrated in the Gulf Coast (PADD 3), comprising most of the demand in that region. Agricultural demand is centered in the Midwest (PADD 2), while residential

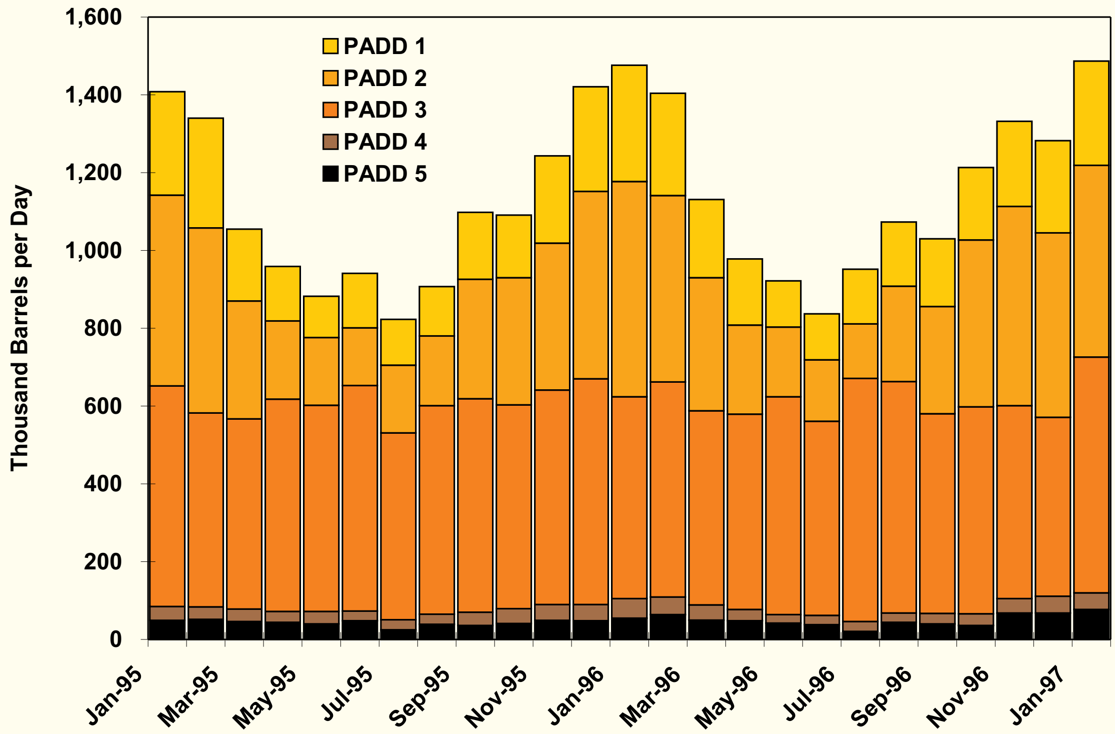
Figure 2.1 Propane Demand by Sector, 1995



Source: American Petroleum Institute, *1995 Sales of Natural Gas Liquids and Liquefied Refinery Gases*.

1 American Petroleum Institute, *1995 Sales of Natural Gas Liquids and Liquefied Refinery Gases,* Table 4, pp. 6 & 7.

Figure 2.2 U.S. Propane Demand by Region, 1995-97



Source: Energy Information Administration, *Petroleum Supply Monthly*, various issues.

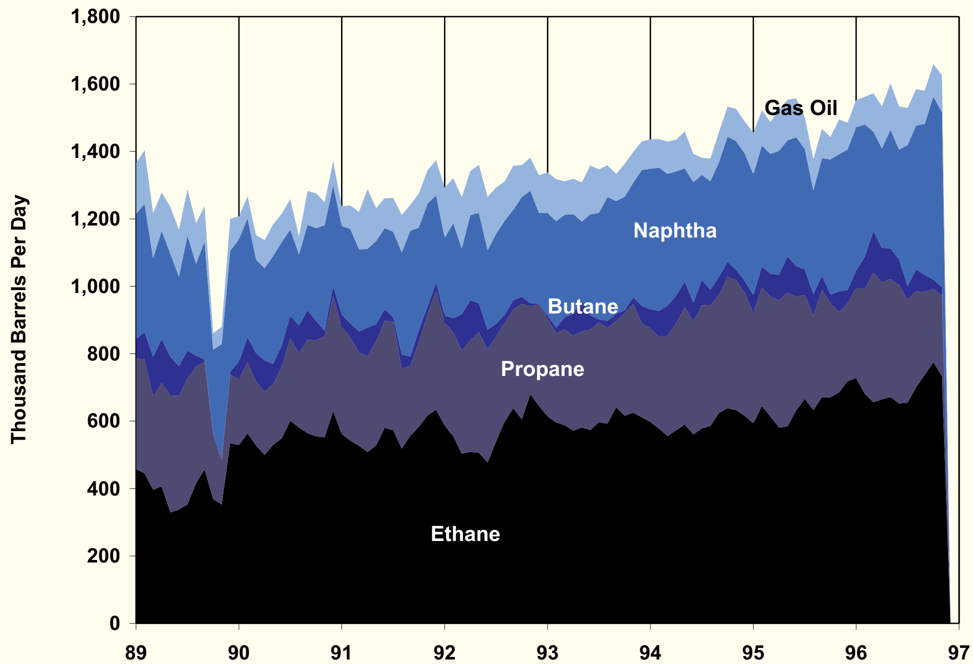
and commercial consumption, largely for space heating, is most prevalent in the Northeast and upper Midwest (parts of PADDs 1 and 2). Because of this geographical concentration of sector demand, a regional breakout of propane demand trends (Figure 2.2) shows that most of the seasonal variation occurs in PADDs 1 and 2.

Petrochemical Industry Is the Largest Demand Sector

Overview

About 43 percent of U.S. propane supply is used in the petrochemical industry. Most of this propane is used as feedstock for olefin plants, which produce the building block chemicals (ethylene, propylene, butylene, butadiene and benzene) from which most other petrochemicals derive. Ethylene is the largest volume building block produced, and so olefin plants are frequently called ethylene plants. Ethylene is a simple molecule, and there are many hydrocarbon feedstocks that can be cracked (broken apart) to create ethylene. The major feedstocks used in these olefin plants are ethane, propane, butane, naphtha and gas oil (Figure 2.3). To understand how much propane these plants use, the factors driving the tradeoffs among the feedstocks need to be explored.

Figure 2.3 U.S. Ethylene Plant Feedstocks, 1989-97



Source: Pace Consultants, Inc., *Hodson Report*, Houston, TX.

Most ethylene plants cannot handle the full range of feedstocks. Some use only the lighter ethane and propane feedstocks, while others use the heavier naphtha and gas oil. However, the plants that can run both lighter and heavier feedstocks still represent a fairly sizable volume, as shown in Appendix A.

The ability to produce ethylene from a variety of different feedstocks makes the economics of feedstocks an important consideration in ethylene plant operations. Thus, the demand for propane as an ethylene feedstock will depend on its economics relative to other feedstocks. The problem involves analyzing feedstock cost, processing cost, multiple product yields and multiple product prices. The market prices for the feedstocks are functions of their values to the petrochemical industry as well as their values for competing uses. For example, propane sometimes demands a high price during the winter in the residential/commercial heating fuels market, diminishing its attractiveness as a chemical feedstock relative to the other feedstocks.

Ethylene Plant Feedstock Demand

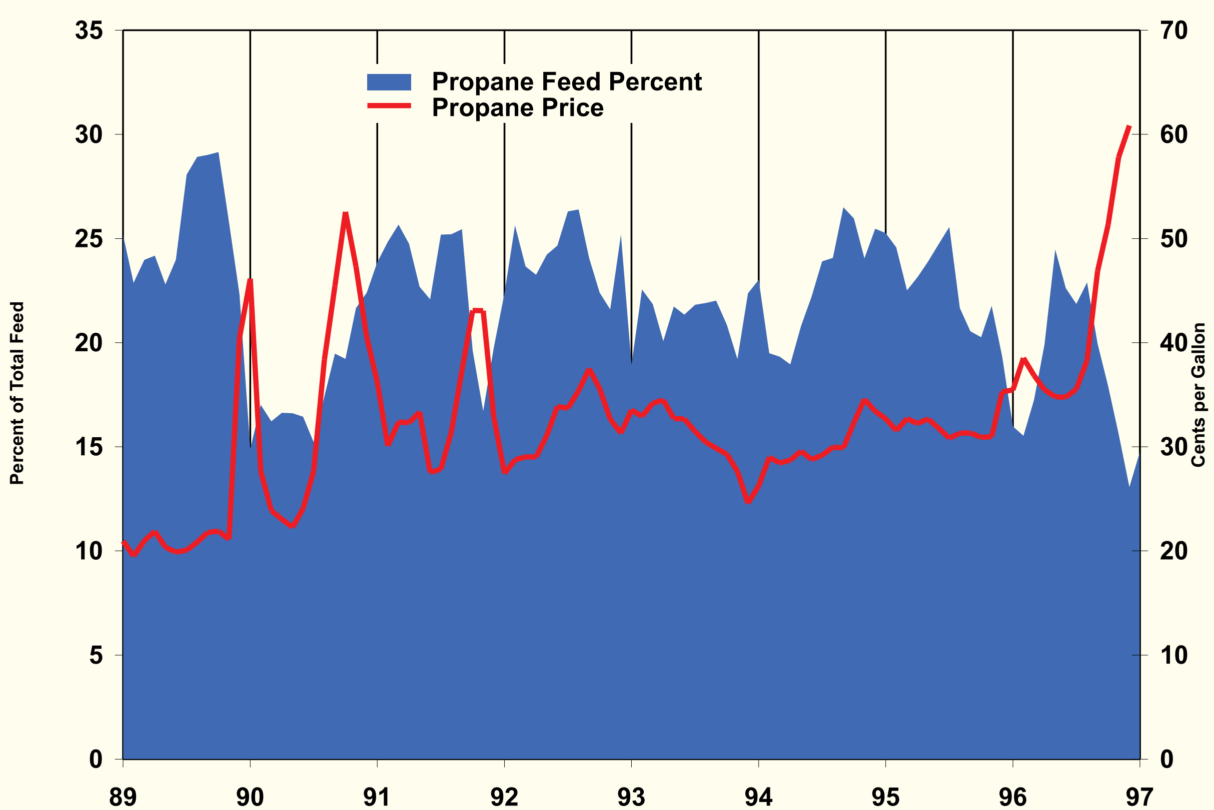
Each feedstock produces a different yield of products (Table 2.1). Ethane represented about 42 percent of total olefin plant feedstock in 1995 and produces the highest percentage of ethylene. Propane represented 23 percent of feedstock in 1995 and produces the next highest ethylene yield, while also producing propylene. Butane has slightly smaller yields of ethylene than propane, but only represented about 4 percent of total feedstock volume in 1995. The more complex

Table 2.1 Olefin Plant Feedstock Yields (Pounds Per Pound of Feed)

	Feedstocks				
Outputs	Ethane	Propane	Butane	Naphtha	Gas Oil
Ethylene	0.80	0.40	0.36	0.23	0.18
Propylene	0.03	0.18	0.20	0.13	0.14
Butylene	0.02	0.02	0.05	0.15	0.06
Butadiene	0.01	0.01	0.03	0.04	0.04
Fuel Gas	0.13	0.38	0.31	0.26	0.18
Gasoline	0.01	0.01	0.05	0.18	0.18
Gas Oil	-	-	-	0.01	0.12
Pitch	-	-	-	-	0.10

Source: Burdick, Donald L. and William L. Leffler, Petrochemicals in Nontechnical Language, Pennwell Publishing Company, Tulsa, Oklahoma, 1990, p. 59.

Figure 2.4 U.S. Propane Price and Share of Ethylene Plant Feedstocks, 1989-97



Source: Feed percent - Pace Consultants, Inc., *Hodson Report*, Houston, TX; Price - Standard and Poor's Platt's.

Table 2.2 Quarterly Ethylene Plant Feedstock Use (Thousand Barrels per Day)						
Quarter	Ethane	Propane	N-Butane	Naphtha	Gas Oil	Total
Q1-94	611	293	43	387	88	1,422
Q2-94	569	296	83	394	92	1,434
Q3-94	576	350	68	335	82	1,411
Q4-94	616	366	48	344	82	1,456
Q1-95	614	360	39	372	105	1,490
Q2-95	613	361	69	361	107	1,511
Q3-95	628	348	91	361	110	1,537
Q4-95	658	292	44	352	82	1,428
Q1-96	710	246	50	417	88	1,511
Q2-96	667	348	107	327	107	1,556
Q3-96	660	335	69	365	125	1,555
Q4-96	738	249	48	472	101	1,608

Source: Pace Consultants, Inc., *Hodson Report*, Monthly Steam Cracker Feedstocks, Houston,TX

hydrocarbons of crude oil-based naphtha and gas oils[2] produce the lowest yields of ethylene, but also produce more by-products than propane and ethane. Plants using ethane and propane as feedstocks were preferred through the 1960's, but in the 1970's concerns over price and availability of natural gas and the potential competing needs for propane caused the industry to design and build plants that crack the heavier feedstocks of naphtha and gas oils. In 1995, naphtha and gas oil represented about 31 percent of olefin plant feedstocks.

Ethane is the predominant feedstock used to create ethylene. As ethylene production has increased, ethane feedstock volumes have also increased. Over the past five years, ethane has averaged 43.3 percent of ethylene plant input. In recent winters, such as 1995/96 and 1996/97, when propane prices increased, propane input declined and ethane input increased, partially to compensate for the drop in propane (Table 2.2). The petrochemical industry is the primary market for ethane, which is otherwise left in the natural gas stream and burned as a fuel when the price drops too low to make extraction and delivery to petrochemical facilities economic.

2 Naphthas can contain hydrocarbons in the C_5 to C_{10} range, while gas oils might have hydrocarbons varying from around C_{10} to C_{40}.

Other Ethylene Feedstocks: Butane, Naphtha and Gas Oils

Butane, like propane, is extracted from natural gas and is produced in refineries as crude oil is made into petroleum products. However, much of the butane produced from refineries cannot be used as ethylene feedstock because of fluoride contamination. Butane is used in other markets besides the petrochemical feedstock market. It is a primary input to make methyl tertiary butyl ether (MTBE), and it is blended directly into gasoline to boost octane levels. However, butane's high volatility limits its direct use in gasoline during the summer. As a petrochemical feedstock, butane has been exhibiting a strong seasonal pattern, representing about 5-6 percent of ethylene feedstock in the summer, and falling off to 2-3 percent in winter months, when it is blended into gasoline.

Naphthas and gas oils derive from crude oil. The primary use for naphthas is in gasoline, and gas oils are used in home heating fuel or diesel fuel. The share of olefin plant feedstocks that naphtha and gas oil represented drifted down from about 40 percent of inputs in 1986 to about 30 percent in 1991. They hovered around 30 percent until 1996. As propane prices climbed at the end of the year, the naphtha and gas oil share of feedstocks rose to over 35 percent again.

The volume of propane used as a petrochemical feedstock varies based on relative prices (Figure 2.4) and margins. Propane prices are most likely to rise during the fall and winter when crop drying and residential demand increase. During colder winters when propane prices increase, petrochemical volumes decline, but in warmer winters, when propane prices stay weak, the volume may remain high.

There are limits to swings in feedstock mix that olefin plants can handle given equipment and process constraints. The maximum use of propane seen since 1986 was 395 thousand barrels per day during July 1995. The minimum use was in January 1990. From November 1989 to January 1990, propane feed to ethylene plants dropped from 319 thousand barrels per day to 131 thousand barrels per day as prices soared due to supply problems during an early winter cold snap. In this case, ethylene plants reduced runs. From August 1996 to December 1996, when prices increased, propane feed to ethylene crackers dropped from 350 thousand barrels per day to 217 thousand barrels per day, but overall feedstock throughput hardly fell. Ethane and naphtha inputs were increased, offsetting the drop in propane. This suggests that at current capacities, petrochemical operators can function at a minimum propane input level near 200 thousand barrels per day, without dropping total feedstock input significantly. Thus, petrochemical demand even during a cold winter could be 200 thousand barrels per day.

Residential/Commercial Demand Is Highly Seasonal

Propane ranks as the fourth most important source of residential energy in the Nation, with nearly 5 percent of all households using propane as their primary heating fuel.[3] Of the 96.6 million households in the U.S., 8.1 million households depend on propane for one use or another. Nationwide, 4.6 million households, or about 57 percent of the households that use propane, rely on propane for their primary heating fuel. Moreover, about a third of all propane users rely on propane for water heating, while slightly more than half of propane users rely on propane for cooking. Propane is most commonly used to provide energy to areas not serviced by natural gas distribution systems. With 20.8 million (22 percent) of all households located in rural areas, the importance of propane as an energy source in rural America is most evident[4] (Table 2.3).

Commercial establishments such as hotels, motels and restaurants use propane in the same way a homeowner does: for heating and cooling air, heating water, cooking, refrigeration, drying clothes, barbecuing and lighting.

Of the 96.6 million households in the U.S., 66.8 million households (69 percent) reside in single-family homes, 24.2 million households (25 percent) reside in multifamily dwellings, while the remaining 5.6 million households (6 percent) reside in mobile homes (Table 2.4). While only 5 percent of all single-family homes are heated by propane, over 21 percent of all mobile homes are heated by propane. Very few multifamily dwellings use propane as their main heating source.[5] Although propane commands only a minor share of the overall heating fuels market, its largest share as a heating fuel resides within the mobile home sector.

Many propane-using households fall into low income levels, and find it difficult to absorb price increases such as those seen in 1996. At the National level, 25 percent of single-family households were eligible for the Low-Income Home Energy Assistance Program (LIHEAP).[6] Within the multifamily sector, 48 percent of the households were eligible for the program, while 40 percent of the households that reside in mobile homes were eligible for heating fuel assistance.[7] However, compared by type of housing unit by type of fuel, the highest concentration of heating fuel assistance went to households residing in mobile homes that use propane as their primary heating

3 Energy Information Administration, Residential Energy Consumption Survey (RECS) database.

4 Energy Information Administration, Residential Energy Consumption Survey (RECS) database.

5 Energy Information Administration, Residential Energy Consumption Survey (RECS) database.

6 The Low-Income Home Energy Assistance Program was established to assist eligible households to meet the cost of heating or cooling in residential dwellings. The Federal government provides the funds to the States that administer the program.

7 Energy Information Administration, *Housing Characteristics 1993,* DOE/EIA-0314(93), “RECS at a Glance,” p. x.

Table 2.3 U.S. Housing Characteristics 1993 (Million U.S. Households)

Household Characteristics	Northeast	Midwest	South	West	U.S.
Total Households	19.5	23.3	33.5	20.4	96.6
Urban	17.6	16.6	23.8	17.9	75.8
Rural	1.9	6.7	9.7	2.5	20.8
LPG (Propane) Used for Any Purpose	1.2	2.2	4.0	0.8	8.1
LPG (Propane) Used for Main Space Heating	0.2	1.8	2.3	0.4	4.6
LPG (Propane) Used for Main Water Heating	0.4	1.0	1.1	0.4	2.9
LPG (Propane) Used for Cooking	1.0	1.0	2.2	0.4	4.6

Source: Energy Information Administration, Residential Energy Consumption Survey (RECS) database.

Table 2.4 Housing Units by Type 1993 (Million U.S. Households)

	Northeast	Midwest	South	West	U.S.
Single-Family	11.9	16.6	24.9	13.5	66.8
Multifamily	7.0	5.3	6.0	5.9	24.2
Mobile Homes	0.5	1.4	2.6	1.0	5.6
Total	19.4	23.3	33.5	20.4	96.6

Source: Energy Information Administration, *Housing Characteristics 1993,* DOE/EIA-0314(93), Table 3.1a, p. 22.

fuel. This is due to the higher proportion of mobile home households that use propane as their primary heating fuel compared with single-family households.

On a regional basis, 1.2 million households located in the Northeast consume propane for all types of uses, or about one out of every sixteen households. Of these, only 0.2 million households (17 percent) use propane as their main heating fuel. In contrast, 0.4 million households use propane as a fuel to heat water (33 percent) and a million households use propane as a cooking fuel (83 percent).

In the Midwest, 2.2 million households consume propane for all types of uses, or about one in ten households. Of these, 1.8 million households use propane as their main heating fuel, while one million households each use propane for water heating and cooking, respectively. In other words, about 82 percent of all propane consumers in the Midwest use propane as their main heating fuel, the highest concentration of any region.

The South, with 4.0 million propane-consuming households, has the highest number of propane consumers of any region. Of these, 2.3 million households, or about 58 percent, use propane as their main heating fuel. Furthermore, 2.2 million households, or 55 percent, use propane for cooking, and 1.1 million households, or about 28 percent, use propane for water heating.

Industrial Demand Tends Not to Disrupt Markets

Industrial use of propane, the third largest sector, includes space heating, brazing, soldering, cutting, heat treating, annealing, vulcanizing of rubber, and use as a fuel in fork-lifts. Most industrial applications for propane are typically not seasonal and tend not to disrupt propane markets. The only exception is when industrial users switch from natural gas to propane for space heating and other applications when natural gas supplies become interruptible during periods of heavy winter demand.

Agricultural Demand Can Contribute to Early Season Market Stress

The agricultural sector is the fourth largest retail propane market, accounting for about 8 percent of total demand. Agricultural sector demand for propane includes many diverse uses such as crop drying, weed control, poultry and pig brooding, and use as a fuel to power farm equipment and irrigation pumps. Crop drying, the largest component of agricultural sector demand, is not only seasonal, but can vary greatly from year to year depending on crop size and moisture content. Agricultural sector demand for propane is primarily concentrated in the Midwest States of Iowa, Illinois, Nebraska, Minnesota, and Ohio.

Ordinarily, agriculture sector demand for propane does not impact regional propane markets except when the confluence of unusually high and late demand for propane for crop drying and colder-than-normal weather in the upper Midwest cause greater-than-normal stock draws. These conditions were exemplified during the fall of 1992 when heavy rains produced a record corn crop that was both extremely wet and later than usual. These conditions also caused the crop drying season to overlap the beginning of the residential heating season and was a major factor for Midwest inventories of propane reaching near-record low levels by the end of the 1992-1993 heating season.

Other Propane Uses Have Little Effect on Winter Markets

Other applications of propane include use in electric and natural gas utility operations, as an alternative fuel for fleet vehicles, gas grills, outdoor gas lights, generators, greenhouse heaters, and recreational vehicles. Electric utilities use propane as a back-up fuel during peak generating periods or peak shaving periods, while natural gas utilities use a propane-air mixture as a supplemental fuel during periods of peak demand. As an alternative fuel, a 25-gallon propane gas tank will take a vehicle farther than 25 gallons of any other alternative fuel, almost twice as far as methanol and four times as far as compressed natural gas. Delivery trucks, police cars, school buses, and taxis are examples of common propane fleets. According to EIA data, over a quarter of all U.S. households use a propane gas grill.[8]

8 Energy Information Administration, *Housing Characteristics 1993*, DOE/EIA-0314(93) (Washington, DC, 1993), p. xi.

3. Propane Supply and Logistics

Demand for propane is met by domestic production from gas processing plants and refineries, net imports, and, during the heating season, by withdrawals from inventory. Production and net imports do not vary seasonally like demand. These supply sources are relatively flat in comparison, being higher than consumption needs in the summer and lower in the winter. This results in stock builds during the summer months and stock draws during winter (Figure 3.1). During the 1995-96 winter heating season, domestic production accounted for more than three-fourths of the supply of propane over the period. The remainder of supply was accounted for by inventory withdrawals and imports, with shares of 14 percent and 8 percent, respectively (Table 3.1).

Table 3.1 Average Propane Supply (Million Barrels per Day)

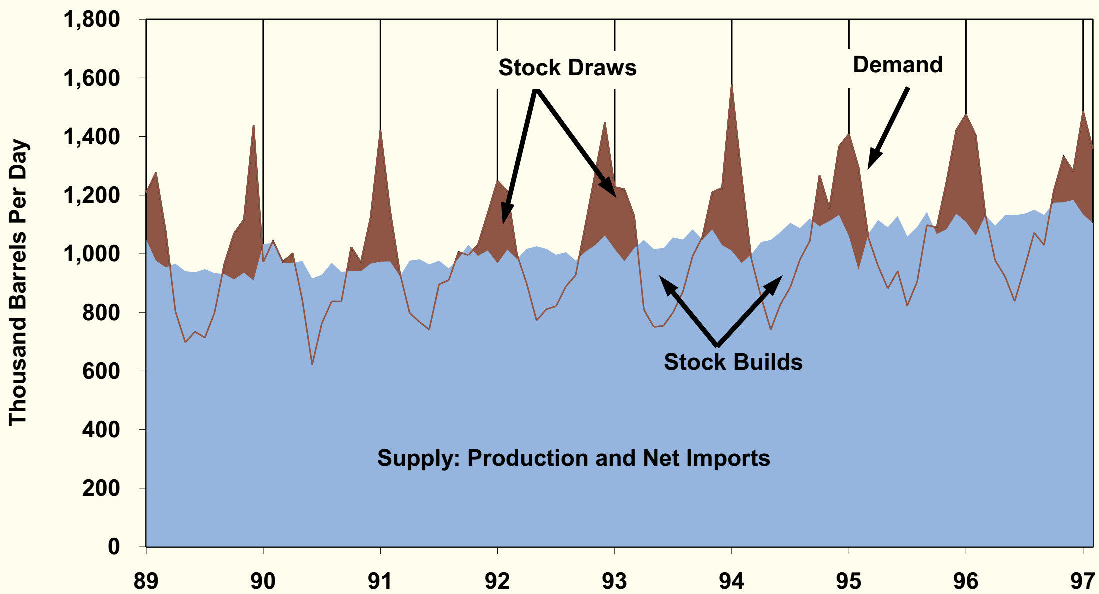
Category	Winter 1993-1994	Winter 1994-1995	Winter 1995-1996
Production	0.93	1.00	1.02
Imports	0.12	0.12	0.11
Stock Change	0.20	0.19	0.19
Total Propane Supply	1.25	1.31	1.33

Note: Averages are calculated by using monthly data for the winter heating season (October through March). Total propane supply is equal to domestic production, imports, and stock change, as reported in various issues of the *Petroleum Supply Annual,* DOE/EIA-0304, Table 2. Total propane supply overstates product supplied due to the exclusion of exports and refinery inputs.

Propane Is a By-Product of Other Production Processes

A unique feature of propane is that it is not produced for its own sake, but is a by-product of two other processes, natural gas processing and petroleum refining. The by-product nature of propane production means that the volume available from this source of supply will not necessarily adjust to changes in price and demand. Natural gas plant production of propane is primarily a function of extracting condensate, or the heavier liquids such as propane, from the natural gas stream in order to prevent the liquids from condensing and causing operational problems in natural gas pipelines. Thus, gas processing plant production correlates with expected demand for pipeline-quality natural gas and is very inelastic over the short term. Refinery production of propane is primarily a function of refinery runs dictated by demand for the major products, such as motor gasoline and heating oil. Because of propane's by-product status, refinery production of propane is also very inelastic in the short term.

Figure 3.1 U.S. Propane Supply and Demand, 1989-97



Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues.

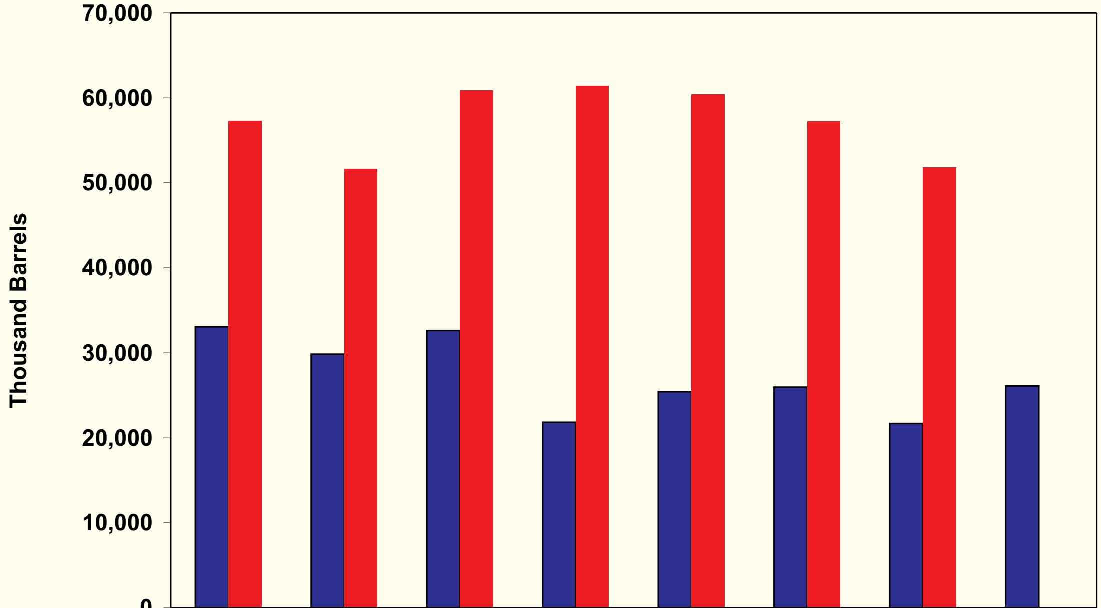
Preliminary data show that domestic propane production totaled slightly more than 1.0 million barrels per day during 1996, providing about 90 percent of total U.S. propane supply. Of this total, propane production at gas processing plants and at refineries accounted for nearly equal shares, 525 thousand barrels per day and 519 thousand barrels per day, respectively. Imports accounted for the remaining 10 percent of propane supply during 1996.

Inventories Are a Crucial Winter Supply Source

Primary inventory withdrawals[1] provide the second largest source of propane during the winter heating season. During the peak demand months of December, January and February, propane inventories supply over 20 percent of demand on average, compared to distillate, for which inventories supply 12 percent of demand during these same peak months. Inventories are built up during the spring and summer months, and typically peak by the end of September. Since 1990,

1 "Inventory withdrawals" is the same as "Stock Change" as reported in the *Petroleum Supply Annual*, DOE/EIA-0304, Table 2.

Figure 3.2 U.S. March and September Propane Stocks, 1990-97



	1990	1991	1992	1993	1994	1995	1996	1997
March	33,053	29,843	32,613	21,814	25,417	25,953	21,674	26,089
September	57,249	51,626	60,849	61,355	60,416	57,221	51,802	

Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues, and Form EIA-807, "Propane Telephone Survey.".

peak inventory levels have ranged from a low of 51.6 million barrels in 1991, to a high of 61.4 million barrels in 1993 (Figure 3.2). Last year, inventories peaked at 51.8 million barrels, the third lowest pre-heating season level in more than a quarter century.

Propane storage consists of three types: primary, secondary, and tertiary. Primary storage consists of refinery, gas plant, pipeline, and bulk terminal stocks. Secondary storage consists primarily of large above-ground tanks owned by propane retail distributors, while tertiary storage consists mainly of non-chemical end-users such as residential and commercial customers. Although chemical companies may hold substantial inventories of propane for their feedstock requirements, their status as an end user precludes their inventories from being counted as primary supply.

Propane storage facilities at the primary level are generally located near the major production and transportation hubs. These facilities consist of pressurized depleted mines and underground salt dome storage caverns clustered mostly in Conway, Kansas, and Mont Belvieu, Texas. The reservoirs are linked directly to the major NGL pipelines and are capable of maintaining high deliverability rates during peak demand periods. Smaller regional storage hubs are located in New York, Ohio, Illinois, Michigan, Minnesota, and Louisiana. Primary storage also includes stocks held at refineries, gas plants, and pipelines.

Mont Belvieu is the center of natural gas liquids fractionation and storage on the Gulf Coast. Located between Houston and Beaumont, the facilities at Mont Belvieu include a number of fractionating plants and pipeline facilities, situated on top of a natural salt dome structure containing millions of barrels of cavern storage for gas liquids. This facility serves the petrochemical industry of the Gulf Coast and is connected to the major pipelines that serve the Southeast, lower Midwest, and East Coast markets.

Conway, Kansas, is also a gas liquids storage and transportation hub, consisting of fractionation and pipeline installations adjacent to cavern storage facilities. Product sold at Conway may be shipped by pipeline throughout the Midwest, or loaded into rail cars for shipment anywhere in the United States. Conway sales dominate the agricultural demand sector as well as serving the large Midwest residential demand region.

Secondary storage consists of pressurized above-ground tanks located at approximately 25,000 retail outlets scattered throughout the United States, with tank capacities of 18,000 to 30,000 gallons.[2] Tertiary storage consists of small above-ground tanks located mostly at residences and commercial establishments.

Table 3.2 Economics of 30,000 Gallon Tank Purchased for Winter Pre-Stocking

Investment	$40,000
Interest Rate	8.25 %
Loan Payment	$341
Year's Payment	$4,090
Propane Purchase (gal)	30,000
June Price ($/gal)	$0.35
Cost of Propane	$10,500
Working Capital Interest Rate	8.25 %
Holding Cost (5 months)	$366
Total Cost	$4,456
Profit (Return on Investment)	$0
Price Increase to Break Even	$0.15

Source: EIA calculations.

At the secondary level, dealers in the northern areas of the Midwest and the Northeast turn their tanks over quickly during the high-demand winter months. They may refill every couple of days during those times. During times when large price increases occurred, such as in December 1989 and last winter (1996/97), the question is sometimes raised why enterprising dealers do not increase their storage, buy propane at low prices during the summer, and then sell it at higher prices during the winter and help to reduce extreme winter market stress. Table 3.2 suggests that the economics may not support such a strategy.

A 30,000 gallon tank might cost $40,000 for the tank investment alone. Dealers would also have to incur costs for installation, insurance, permitting, and additional infrastructure, at a minimum. The loan payment for the tank, assuming a modest 8.25 percent loan for 20 years,

2 National Propane Gas Association, *Facts About Propane*, Lisle, Illinois.

would be over $4,000 per year. If 30,000 gallons of propane were purchased during the summer at 35 cents per gallon, the dealer is tying up his or her money for 5 or 6 months until the propane is sold in December. An additional working capital charge representing the interest on this money adds another charge. In total, the tank and working capital are costing the dealer almost $4,500 per year. In order for the dealer to break even (earn no profit), the propane price would have to increase 15 cents per gallon between the summer and winter. Table 3.3 shows what spot prices did since 1990. The dealer would have lost money in all years but one or two, and those profitable years do not make up for the losses. From the consumers' perspective, paying a very high price occasionally may be less costly in the long run than paying for a system that includes higher storage levels designed to mitigate the occasional high price.

Table 3.3 December Spot Prices Minus June Spot Prices
(Cents per Gallon)

	Mont Belvieu	Conway
1990	16.4	13.2
1991	5.3	2.2
1992	-2.6	8.2
1993	-8.1	-8.0
1994	4.6	2.3
1995	3.5	6.7
1996	26.1	48.5

Source: Standard and Poor's Platt's.

This illustration also serves to explain why most storage takes place at primary-level areas like Conway or Mont Belvieu rather than the secondary level. The "tankage" cost[3] at Mont Belvieu is around 0.25 cents per gallon per month, and Conway is closer to 0.4 cents per gallon per month. The comparable cost of the secondary 30,000 gallon tank shown in Table 3.2 is 1.1 cents per gallon per month, which is a low estimate since it does not include all charges associated with the tank.

While dealers turn their inventory over quickly, homeowners have a longer turnover time. Single-family homeowners in the northern areas that use propane for space heating, hot water heating and cooking typically will have a 500 gallon tank. Home fuel oil tanks for space heating usually run about 275 gallons. No. 2 heating oil has about 52 percent more BTU's per gallon than propane, so the "heating value" of a typical residential propane tank is only about 20 percent greater than that of a heating oil tank, in spite of the much greater volume. Since fuel oil is generally limited to space heating, the tank turnover may be similar for fuel oil and propane during the winter for homeowners in the same area. During the peak demand winter periods, homes using propane for space heating might need to be filled every 60 days. Filling is normally done when a tank is about two-thirds to three-quarters empty. Thus, if prices have risen temporarily, some homeowners will pay the higher prices, but others may miss the price runup if it only lasts a month or so. Mobile home users, on the other hand, have smaller storage capability and are more likely to require refills during price increases simply due to the higher frequency of refills.

3 Tankage cost does not include the holding cost of the propane.

Could a homeowner benefit economically by having extra propane storage to avoid purchasing during high price times? Retail price data collected by EIA since the fall of 1993 indicate that homeowners would probably not benefit from holding more storage. Consider the case of two homeowners in the Midwest, one with a 500-gallon tank and one with 1000 gallons of capacity. These homeowners each typically purchase about 900 gallons of propane over the year. The purchase patterns might be as shown in Table 3.4, which assumes the 500-gallon tank owner is completely drawn down (i.e., 2/3 empty) and must fill in December and again in February. The 1000-gallon tank homeowner is trying to save by purchasing 400 gallons of the 900 gallons needed during the year in September, when prices are lowest, and avoiding purchasing during December when prices are high.

Table 3.4 Purchase Pattern Examples of Two Homeowners with Different Tank Sizes

	500-Gallon Tank (Gallons)	1000-Gallon Tank (Gallons)
September	100	400
December	333	0
February	333	333
April	134	167

Source: Energy Information Administration calculations.

EIA retail prices in the Midwest indicate that during the winters of 93/94, 94/95, and 95/96, the large-tank owner would have saved \$9, \$12, and \$22 respectively (excluding consideration of any tank costs). However, over the winter of 1996/97, the large tank owner would have saved \$123. The additional 500 gallons of storage might conservatively cost \$4-\$5 per month, or \$50-\$60 per year. Thus, over the last four winters, the large-tank homeowner would not have recovered the additional tank costs, even considering this unusual past winter.

Imports Provide the Swing Supply To Meet Demand

Imports provide the smallest component of U.S. propane supply. However, imports provide a vital source of supply when consumption exceeds available supplies of propane from domestic production and inventories. Imports can take several weeks or more to arrive, so they do not always offer much cushion for unexpected demand increases or supply shortages. During the 1995-1996 heating season, imports totaled 113 thousand barrels per day, or slightly less than 9 percent of total propane supply. In addition to winter needs, imports provide an important source for incremental supplies during the stock building period which typically lasts from April to September.

Imports of propane are primarily of two origins, by pipeline and rail car from Canada and by tanker from such countries as Algeria, Saudi Arabia, Venezuela, Norway, and the United Kingdom. Canada is the largest exporter of propane to the United States, generally accounting for more than two-thirds of all U.S. imports. Because Canada consumes only about half its supply of propane, the remainder is generally exported to the United States via pipeline and rail car into the upper Midwest and Northeast regions. However, when the northern regions of the United States are experiencing severe cold weather, Canada is usually suffering with the same weather. Thus, marginal increases in propane imports from Canada during such times may not be available.

Non-Canadian imports are waterborne supplies mostly from countries in the Persian Gulf, North Africa, the North Sea, and South America. Most waterborne imports flow into the East Coast (PAD District I) and Gulf Coast (PAD District III) regions of the United States. Waterborne imports into the East Coast region are typically highest during the winter months when peak winter demand requires supplemental sources of supply. Conversely, waterborne imports into the Gulf Coast region are typically highest during the spring and summer months when primary stockholders are building their inventories for the next winter heating season.

Midwest and East Coast Pipelines Form Transportation Backbone

The primary mode of transporting propane within the United States is by interstate pipelines. Approximately 70,000 miles of pipelines (Figure 3.3) are dedicated to the domestic movement of NGL's.[4] The NGL pipeline system is most developed along the corridors between production areas and petrochemical consumers along the Gulf Coast (PAD District III) and the agricultural-industrial consumers in the Midwest (PAD District II). The Northeastern States and the South Atlantic States are each served by a single pipeline. The upper Midwest is also served by two lines from Canada. Most interstate pipelines either originate from, or connect to, one of the regional supply hubs situated at Conway, Kansas, Mont Belvieu, Texas, Medford, Oklahoma, Hattiesburg, Mississippi, Chicago, Illinois, and Sarnia, Ontario, Canada. Local markets are serviced by the numerous distribution terminals located along the pipeline.

One of the major drawbacks of the pipeline grid is the lack of an adequate link between storage hubs in the Midwest and Gulf Coast regions. Short-term supply imbalances generally have to rely upon rail car and truck movements, which can be time-consuming and very costly. A small pipeline owned by Koch Industries runs between Medford, Oklahoma, and Mont Belvieu. It can move about 30,000 barrels per day of natural gas liquids, including propane, in either direction between Medford and Mont Belvieu, but it does not ordinarily ship propane north to Medford.

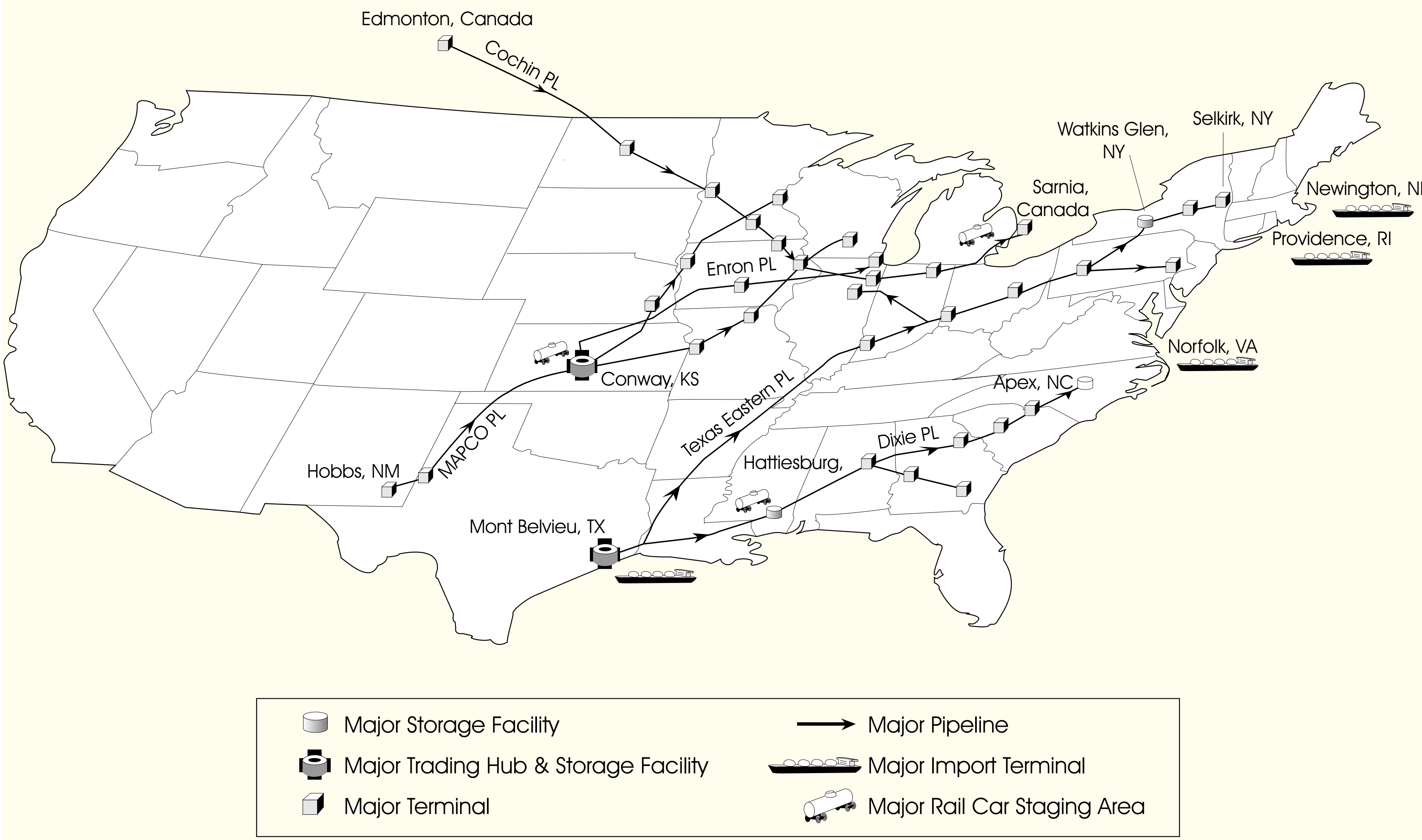
Other modes of transport (Figure 3.4) include about 22,000 rail tank cars, 6,000 highway bulk transports (large tanker trucks), 18,000 bobtails (local delivery trucks), about 60 inland waterway barges, and several ocean-going tankers.[5] A pressurized rail car holds about 30,000 gallons of propane, while a highway bulk transport can carry anywhere from 7,000 to 12,000 gallons of propane. Bobtails range from 1,000 gallons to 3,000 gallons of propane carrying capacity.

The Northeast is the region farthest from the major propane supply centers of the Nation, and has the lowest concentration of residential households using propane as their main heating fuel. The East Coast, which includes the Northeast region, receives more than one-half of its supply of propane, via pipeline, from the U.S. Gulf Coast. The remainder comes from production within the

4 National Propane Gas Association, *Facts About Propane,* Lisle, Illinois.

5 National Propane Gas Association, *Facts About Propane,* Lisle, Illinois.

Figure 3.3 Major Natural Gas Liquids Delivery Systems

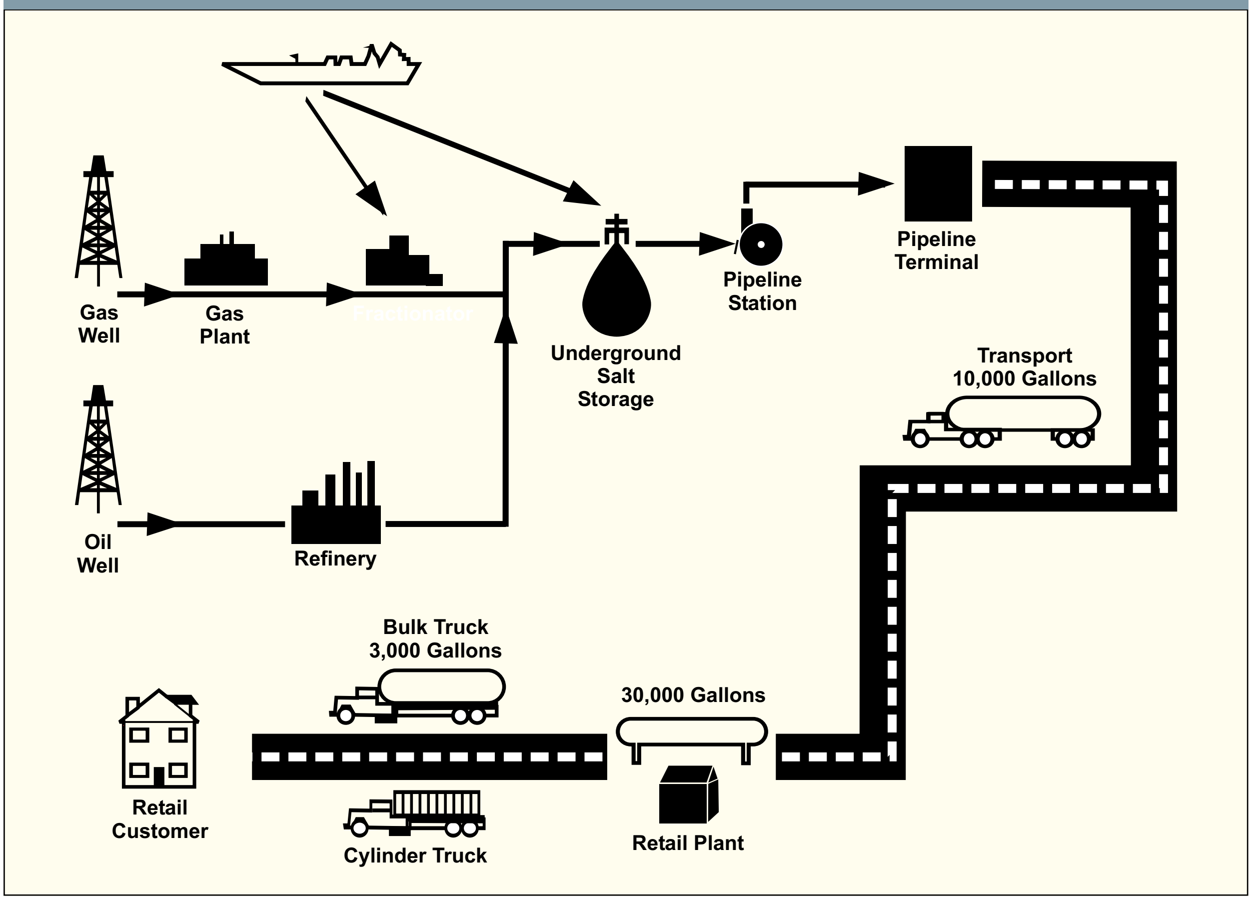


Source: Energy Information Administration.

region and imports.[6] Moreover, the New England area remains particularly vulnerable to severe weather-related supply disruptions because of its dependence on non-pipeline supplies of propane, via waterborne imports, truck transports, and rail car shipments.

Nearly three-fourths of the Midwest's supply of propane is derived from domestic production, with imports from Canada and interregional movements accounting for the remainder. The Midwest region contains abundant storage capacity and is served by several major propane pipelines both from the U.S. Gulf Coast and from Canada. The Midwest's high concentration of heating fuel use of propane, combined with the prevalence of severe weather, particularly in the upper Plains States, make the region susceptible to weather-driven demand surges. The major propane supply hub for the Midwest is located in Conway, Kansas, and primarily supplies the heating and agricultural markets in the region.

Figure 3.4 Simplified Propane Industry Logistics



Source: Energy Information Administration.

6 Energy Information Administration, *Petroleum Supply Annual 1995*, DOE/EIA.-0340(95), Table 5, p.37.

Refinery and gas plant operators on the Gulf Coast produce in excess of the South's demand for propane. Consequently, about one-sixth of the region's production of propane is transported to other regions of the United States.[7] Because of the South's proximity to the major propane supply sources and the lack of severe weather in the region, supply disruptions are uncommon. The propane distribution system that serves parts of the Midwest and the East Coast originates in the Mont Belvieu area of Texas. This region not only serves as the major hub for the heating fuels markets in the Midwest and East Coast regions, but also for the petrochemical industry concentrated along the Louisiana and Texas Gulf Coasts.

7 Energy Information Administration, *Petroleum Supply Annual 1995,* DOE/EIA-0340(95)/1, Table 9, p. 41.

4. Propane Markets

Propane markets are in some ways more complex than those for other petroleum products, due to factors such as the unique by-product nature of production, the many end-use markets propane serves and the different regional characteristics of those markets. However, several primary factors emerge that drive propane prices and explain propane price movement from the spot markets in Conway and Mont Belvieu through to the retail customer. This chapter reviews the major factors affecting normal propane price behavior and explores propane price spikes. It also defines the price structure used in the propane markets and explores how quickly prices move from the major storage centers in Kansas and Texas to the ends of the pipelines and finally through to the retail customers.

Winter Supply/Demand Balance and Other Factors Affect Prices

Propane prices at all levels of the distribution chain are subject to a number of influences, some of which are common to all petroleum products, and others unique to propane markets. Factors affecting the spot markets also eventually travel down the system to affect the other distribution levels. The primary determinant of spot propane prices, as with most commodities, is the balance of demand and available supply, often on a regional basis. Additionally, propane prices are influenced by crude oil and natural gas prices, competition with other commodities used as fuels or feedstocks, and intangible factors such as uncertainty about future supply or demand, causing marketers to bid up prices as they rush to buy available supplies.

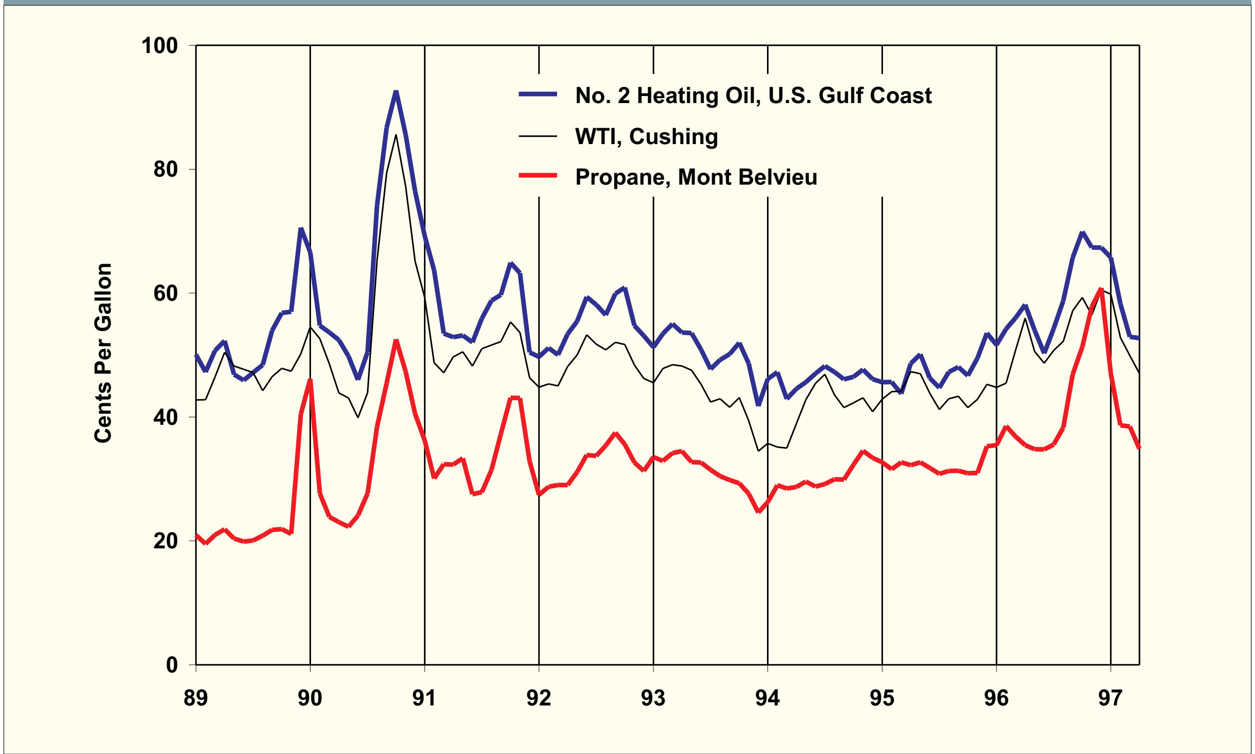
The balance of supply and demand for propane is a complex relationship, subject to changes in domestic production, world price relationships, weather, and inventory levels, among other factors. In spite of the complexity, several factors stand out that influence the supply/demand balance and thus price.

Winter's Influence on Propane Supply/Demand Balance

Winter weather can be a very important factor affecting propane prices. As noted in Chapter 2, average temperatures, expressed as heating degree-days, are a measure of heating demand, which directly affects about one-third of propane consumption on an annual basis, and a much greater share during the heating season. Weather, in terms of both temperature and precipitation, is also a major influence on the size, timing, and moisture content of corn and other crops which are dried using propane-fueled equipment.

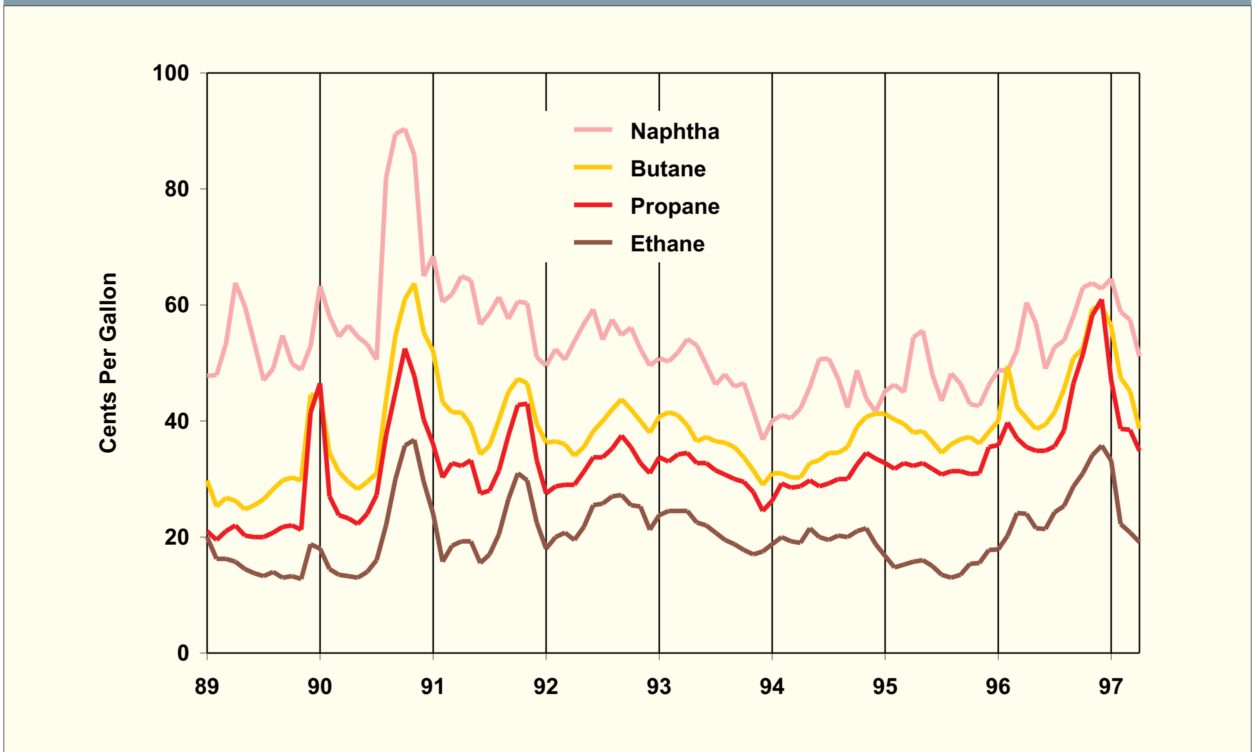
The market is tighter during the fall and winter months when stocks are being drawn down as demand outstrips production and imports. Colder-than-normal weather can put extra pressure on propane prices since there are no readily available sources of increased supply. (Increased imports can take several weeks or more to arrive.) A critical supply/demand signal to markets is a large

Figure 4.1 Propane, Heating Oil, and Crude Oil Spot Prices, 1989-97



Source: Standard and Poor's Platt's.

Figure 4.2 Ethane, Propane, Butane, and Naphtha Spot Prices, 1989-97



Source: Standard and Poor's Platt's.

stock draw in early winter. Cold weather early in the heating season can cause a higher price response than later, since early drawdown of stocks affects supply availability for the rest of the winter. Stocks are an important source of winter propane supply, filling over 20 percent of peak winter demand on average, and one-fourth of peak winter demand in the Midwest.

Weather can result in very different regional price behavior. Although cold weather affects the entire northern United States, regional impacts can vary greatly. Since the upper Midwest supply system is essentially independent from the Gulf Coast and East Coast supply system, Midwest winter conditions can affect Conway prices and Midwest retail prices very differently than Mont Belvieu prices and retail prices in the Northeast.

The relationship between weather and prices can be seen in Figure 4.1. During cold spells such as December 1989, both propane and heating oil were pulled higher as demand increased and markets tightened, although propane generally increases more on a percentage basis. (This is discussed in more detail below.) The correlation between propane and heating oil prices is not due to propane/heating oil substitution, of which there is very little in the short term. The correlation results because liquid propane tends to be used in the same market areas where heating oil is used, and these markets tend to be areas that natural gas does not serve. Being in the same areas, both heating oil and propane are subject to many of the same demand pulls during cold weather.

Petrochemical Industry's Role in Supply/Demand Balance

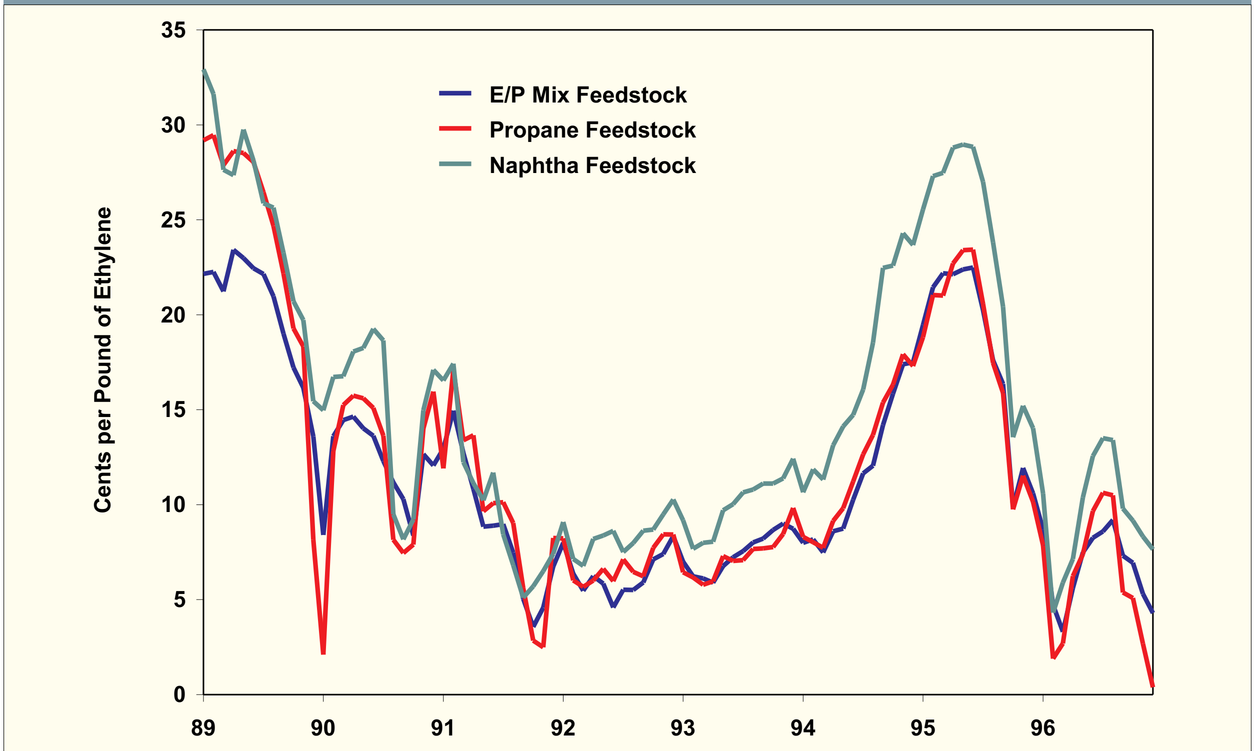
The winter weather influence mainly affects demand in the residential/commercial sector. The single largest demand sector, the petrochemical industry, also can affect the supply/demand balance. This sector is price-sensitive, and pulls back on propane use when prices increase, sometimes "freeing" as much as 150 thousand barrels per day or more for a short time. Thus, the petrochemical sector tends to help moderate tight supply/demand balances.

Relative feedstock cost is a primary factor driving the volumes of propane used for petrochemicals. The prices of the olefin plant feedstocks (ethane, propane, butane, naphtha, and gasoil) are a function of price competition in their alternative markets as well as of the supply/demand balance for petrochemical use. In general, ethane prices are less than propane prices, propane is less than butane, and butane is less than naphtha. As a rule, the higher the molecular weight and energy density, the higher the price (Figure 4.2).

There is a seasonal interplay between the five petrochemical feedstocks, driven by relative prices. Butane and gas oil (the smallest volume feedstocks) both drop back during the winter when their higher value-added markets (gasoline and heating fuel use) are strongest and prices are higher. Propane also frequently loses feedstock share in winter to serve its higher value-added heating fuel or crop-drying markets. This does not occur every winter; for example in 1993 and 1994, winter prices were weak, and propane use did not drop. Ethane and naphtha both tend to increase share in winter.

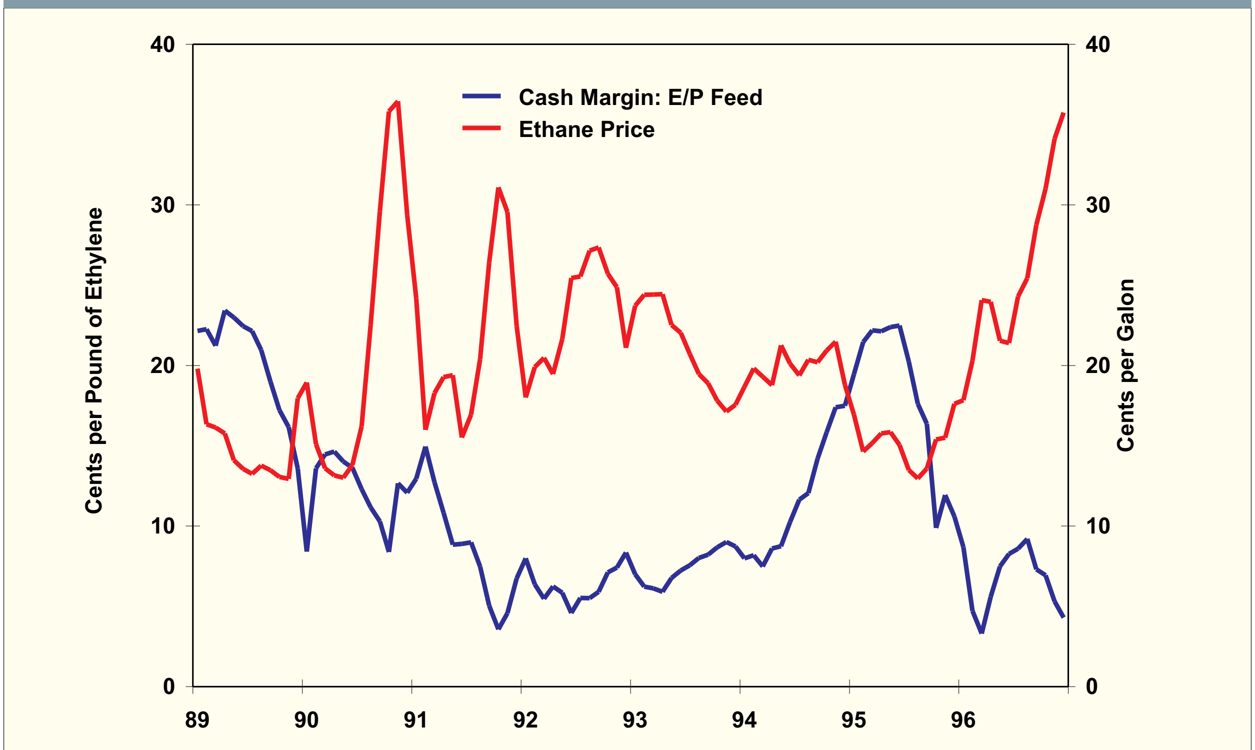
Ethane has only two markets: petrochemical use or being left in natural gas to be burned as a fuel. Ethane prices tend to track propane prices, but do not move as much as propane during times of

Figure 4.3 Wright Killen Ethylene Cash Margins Plants Using Propane and E/P Mix Feedstock, 1989-96



Source: *Oil and Gas Journal.*

Figure 4.4 Wright Killen Ethylene Cash Margin and Ethane Price (Plants Using E/P Mix Feedstock), 1989-96



Source: Margin - *Oil and Gas Journal;* Price - Standard and Poor's Platt's.

propane supply stress such as December 1989 and January 1990, or last winter, but show greater price change than naphtha or gas oil.

Naphtha's alternative use is in refinery gasoline production. As such, its price usually follows that of crude-based fuels rather than petrochemical feedstock prices, and it is less sensitive to heating fuel market stress than is propane. When the heating fuel markets have supply or demand problems that cause No. 2 heating oil and propane prices to spike, naphtha prices frequently increase less than those for heating oil, and much less than propane prices.

While feedstock costs change, ethylene prices do not necessarily follow. Thus, a feedstock price runup results in a decline in margins. The ethylene margin "earned" for each feedstock helps to drive the substitution decision. The ethylene margin contributions from different feedstocks are usually calculated per pound of ethylene produced. It takes more of some products than others to produce a pound of ethylene, and the investment in naphtha and gas oil feedstock ethylene plants is higher than in propane and ethane feedstock facilities. Thus, a higher margin is required from the naphtha and gas oil plants to earn a comparable return on investment.

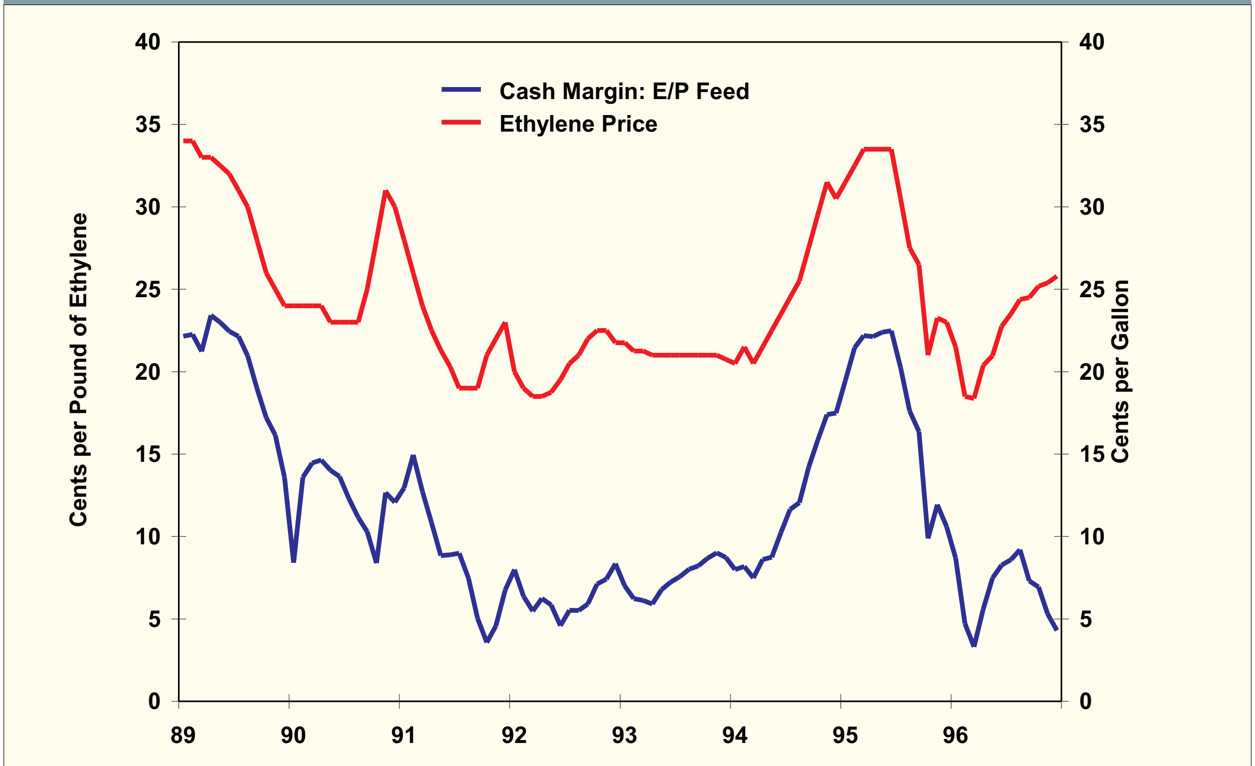
The propane, ethane/propane mix, and naphtha margins all move in the same direction, but vary in degree of change (Figure 4.3). The margins are dependent on both feedstock cost and ethylene price (Figures 4.4 and 4.5). Ethylene price has a predominant impact on margins, but during times of feedstock price runups, rising feedstock prices usually pull margins down, as in late 1989 and in 1996. Margins declined for all feedstocks in these years, but fell most for propane. The E/P mix (80 percent ethane/20 percent propane) margin also fell dramatically as ethane's price rose with propane. The naphtha margin declined the least.

The ethylene price and thus ethylene margin variation is tied to capacity utilization. The petrochemical industry goes through cycles of expansion and overcapacity, followed by demand eventually filling the capacity and increasing utilization. Ethylene prices and margins are heavily influenced by these cycles. Feedstock costs generally have less effect on margins than ethylene price. However, when feedstock price runups occur, they cannot be passed through to the petrochemical customers (i.e., ethylene prices are not usually affected), and margins fall. When propane prices spike, ethane prices follow, giving petrochemical operators feedstock cost pressure on margins from almost two-thirds of their inputs. Even when propane feedstock volume is reduced, ethane prices are still high, causing margin declines. Thus petrochemical plant operators have a strong incentive to back down on propane as quickly as possible when propane prices increase. It is this strong price incentive that causes drops in petrochemical propane demand at times when the winter residential market stress is pushing up prices.

Crude Oil and Natural Gas Price Influences on Spot Propane Prices

In addition to the supply/demand balance, it appears that crude oil prices and to a lesser degree natural gas prices have some influence on propane prices. Because propane is produced from both crude oil refining and natural gas processing, its prices are influenced to some degree by changes in the cost of either of those commodities. The impact of crude oil can be seen most dramatically during times of large crude oil price changes, such as during the Gulf War. When both crude oil and

Figure 4.5 Wright Killen Ethylene Cash Margin and Ethylene Price (Plants Using E/P Mix Feedstock), 1989-96



Source: Margin - *Oil and Gas Journal;* Price - Standard and Poor's Platt's.

heating oil prices are increasing, propane price also will be increasing, and it can be difficult to separate how much of the change in propane price is due to feedstock price influences and how much is due to heating market supply/demand influences.

Propane Prices Spike Higher than Other Fuels

A phenomenon seen with some frequency in propane markets is that of price spikes, i.e., disproportionate increases in price beyond that expected from normal supply/demand fundamentals. Though there is no perfect explanation for this phenomenon, the main cause appears to lie in the logistical difficulty of obtaining resupply during the peak season. Because propane is produced at a relatively steady rate year-round by refineries and gas processing plants, there is no ready source of incremental production when supplies get tight. The Midwest appears to be particularly prone to very rapid price runups during the high-demand season. When demand outstrips readily available supplies in the mid-continent region, extra supply would have to come largely from the Gulf Coast, and transportation between the two regions is limited and expensive. When all heating fuel markets are stressed, propane's supply inflexibility manifests itself in larger percentage price increases than heating oil. For example, from November 1989 to January 1990, propane prices jumped 119 percent, while heating oil increased only 30 percent.

Defining Propane Price Structures

Spot Markets

As is the case with crude oil, natural gas, and most petroleum products, propane is widely traded on so-called "spot" markets, centering around storage and transportation hubs. A spot transaction is typically defined as a one-time sale at an agreed-upon price, as opposed to recurring, contractual sales, or those made at posted prices available to other buyers or sellers. Spot sales do not typically involve an organized exchange, but rather occur directly between producers, consumers, or middlemen, normally by telephone. A recent development is an electronic bulletin board service operated by a major pipeline company, facilitating spot market transactions among producers and traders. Most propane spot transactions in the United States involve delivery of product at either Mont Belvieu, Texas, or Conway, Kansas, the two major primary storage areas in the United States. Daily prices for trades made at these locations are widely reported by trade press and wire services.

Because of Mont Belvieu's proximity to propane production and storage facilities, the Gulf Coast petrochemical industry, and major pipelines to the eastern portion of the United States, product delivered at Mont Belvieu can be used to serve over half of U.S. demand, including much of the petrochemical, industrial, and residential/commercial sectors. Propane imported to or exported from the Gulf Coast is typically benchmarked to a Mont Belvieu price.

Product sold at Conway may be shipped by pipeline throughout the Midwest, or loaded into rail cars for shipment anywhere in the United States. Conway sales dominate the agricultural sector, as well as serving the strong residential market of the upper Midwest.

Futures Market

Since 1987, propane futures trading has been available on the New York Mercantile Exchange (NYMEX). Trading is conducted for the next 15 calendar months, with a contract size of 1,000 barrels (42,000 gallons) each. The specified delivery point is Mont Belvieu, Texas.

Propane futures contracts provide the opportunity for producers, marketers, and consumers to lock in their costs or revenues for future periods by hedging their expected cash transactions with offsetting positions in the futures market. Trading volumes for the NYMEX propane contract are much less than those for crude oil, gasoline, and heating oil, both in absolute terms and as a percentage of overall demand. A number of factors may account for this limited participation, including the lack of a corresponding options contract, and the limited infrastructure linking Mont Belvieu to the mid-continent region.

Terminal (Rack) Prices[1]

Wholesale sales of propane from producers and major interstate suppliers to local distributors are typically made at the terminal level in truckload quantities. The price structure for this type of sale, for propane as for other petroleum products, is referred to as terminal, or "rack" pricing, so called because the transaction occurs on delivery at the terminal loading rack.

Competition between multiple suppliers at most terminals typically results in rack prices being set slightly above the total of the spot price for the appropriate supply hub (Mont Belvieu or Conway) plus the cost of pipeline shipment to the terminal and any terminaling cost. The increment above the tangible costs of the delivered product allows for the shipper's carrying cost (if any) for the product, and a profit on the transaction. Because product at most pipelines and terminals is available to a number of suppliers, either by physical shipment or exchange, competition typically keeps the per-gallon profit margin on rack sales relatively small.

Retail Prices

The retail price structure for propane tends to be much more complex than that for other major petroleum products, due to the wide range of volumes purchased, means of delivery, and classes of trade served. A local propane distributor typically makes sales ranging from residential or commercial deliveries of hundreds of gallons or more, down to barbecue grill tanks holding about 5 gallons. Additionally, some dealers now sell propane as an alternative fuel for on-highway use, filling a vehicle's fuel tank as a service station would with gasoline or diesel fuel.

Dealers use a variety of pricing schemes for retail sales. These include the following:

- Cash versus credit - Dealers will offer customers a lower price if they pay within a certain period of time. This is known as the cash price. Typically payment must be made within a ten day period by the customer; however, the cash price period varies by individual dealers.
- Tier pricing - The dealer establishes a price based upon the amount of product delivered or used by the customer over a year's time. The more product used or delivered, the lower the price per gallon of propane. Average usage varies by region of the country. A typical residential user in upstate New York may use between 750 - 1000 gallons of propane a year, while a similar customer in North Carolina may use around 250 - 400 gallons per year.
- Capped or fixed price - The customer contracts a price for a certain amount of propane for a specified period of time. This type of pricing scheme is commonly used by commercial or industrial customers who purchase large volumes of propane, usually over 1000 gallons .
- On-demand versus keep-full - A service whereby the customer requests the dealer to monitor the amount of product in a residential customer's tank. The customer has the option of either calling

1 EIA reports wholesale prices associated with sales for resale. The EIA resale prices are associated with sales to purchasers who are other-than-ultimate customers, and thus include terminal as well as spot prices.

the dealer for product (on-demand) or the dealer automatically fills up the tank when product reaches a certain level (keep-full).

- Summer fill - The price for propane is usually less in the summer months when demand for propane heating is low. Hence, residential customers have the option of filling up their tanks with propane when prices are lower than during peak demand times. Although not commonly used by residential customers, summer fill programs are currently under consideration by State agencies as a means of saving money for low income households. To date, very few States use summer fill programs. Currently only South Dakota, New Hampshire, and Wyoming have programs which take advantage of summer pre-purchase agreements.
- Tank ownership - Since tanks are very expensive, small volume users such as residential customers rarely own their tanks. Tanks are usually owned by apartment owners, farmers, or wealthier individuals who can afford them. Owners designate who can fill their propane tanks as long as the person is certified to follow fire and safety regulations. Dealers do not allow other dealers to fill their tanks even if the employee is certified.

Prices Move Quickly Through the Distribution System

As spot prices change at major propane buying centers such as Mont Belvieu and Conway, prices further along the distribution chain begin to reflect those changes. Propane price changes travel relatively quickly through the system, partially due to the result of fairly frequent stock turnover at the retail distribution level.

Using weekly terminal price data, EIA explored the changes in terminal prices as a function of changes in spot prices from the major area serving the terminal. If Conway spot prices increase 10 cents on Friday, terminal prices at Pine Bend, Minnesota, and Lemont, Illinois, tend to pick up 8 cents of the increase on Monday, and the remaining 2 cents over the next two weeks. These terminals are also near refining centers that produce propane, so their quick response to spot prices was not surprising. If Mont Belvieu prices increase 10 cents on Friday, Princeton, Indiana, sees about 7 cents of the increase on Monday, and Todhunter, Ohio, and Selkirk, New York, being farther away, pick up about 6 cents of the increase. About 3 cents is picked up the following week. (See Appendix B for more details.)

Using monthly resale and residential propane price data, EIA also explored changes in residential prices relative to changes in spot and/or resale prices.[2] In the U.S. as a whole, if spot prices at Mont Belvieu change by 10 cents, it was found that approximately 6 cents is passed through to resale prices in the current month (with an additional 4 cents in subsequent months). If resale prices change by 6 cents, 3 to 4 cents is passed through to residential prices during the current month.

2 Formal testing of price symmetry/assymmetry was not done; however, the models fit the actual data equally well during upward or downward price changes.

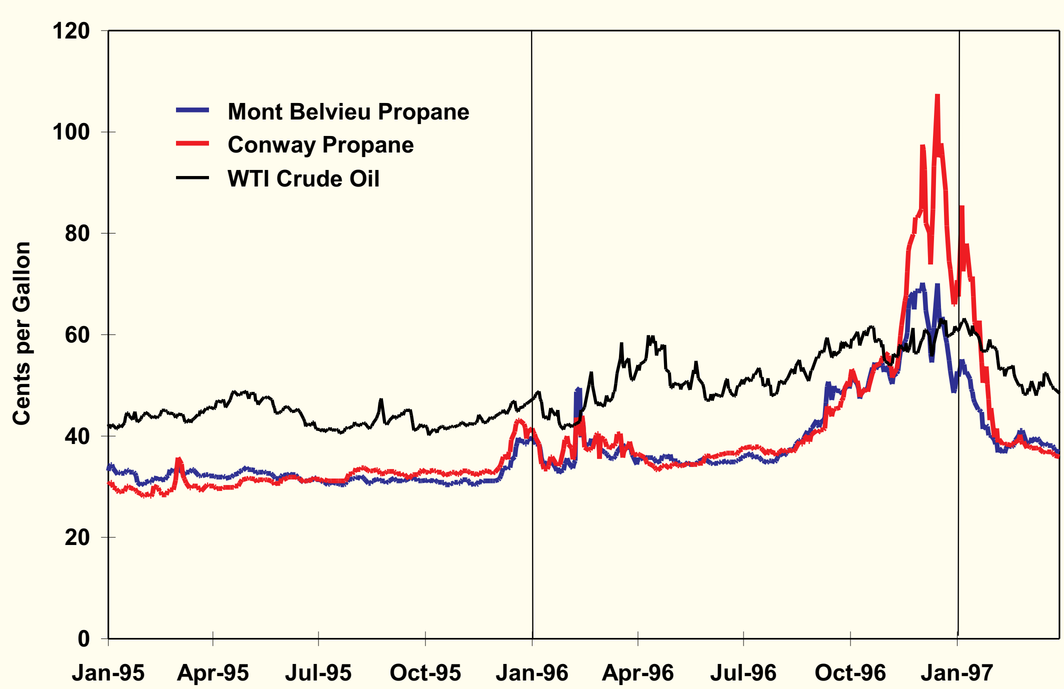
Narrowing the focus to PADD 1, comparable results were obtained. In particular, if spot prices at Mont Belvieu increase(decrease) by 10 cents, then resale prices were found to increase (decrease) by slightly less than 7 cents in the current month (with an additional 4-cent passthrough in subsequent months), and if resale price were to change by 7 cents, then about 3 cents would be passed through to residential prices in the current month. Thus, as expected, the passthrough of spot price changes through to residential prices tended to be much slower than that from spot to terminal prices.

5. Propane Supply, Demand, and Prices in the 1996-97 Heating Season

In the fall of 1996, spot propane prices at Mont Belvieu and Conway rose together from about 36 cents per gallon at the beginning of August to 50 cents at the end of September, which is the traditional beginning of the winter heating season (Figure 5.1). Propane prices stood at the highest pre-heating-season levels since 1990. Prices continued to rise through October, and in November, Conway prices, which reflect volumes serving the Midwest, began to split away from Mont Belvieu. Conway prices soared, peaking at 107.5 cents on December 16. Mont Belvieu stayed strong, but did not follow Conway's rapid ascent, peaking at 70.3 cents on December 3. Both Conway and Mont Belvieu prices fell after the mid-December peak, with Conway falling faster and reaching parity with Mont Belvieu by mid-February. Terminal and retail prices downstream from Conway and Mont Belvieu lagged behind changes in spot markets with significant regional differences, but all propane prices returned to more seasonal levels by March.

The dramatic price increase that occurred this past winter can be separated into two parts. The first part occurred from August through early November and appeared to be due primarily to crude oil

Figure 5.1 Propane and Crude Oil Spot Prices, 1995-97



Source: Reuters Ltd.

price increases and some added heating market pressures resulting from strong, early heating-season demand in the Midwest. The second part of the runup from November through January was characterized by a wide differential between Conway and Mont Belvieu prices. While both Conway and Mont Belvieu spot markets were still being bouyed by crude oil prices, regional heating market factors affecting the Midwest continued to pull Conway spot prices well above Mont Belvieu. The Midwest experienced unusually large demand in October and November from both early cold weather and late crop-drying needs. This pulled stocks down to very low levels before the normal peak demand months of December, January and February. With stocks normally supplying about one-fourth of PADD 2 demand during these peak months, the difficulty of re-supply at that time of year, and prospects for more cold weather, marketers rushed to buy available supplies, resulting in upward pressure on prices. By the second half of December, warmer weather had arrived in most areas, and the markets began to soften. By January, prices were tumbling rapidly and the crisis was over. The remainder of this chapter reviews the evolution of the supply/demand fundamentals and the price responses during the fall and winter of 1996/97.

Regional Demand Played Major Role in Conway Price Increase

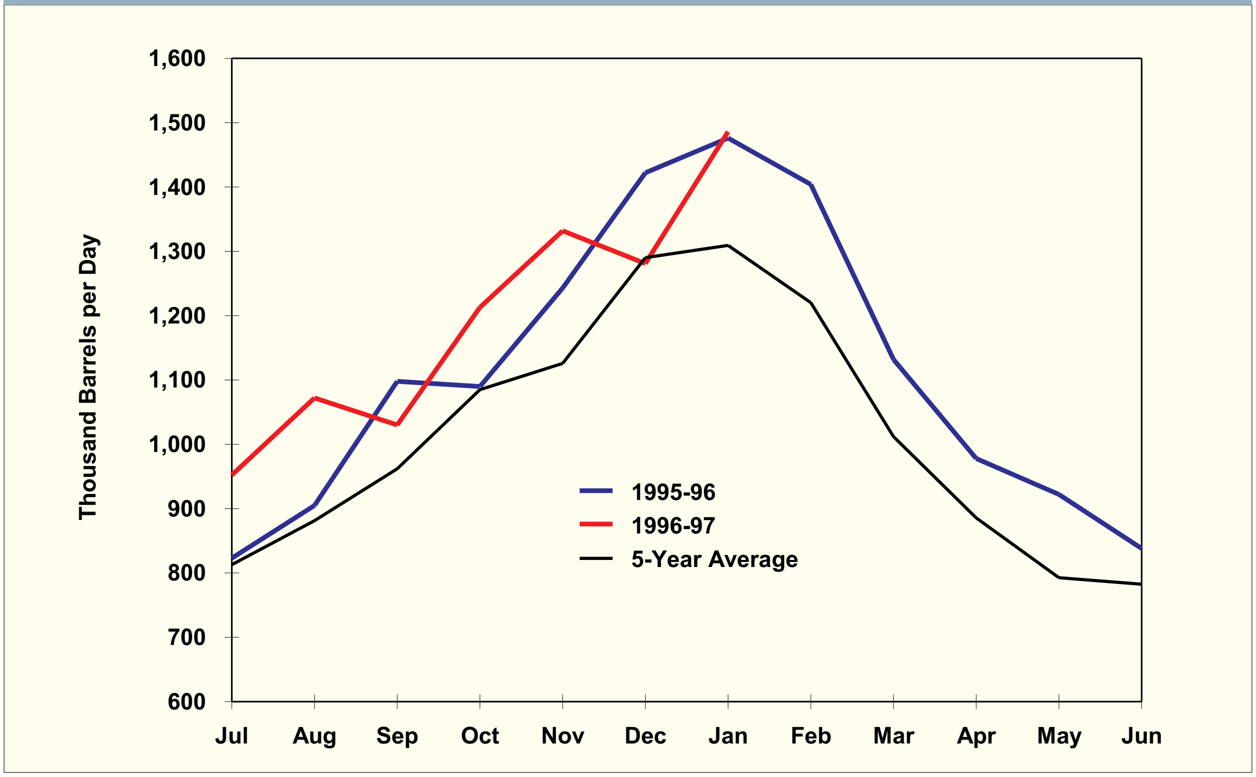
U.S. propane demand was higher in 1996 than in 1995, averaging 3.5 percent over the previous year (Figure 5.2). However, annual demand in PADD 2 averaged almost 11 percent higher in 1996 than in 1995. By the end of September, U.S. demand was averaging over 4 percent higher than in 1995, while in the Midwest (PADD 2), it was running almost 7 percent higher. Petrochemical use of propane in producing ethylene, which generally does not affect PADD 2 demand, averaged less in 1996 than in 1995, indicating that strong pre-season demand was coming mainly from other end-use sectors. Strong heating fuel demand during the first quarter of 1996, resulting in low inventories at the start of the heating season, was one of the contributing factors.

Colder-than-normal U.S. average temperatures during October (5.9 percent) and November (18.0 percent) caused earlier than expected demand for propane for residential heating (Figure 5.3). The East North Central and West North Central regions experienced the most severe cold temperatures. Propane prices had started rising in August, prior to the change in weather. This increase in price apparently prompted some residential consumers to hold off filling their tanks in anticipation of lower propane prices, according to one study.[1] If this did occur, their refill needs may have added to the normal increase in demand that would have occurred as a result of the cold weather.

In addition to the cold-induced demand, agricultural crop drying demand, which affects the Midwest (PADD 2), was strong. The situation was a repeat of the conditions that caused market unrest during the fall of 1992, when heavy rains produced a record corn crop that was both extremely wet and later than usual. These conditions also caused the crop drying season to overlap the beginning of the residential heating season and was a major factor for Midwest inventories of

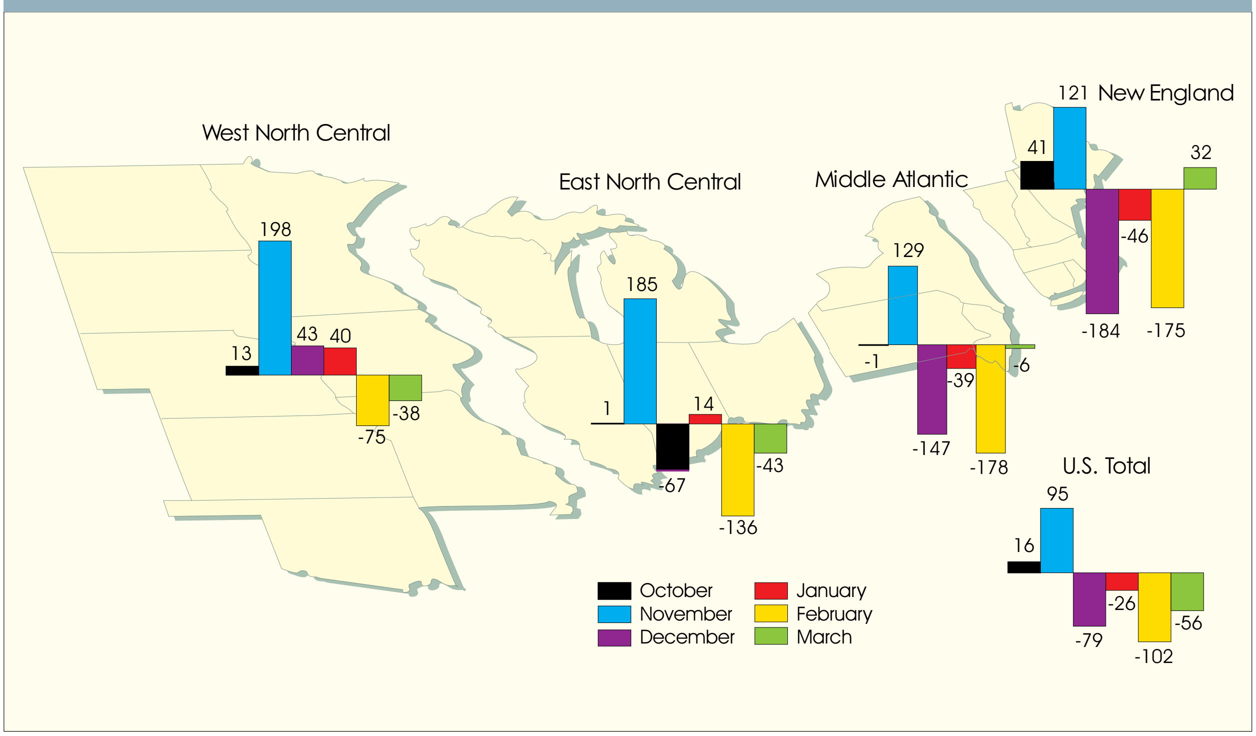
1 S.C. Whitley, “The State and Near-Term Future of U.S. and International Propane Markets,” Purvin and Gertz, Inc., October 1996, Houston, TX.

Figure 5.2 U.S. Propane Demand



Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues.

Figure 5.3 Heating Degree-Days vs. Normal by Census Region, Winter 1996-97



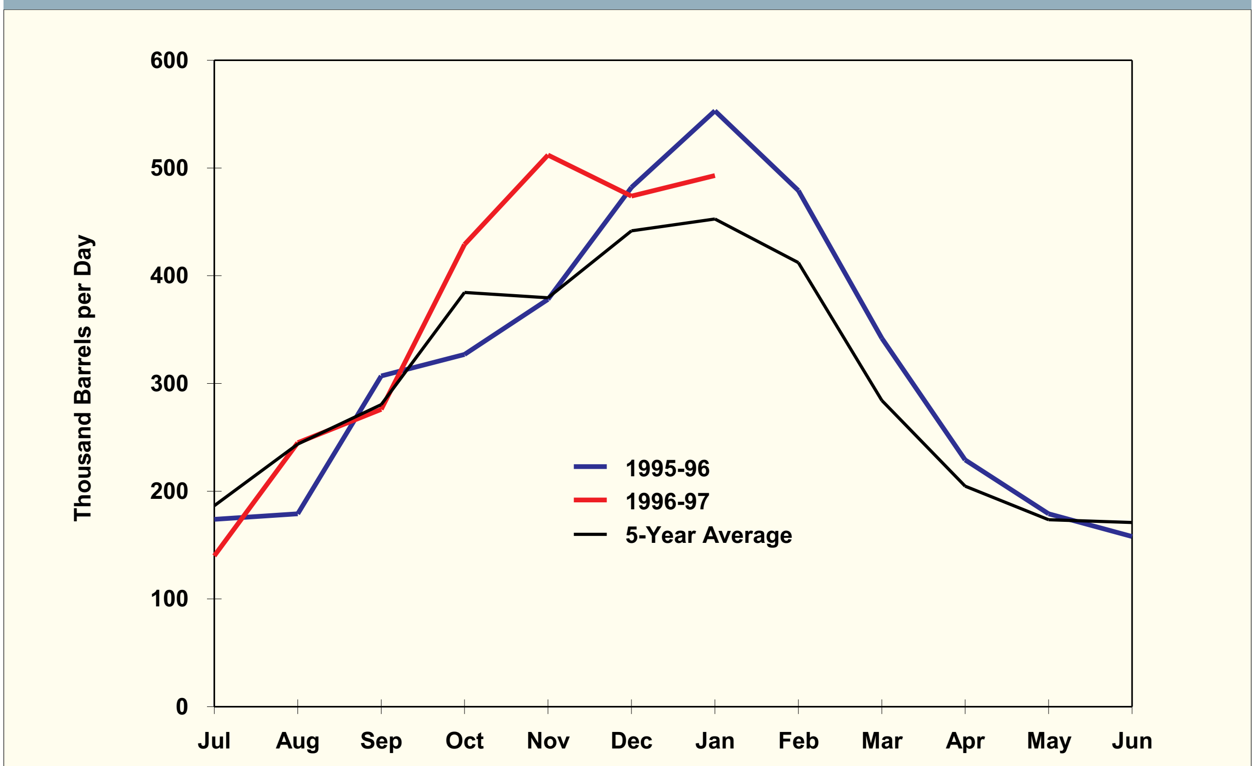
Source: National Oceanic and Atmospheric Administration.

propane reaching near-record low levels by the end of the 1992-1993 heating season. The 1996 U.S. corn crop measured 9.0 billion bushels, making it the third highest on record.[2] This was due to the absence of major freezes in principal growing regions through mid-October which allowed the crops ample time to reach maturity. However, because of the large crop, progress on the corn harvest in most areas fell behind the 5-year average and caused the corn drying season to overlap the beginning of the heating season.

The combination of cold and late crop drying caused a spurt in Midwest demand (PADD 2) in October, followed by a spectacular increase in November. November's PADD 2 demand was almost as high as the prior cold January demand (Figure 5.4). This Midwestern demand surge was a major factor behind the beginning of the Conway spot price increase over Mont Belvieu.

In December and January, the cold weather moderated in all but the West North Central region, where temperatures remained below normal through January. U.S. demand had climbed to 1,332 thousand barrels per day in November, but fell back to 1,281 in December with the mild weather.

Figure 5.4 PADD 2 Propane Demand



Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues..

2 *Agricultural Outlook,* Economic Research Service, U.S. Department of Agriculture, November 1996.

Colder weather in January (but still warmer than normal) caused demand to increase to 1,486 thousand barrels per day, which was about the same level as in January 1996. PADD 2 demand peaked in November at 512 thousand barrels per day before falling back somewhat to 474 thousand barrels per day in December. In January, the cold weather in PADD 2 caused demand to climb back to 493 thousand barrels per day, which was lower than the 1996 January level of 553 thousand barrels per day, but still higher than average.

1996 Production & Import Growth Not Enough to Rebuild Stocks

Production

Total propane production in 1996 was 23 thousand barrels per day (2.2 percent) higher than the prior year's level. With demand increasing on average 39 thousand barrels per day in 1996, production did not keep pace. Refinery production was up 3.3 percent over 1995, while gas plant production showed a relatively modest gain of 1.1 percent between 1995 and 1996. Propane supply from natural gas plant processing and refinery production posted its seventh consecutive yearly increase during 1996, averaging slightly more than 1.0 million barrels per day. The increase in refinery production of propane over the last several years has been attributable to higher co-production of other petroleum products such as distillate fuel oil and motor gasoline. Moreover, the respective shares of propane supply from gas plants and refineries was roughly equivalent during 1996, measuring 525 thousand barrels per day at gas plants, and 519 thousand barrels per day at refineries.

Mexican LPG Plant Explosion Worries Markets Briefly

A factor that initially caused much concern about potential propane imports to the U.S. Gulf Coast was the July 26, 1996, explosion of Mexico's Cactus gas plant. The plant, one of the largest in the world, accounted for nearly one-third of Mexico's LPG production. Although the United States has been a net exporter of propane to Mexico since 1992, industry observers were unsure of the impact the loss of this plant would have on world propane trade and the resulting prices the United States would have to pay for imports from other countries. However, immediately following the explosion, Petroleos Mexicanos (Pemex), the state-run oil and gas company that operates the Cactus gas plant, contracted to purchase 6 large propane cargoes from Saudi Arabia over a six-month period. The action by Pemex eased some fears of a potential squeeze on U.S. Gulf Coast propane supplies as was evidenced by the absence of any discernible increase in U.S. spot prices due to the Mexican plant explosion. Moreover, net exports of propane from the U.S. Gulf Coast (PAD District 3) to Mexico dropped by nearly 0.7 million barrels between 1995 and 1996.

Imports

Since 1996 demand growth exceeded supply increases, imports helped to meet demand. Propane imports measured a near-record 119 thousand barrels per day during 1996, about 17 percent above the prior year level. Much of the yearly increase occurred during the first and fourth quarters in response to the harsh winter weather early in the year and the shortfall in inventories during the latter part of the year. While imports from Canada increased over 1995 levels, most of the year-to-year increase was from waterborne imports. Net imports were further augmented by a 10 thousand barrel per day reduction in exports in 1996 from 1995, despite Mexico's increased need for propane imports as a result of a major plant explosion (see box).

Strong first quarter demand for propane, the result of severe winter weather, was met primarily by significantly higher imports from Canada. However, by the fourth quarter, waterborne imports had surpassed imports from Canada as the largest incremental supply of propane for 1996. Algeria accounted for the largest share of waterborne imports during the year, followed by imports from Venezuela and Norway. Despite relatively high Gulf Coast spot prices, European and Asian markets essentially outbid U.S. marketers for surplus world propane supplies during most of 1996.

The Midwest receives most of its imports from Canada. Even though cold weather affected Canada as well as the United States, imports into PADD 2 increased from 31 thousand barrels per day in September to 57 in October and 78 thousand barrels per day in November. They stayed above 70 thousand barrels per day in December and January, helping to serve the strong regional demand.

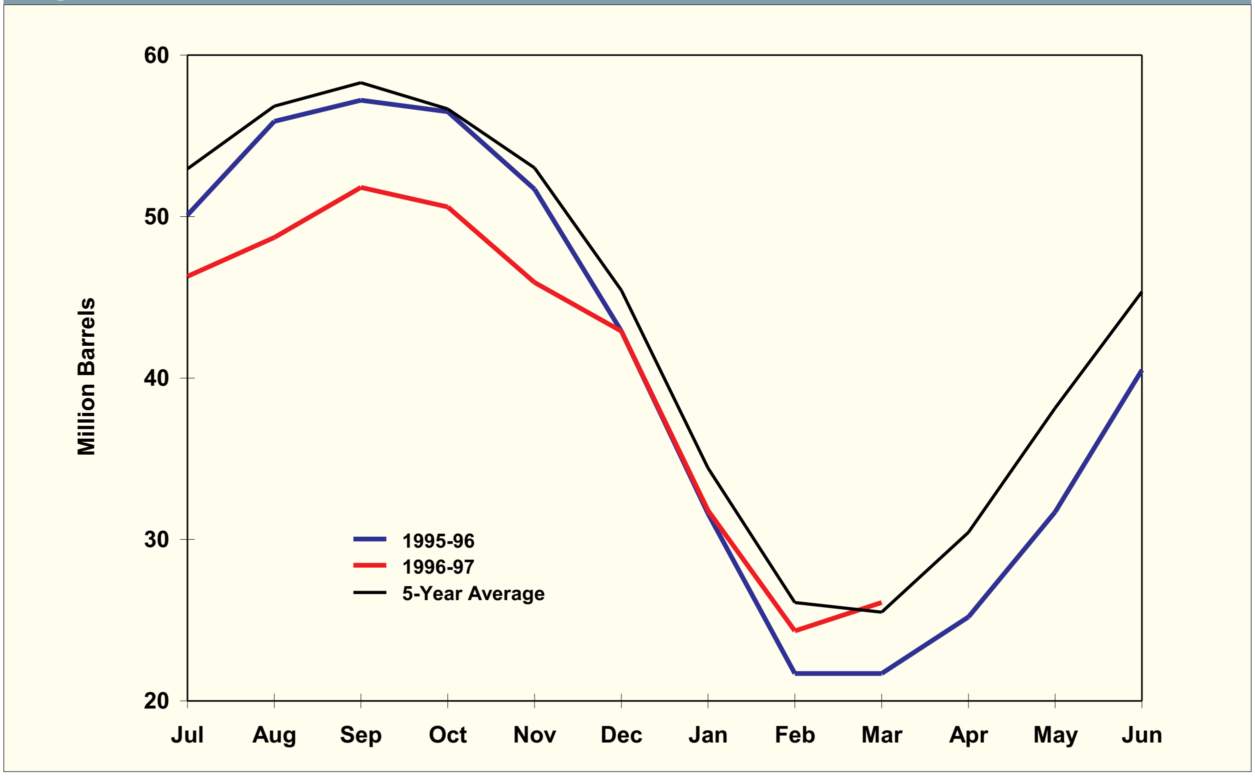
Pre-heating Season Inventory

U.S. inventories of propane as of September 30, 1996, stood at 51.8 million barrels, the third lowest level ever for the start of a winter heating season (Figure 5.5). However, the causes for the low pre-winter season inventories were essentially rooted in developments that occurred during the prior heating season. Specifically, widespread, sustained winter weather during the prior year heating season pulled U.S. inventories of propane down to 21.7 million barrels by March 31, 1996, their lowest March level in more than a quarter century. The draw on U.S. inventories during winter 1995/96 totaled a near-record 35.5 million barrels.

From March 31 to September 30, 1996, U.S. inventories of propane were replenished by 30.1 million barrels, a level slightly below the 5-year average of about 31.2 million barrels. However, with a below-average stock build and a low starting level from which inventories were built, total U.S. primary inventories fell short of their average range by the start of the 1996-1997 winter heating season. Peak inventory levels have varied over the years, but industry analysts have generally seen 60 million barrels at the start of the heating season as the target level needed to meet likely demand requirements with minimal potential for significant disruption.

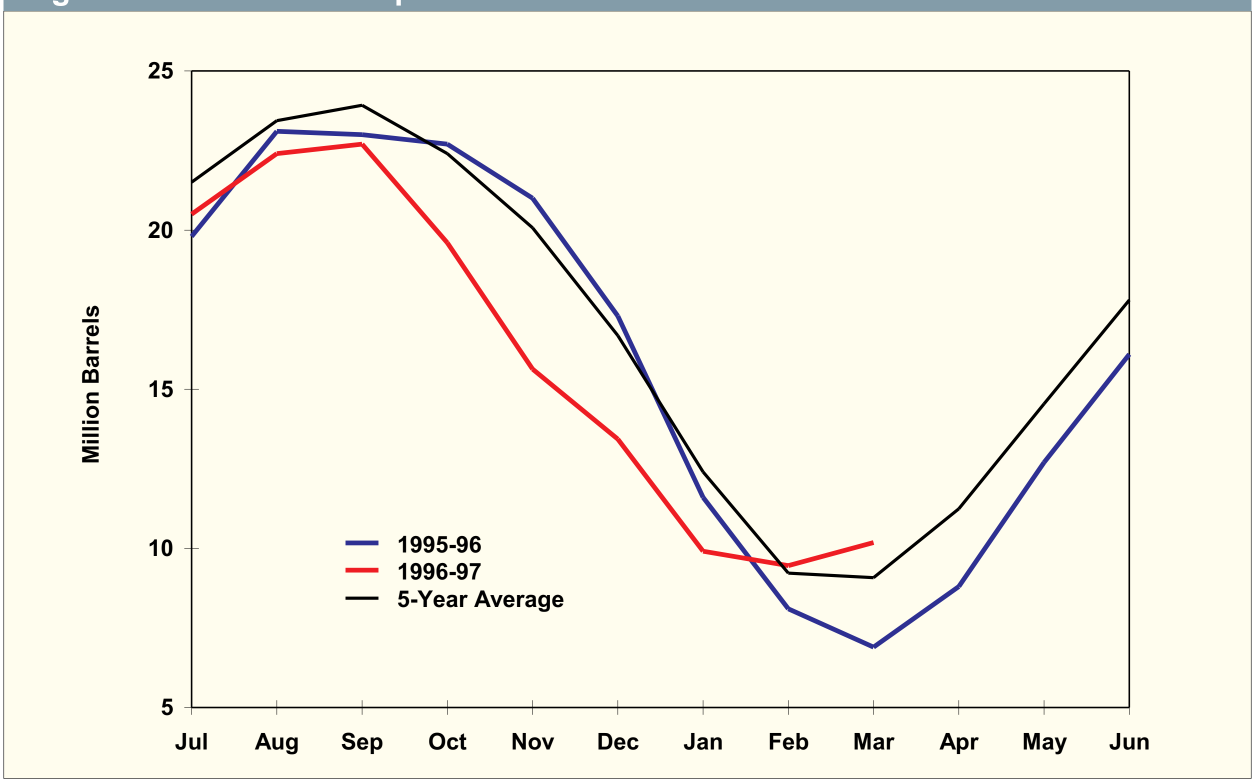
At the beginning of the heating season (end of September), the inventory shortfall was coming from PADD 3 (Gulf Coast), which stood almost 23 percent below its 5-year average stock level for the month. All other regions were closer to normal levels. PADD 2 stood at 22.7 million barrels, just under the 1995 level of 23 million barrels, and 5 percent below the 5-year average (Figure 5.6).

Figure 5.5 U.S. Propane Stocks



Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues, and Form EIA-807, "Propane Telephone Report."

Figure 5.6 PADD 2 Propane Stocks



Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109, various issues, and Form EIA-807, "Propane Telephone Report."

Winter Inventory

PADD 3 experienced smaller-than-normal draws in October and November, and ended the months at about 14 percent and 11 percent below average respectively. Finally in December, PADD 3 recovered to only 1 percent below the December five-year average. Some slippage occurred in January that put PADD 3 back to 7.0 percent below average, but the end of winter was in sight.

PADD 2 (the Midwest) had the opposite experience of PADD 3. The PADD 2 demand surges in October and November pulled regional stocks down from slightly below average to 22 percent below average. End-of-November stocks were 15.6 million barrels, which was 5.4 million barrels below November 1995 levels. Stocks in the Midwest normally supply about one-fourth of demand during the peak demand months of December, January and February. Thus, the Midwest was potentially facing the need to draw about 10 million barrels more of stocks over the next three months. Such a draw would bring end-of-February stocks down to 5.6 million barrels. The lowest stocks recorded for PADD 2 were 5.7 million barrels in March of 1970. With cold weather continuing, at the end of November, concern over supplies for the Midwest was very high.

Midwest December demand fell below November's, and was below 1995 December demand, but it stayed above the 5-year average for the month. Continued strong imports and increases of deliveries from other PADDs into the region helped to slow the stock fall, but by the end of January, stocks were still low at 10.3 million barrels, which is over 17 percent below the five year average. February brought relief, as demand fell back by more than 100 thousand barrels per day. PADD 2 stocks ended February at 9.7 million barrels, 6 percent above the five-year average.

1996 Winter Prices Rose with Crude Oil, but Midwest Prices Spiked

The price runup in 1996 can be explained by looking at the spot price increases that occurred during two time periods, the fall (August through early November) and November through January. The two major spot markets, Mont Belvieu and Conway, behaved similarly during the first period, but split apart dramatically during the second.

As August began, PADD 3 stocks were running particularly low. In addition, crude oil prices began to increase (see box). In response to the combined influences of the underlying crude oil prices and propane supply and demand developments described above, spot propane prices began to rise gradually in August from their steady summer levels at about 35 cents per gallon. Crude oil prices continued to climb fairly steadily through October. By the traditional starting point of the heating season on October 1, the spot price for propane had surpassed 50 cents per gallon at both Mont Belvieu and Conway, 20 cents and 17 cents, respectively, higher than the same point the year before.

During October and November, however, PADD 2's very high demand drew its stocks down to over 22 percent below average. This caused the Conway market to pull apart from the Mont Belvieu market in November, giving rise to a 6-cent-per-gallon Conway premium on average for the month.

Crude Oil Prices Increased Significantly in 1996

As discussed in Chapter 4, movement in crude oil prices has an impact on propane prices, but the linkage is typically less direct than for gasoline or distillates. Since only about half of propane is derived from crude oil refining, and less from natural gas processing, and propane does not constitute a major product of either industry, propane prices are somewhat insulated from those of either raw material.

World crude oil price levels increased strongly in early 1996, as a late-winter cold spell boosted heating fuel demand, increasing refinery runs and creating a strong draw on already-low crude oil inventories. After peaking in late April, crude oil prices eased through mid-summer, but began to rise again in early August. Repeated delays in the long-expected return of Iraqi crude oil exports, along with rising world demand and persistently low stock levels, pushed prices up nearly $5 per barrel over a 3-month period. Crude oil prices fell back somewhat in late October, but surged again through the end of the year, with the spot price of West Texas Intermediate (WTI) peaking at $26.55 per barrel, the highest level since the Gulf War in 1991.

In January, crude oil prices again began to soften, as limited Iraqi crude oil sales began to reach the market, and as milder weather in the United States (and in Europe) allowed refiners to perform maintenance that had been delayed in the fall. WTI spot prices fell over $6 per barrel from their year-end peak to the end of March, and were continuing to decline in early April.

The stage was set for what occurred next in December. Resupply is difficult after an early winter stock withdrawal, since production remains relatively constant, and increased imports take time to arrive. PADD 2's stocks were very low at the end of November, and because PADD 2 normally supplies about one-fourth of its demand from stocks through the peak months of December through February, concerns were running high over supply adequacy for the rest of the winter. It appeared that there were less than 9 million barrels of stocks over working levels. Normally, December through February draws average 10 million barrels. In a period of less than 4 weeks through December 3, the Conway propane spot price nearly doubled, jumping 46 cents to 97.5 cents per gallon. The cold was not showing any signs of quickly abating, and in mid-December, weather forecasts showed that arctic temperatures were expected to persist through January. Following the initial peak in early December, prices corrected rapidly downward for a week, then rose to a second peak in mid-month, following the long-term weather forecast, with the Conway spot price reaching the highest level on record at 107.5 cents per gallon. This was 37 cents per gallon over Mont Belvieu.

During December, Mont Belvieu showed more strength than the movements in crude oil would normally have implied. Some pressure may have been coming from the stock situation in PADD 3, but although Mont Belvieu stocks were low, the regions it serves experienced mild December weather, and stocks were getting closer to normal levels. Mont Belvieu showed additional upward price pressures in response to Conway. Despite the difficulty of moving product directly from the Gulf Coast to the mid-continent, the differential between the two grew large enough for suppliers to move product between regions by truck or rail, pulling prices on the Gulf Coast up slightly, even though the small Koch pipeline that connects the two storage centers was shut down for most of the winter following an explosion near Dallas on August 24.[3]

Shortly following the mid-December weather forecast, warm weather arrived and new forecasts indicated moderating temperatures. Marketers' concerns over supply uncertainty relaxed, and Conway prices fell rapidly. Prices also fell at Mont Belvieu in the last half of December, as milder temperatures allowed overall U.S. inventories to approach year-ago levels. After one more brief uptick in the first week of January, spot propane prices at both major centers continued to declined rapidly, falling below 40 cents at both Mont Belvieu and Conway by the beginning of February. Spot markets were uneventful for the remainder of the heating season, as continued mild temperatures and the lull in petrochemical demand due to high prices pushed stocks above 1996 levels in all regions.

Terminal (Rack) Propane Prices

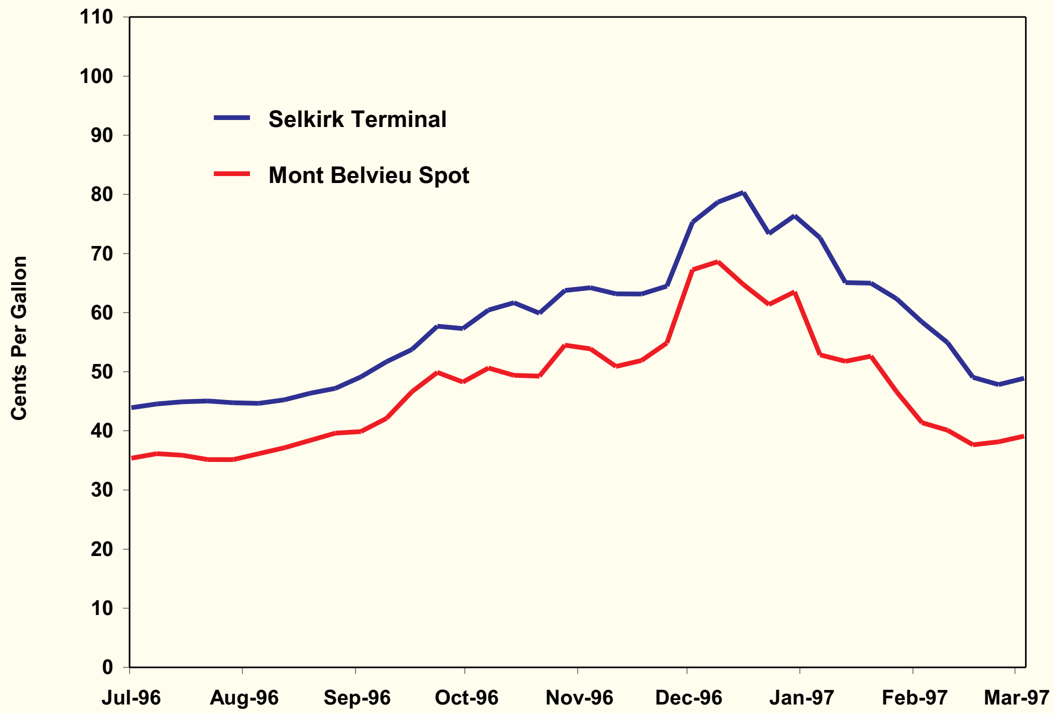
Terminal prices tracked spot prices fairly closely, even at those terminals at the ends of the major pipelines like Lemont, IL and Selkirk, NY. While there is some delay, the speed with which spot price changes are reflected at the terminal is shown in the weekly prices of Figure 5.7 and 5.8. Most dealers turn their tanks around in several days, so they would have emptied and filled their storage 2 or 3 times between weekly price quotes, which is one of the reasons price changes are reflected so quickly at the terminals. Even at Selkirk, which is served by Mont Belvieu, price changes are reflected quickly, albeit slightly slower than at Lemont.

Residential Propane Prices

Propane prices at the retail level over the past winter followed the regional trends seen in spot markets, with delays reflecting the logistical and financial pass-through of higher product costs. Weekly residential prices collected under the EIA/State Heating Oil and Propane Program (SHOPP) showed prices in PADDs 1 and 2 reaching the highest levels recorded since propane was added to the program in the fall of 1990 (Figure 5.9).

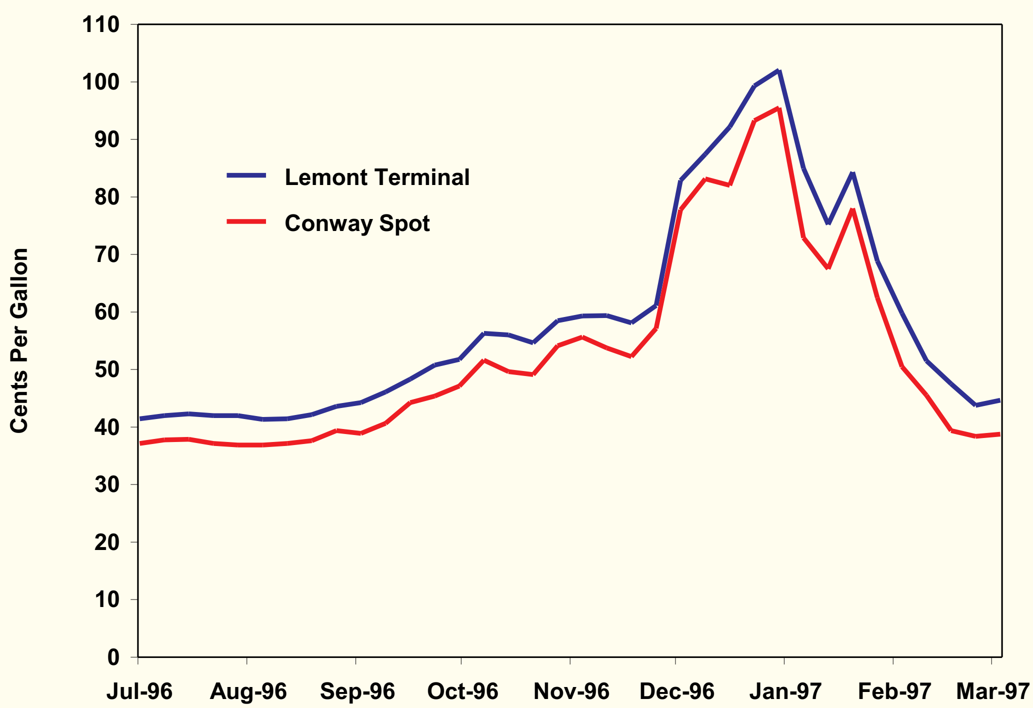
3 Weekly Propane Newsletter, Volume 26, Number 36, Butane-Propane News, Inc. (Arcadia, CA, September 3, 1996) p.1.

Figure 5.7 Mont Belvieu Spot and Selkirk Terminal Propane Prices, 1996-97



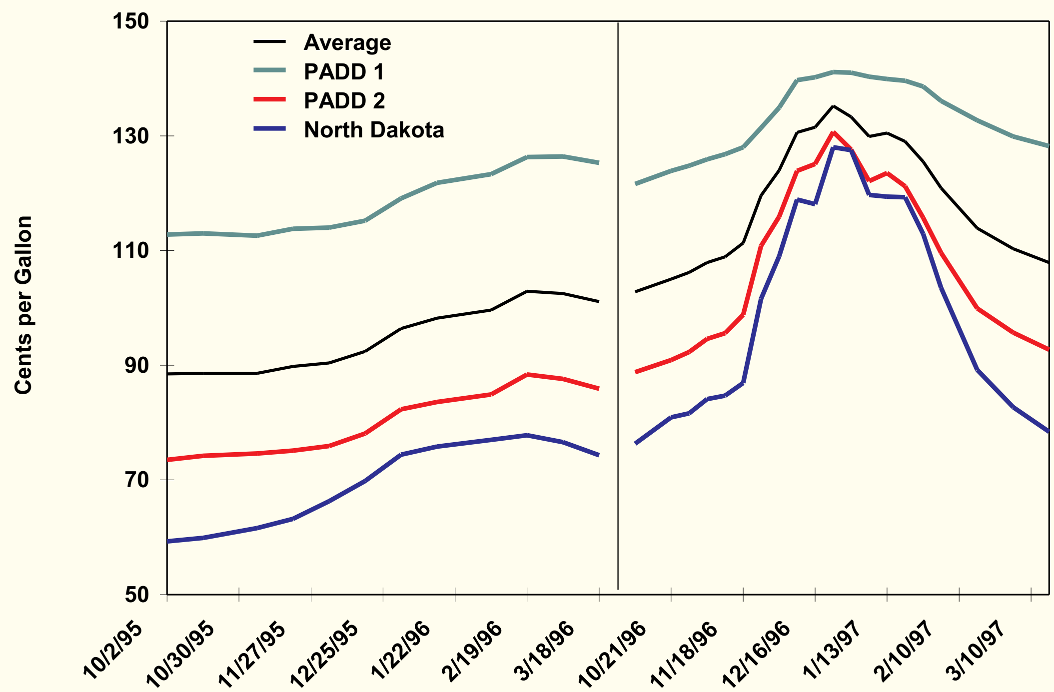
Source: Spot-Standard and Poor's Platt's; Terminal-Oil Price Information Service.

Figure 5.8 Conway Spot and Lemont Terminal Propane Prices, 1996-97



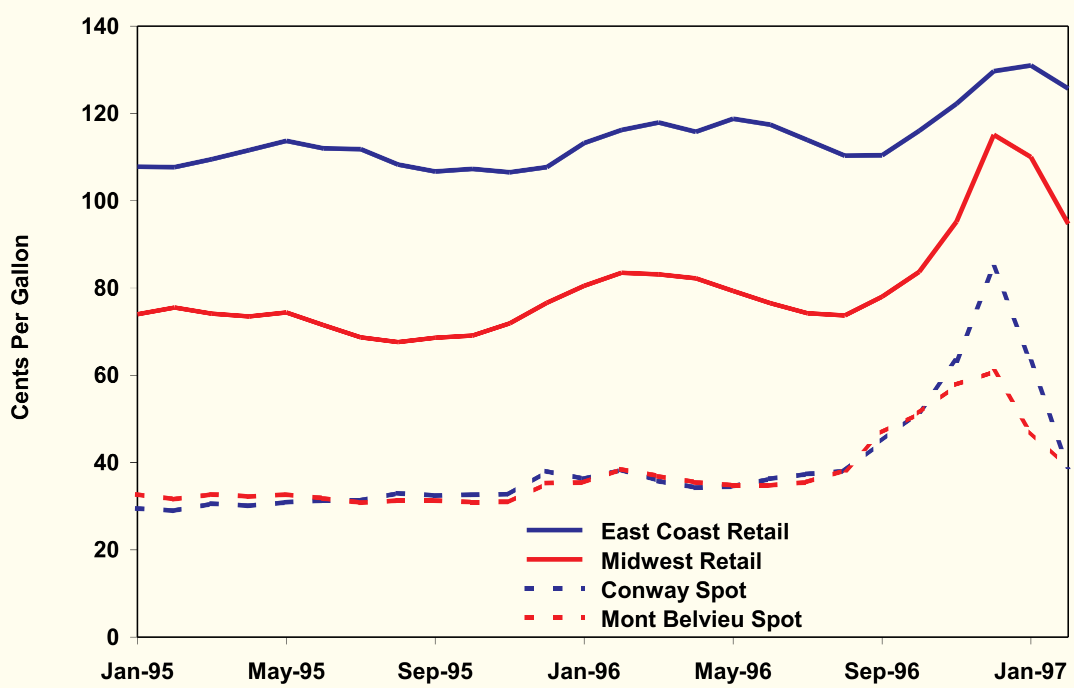
Source: Spot - Standard and Poor's Platt's; Terminal - Oil Price Information Service.

Figure 5.9 SHOPP Residential Propane Prices, 1995-97



Source: Energy Information Administration, State Heating Oil and Propane Program.

Figure 5.10 Retail and Spot Propane Prices, 1995-97



Source: Retail - Energy Information Administration; Spot - Reuters Ltd.

Residential propane prices began the 1996-97 heating season near the levels at which they had ended the previous season in March 1996. Although prices at all levels had declined significantly over the summer, the increases in spot and rack prices that had already occurred by October were reflected in the first seasonal collection of SHOPP prices.[4] As the season progressed, the regional residential price averages quickly began to reflect the rapid increases in underlying wholesale prices, especially in PADD 2. Not surprisingly, the states that experienced the largest percentage price increases during the winter were in the Midwest. North and South Dakota both experienced almost a 68 percent increase between October and December. North Dakota's price began October at 76.3 cents per gallon and peaked at $1.28 on December 23. South Dakota was not far behind, beginning October at 70.8 cents per gallon and peaking near the end of December at $1.19. Iowa and Wisconsin were next, increasing 64 percent and 57 percent respectively.

On average, households who used propane for space heating spent more to heat their homes during the 1996/97 heating season than in recent past seasons. Based on heating degree-days (see Figure 5.3), the Midwest was about 2.0 percent colder than normal during the 1996/97 winter season. Using the Residential Energy Consumption Survey data, consumers in the Midwest typically use 908 gallons of propane per year for space heating. Adjusted for heating degree-day usage, these same consumers would have used 917 gallons of propane this past winter. Using a 5-year average residential propane price of 76.3 cents per gallon from the SHOPP survey, a Midwest consumer would have paid approximately $691 to heat their home with propane. During the 1996/97 heating season, Midwest consumers paid an average residential price of 105.8 cents per gallon, or a total of $970, to heat their homes with propane. This was an increase of $278 or roughly 40 percent more on space heating than during a normal season.

Households in the Northeast also spent more on propane, but their increase in expenditures was much less. A typical household in the Northeast uses 580 gallons of propane for space heating. Based on heating degree-days, this same household would have used 555 gallons during the 1996/97 heating season, since this past winter was warmer than normal for this area of the country. The 5-year average residential price in the Northeast was 120.6 cents per gallon. Therefore, Northeast consumers would expect to pay roughly $699 for propane space heating. The average 1996/97 price was 135.5 cents, which resulted in Northeast consumers expending $752, $53 (8 percent) more than in past heating seasons.

Fuel cost increases such as those seen this past winter had a significant impact on those consumers with fixed incomes or those qualifying for federal assistance. In the Midwest, where cost increases were highest, approximately 27 percent of the households who use propane were eligible for LIHEAP. Although cost increases in the Northeast weren't nearly as severe, about 22 percent of this region's propane-using households were eligible for LIHEAP.

4 The SHOPP semi-monthly survey of residential prices is only conducted from October through March, as a cooperative effort with various State agencies. Last winter, prices were collected weekly from mid-October through early February because of price volatility. EIA also collects monthly retail prices throughout the year on all major petroleum products, including propane, in order to fulfill its broad mandate for comprehensive price statistics.

The typical pattern in pass-throughs of petroleum product prices from wholesale to retail is that wholesale increases and decreases are reflected with some delay in retail prices. However, when rapid changes occur in spot markets over short time frames (i.e., days) the full increase is never seen at retail, because the market reverses before retail prices have fully absorbed the increases. That pattern generally held true during the 1996-97 heating season, as retail markets reached their peak about a week after spot prices, but in the extreme case of PADD 2, fell about 15 cents short of the rise in the Conway spot market, which supplies most of the region.

On a monthly average basis, the sharp fluctuation in Conway prices is reflected in the Midwest retail market (Figure 5.10). While the Midwest retail market peaked in December with the spot market, the lag effect dampened the retail increase. As the spot market fell back quickly in January, the January downturn pulled the retail off from its peak, even though retail prices were still feeling some effects of the sharp increases in December. The slower movements in the Mont Belvieu market carried into the East Coast market with characteristic lags. The East Coast market peaked in January, one month after the Mont Belvieu market.

Government Actions Provided Market Information and Financial Assistance

The price runup at Conway this past winter was an illustration of the psychology that can drive prices when supply concerns emerge. No shortages occurred, but fear of shortages in markets like propane where little near-term re-supply capability exists can have a large impact on price. During the 1996/97 heating season, the federal government took a number of measures to keep the American public informed of changes in the propane market. In addition to releasing data on a more timely basis and preparing numerous reports, articles, and presentations via publications, fax, and the Internet, other efforts and programs were utilized as follows:

- The State Heating Oil and Propane Program - A cooperative agreement between EIA and twenty-four State Energy Offices located in the Northeast and Midwest. State Energy Offices collect residential propane and heating oil prices during the winter heating season. The data, collected on Mondays, are transmitted to EIA where they are published each Friday in publications and via the Internet. The survey is conducted twice a month; however, during the 1996/97 heating season, the collection cycle was changed to weekly to monitor the volatility of the residential propane and heating oil prices. The SHOPP program allows States to set up energy programs to track market conditions in their State.
- The Energy Emergency Communications Protocol - An agreement between DOE/EIA and the National Association of State Energy Officials (NASEO) establishing a communications protocol during energy emergencies. The agreement contains a communication plan which outlines the tools, data requirements, and responsibilities of each organization during energy disruptions. Through use of an electronic energy information mailbox and telefaxes, DOE/EIA was able to receive as well as provide information to State Energy and Emergency Management Offices regarding any concerns and/or problems associated with transportation logistics, motor carrier driver waiver restrictions, refinery problems, and heating fuel shortages.

- Federal Agency Coordination Efforts - DOE worked very closely with various Federal agencies in coordinating programs used to aid American citizens. For example, the DOE worked with the Department of Transportation to streamline paperwork in the event truck driver hour waivers were needed. DOE/EIA and the Department of Health and Human Services (HHS) were actively involved in monitoring the release of LIHEAP funds. EIA was able to provide residential heating oil, propane, and natural gas price information to HHS to aid them in determining allocations for release of emergency contingency funding. As a result, an early release of emergency home energy funds amounting to $5 million was approved for North and South Dakota. Later, President Clinton released an additional $210 million to cover total U.S. needs. DOE/EIA also worked closely with NASEO and trade associations such as the National Propane Gas Association to keep communication lines open between dealers and State energy representatives.

- Conference calls - This past heating season DOE/EIA participated in numerous conference calls with States located in the Midwest and Northeast. The calls were initiated to help State agencies exchange information regarding escalating propane and heating oil prices. Information was also exchanged regarding Low Income Housing Energy Assistance (LIHEAP). The calls kept States abreast of actions regarding release of the LIHEAP funds. States were also able to exchange information with respect to programs such as summer fill.

- Conferences and meetings - Each fall the DOE/EIA cosponsors the Winter Fuels Conference with . The Conference provides energy officials with information about heating fuels outlooks for the upcoming heating season and encourages officials to exchange information relevant for monitoring energy information. In addition, each preseason EIA sponsors the State Heating Oil and Propane Meeting for States who participate in the SHOPP program. Last fall, EIA also participated in the North Atlantic Regional meetings held with State, transportation, and industry officials in the New England region to obtain and exchange information regarding propane and heating oil supplies for the upcoming heating season.

6. Conclusion and Outlook

Propane has become an increasingly significant element in U.S. and world energy markets in recent years. It has long proven its versatility as a fuel for space heating and other residential uses, for industrial and agricultural applications, and for internal combustion engines. The single largest demand sector for propane is as a feedstock for petrochemical manufacturing.

The fall 1996 period was the fourth time in the past decade in which propane prices rose rapidly over a very short period of time. Spot propane prices at Mont Belvieu, Texas, and Conway, Kansas, the major propane storage and distribution centers in the United States, rose together from about 36 cents per gallon at the beginning of August to 50 cents by the end of September, the traditional beginning of the heating season (Figure E.1). Propane prices stood at the highest pre-season levels since 1990. They continued to rise through October, and in November, Conway prices soared, peaking at 107.5 cents per gallon on December 16. Mont Belvieu prices stayed high, but did not follow Conway's rapid ascent, peaking at 70.3 cents on December 3. Both Conway and Mont Belvieu prices fell in mid-December, with Conway falling faster and reaching parity with Mont Belvieu by mid-February. Retail prices downstream from Conway and Mont Belvieu lagged behind changes in spot markets with significant regional differences, but all propane prices returned to more seasonal levels by March.

EIA's analysis concluded that winter 1996-97 propane market behavior can be explained by a combination of fundamental market factors, as follows:

- **The propane price increase from August through early November appeared to be due to price increases in crude oil, low stocks at the beginning of the heating season, and diminished prospects for late stock recovery, mainly as a result of strong demand in the Midwest.**
  - Since crude oil is a major propane feedstock, propane prices generally follow significant crude price movements. Crude oil prices increased over $5 per barrel from late July to mid-October, with propane keeping pace.
  - Propane prices are also sensitive to early-winter stock levels, because stocks are an important supply source during the peak heating season. U.S. propane stocks normally supply about 20 percent of demand during the high-demand months of December, January and February, compared to distillate stocks, which supply about 12 percent of demand during these same months. Nationally, propane inventories at the end of September were at their third lowest level for the start of the winter heating season. Most of the shortfall was on the Gulf Coast, and was the result of a slightly below-average summer stock build and a low starting level at the end of winter 1995-96. Cold weather and late crop-drying needs boosted demand in the Midwest (PADD 2) in October, dashing any hopes of a late stock recovery.
  - Domestic propane supply is relatively inflexible, compared to other heating fuels, because propane is produced as a by-product of both petroleum refining and natural gas processing.

Increased import/export flows can require weeks to meet resupply needs, and may only come at high prices, based on world market conditions.

– Demand is also relatively inflexible. Residential/commercial and agricultural demands are largely determined by weather, and little fuel switching capability exists. The petrochemical sector, however, generally acts to moderate market stress. Financial incentives stimulate this sector to reduce propane use when propane prices rise relative to other petrochemical feedstock prices. From August through December 1996, petrochemical use of propane dropped by over 130 thousand barrels per day in response to price increases.

- **Continued high crude oil prices supported both Mont Belvieu and Conway prices through the remainder of the winter. However, Conway prices rose much more rapidly than those at Mont Belvieu, due to colder-than-normal weather in the Midwest through December, following extraordinarily strong Midwest demand in October and November that depleted Midwest stocks prior to the peak demand months.**

– Crude oil prices remained high through December, providing no relief to propane prices. Crude prices alone probably would have kept propane prices through December higher than those of the previous year, but other factors caused propane prices to rise well above the crude oil influence.

– The Midwest started the heating season with stocks only slightly lower than normal, but high demand in October and extraordinarily high demand in November from crop drying and unusually cold weather drew PADD 2 stocks down to 22 percent below its 5-year average by the end of November. A similar situation, though with some differences in timing, occurred in late 1992 and early 1993. In the Midwest, stocks supply about 25 percent of demand during the months of December through February, and the upper Midwest is relatively isolated from Mont Belvieu supplies. End-of-November stock levels in the Midwest were not high enough to sustain even normal stock draws during the next three months without dipping below minimum working stock levels.

– With forecasts for very cold weather to continue, and the inherent inflexibility of the supply system to provide additional stocks quickly, marketers rushed to obtain available supplies, bidding up Conway prices well above Mont Belvieu in November and December. The price difference rose high enough to attract some rail and truck transportation from Mont Belvieu. Mont Belvieu prices were pulled higher in response to Conway, despite the fact that areas served by Mont Belvieu had experienced a mild December, which allowed Mont Belvieu stocks to recover toward normal levels.

– Finally, in December, as temperatures in the Midwest returned to more seasonal levels, and those in the rest of the country were warmer than normal, prices began to fall. By January, even though major areas in the Midwest were still colder than normal, the mild weather in areas outside the Midwest, coupled with falling crude oil prices, caused both Mont Belvieu and Conway prices to tumble rapidly back to more normal levels.

This examination of propane supply, demand, and market conditions during the winter 1996-97 contains implications for future heating seasons. Without significant and unexpected improvements in industry infrastructure (e.g., increasing pipeline capacity between major storage hubs or secondary storage capacity), U.S. propane markets, particularly in PADD 2, will likely continue for the foreseeable future to be susceptible to the type of regional supply squeeze that was seen during the past winter. Propane demand is expected to continue to grow at a slow but steady pace, while domestic propane production is limited by refinery capacity and natural gas production.

Infrastructure improvements are very expensive, particularly for gas liquids, which must be stored in pressurized tankage. Finally, options available to consumers are limited, as home storage tanks are most often owned and controlled by suppliers.

The outlook for propane supply and prices during the 1997-98 heating season, based on limited indicators available at this time, appears to be significantly more favorable for consumers than that of the past winter. Several factors drive this assessment:

- **World crude oil price levels, underlying all petroleum product markets, are widely expected to be significantly lower in the fall of 1997 than in 1996.** While average fourth quarter 1996 world crude oil prices were more than $6 per barrel above the previous year, EIA forecasts fall 1997 prices to reflect a decline of more than $3.50 per barrel from 1996. A building surplus in world crude oil supplies, as rising production outstrips demand, has resulted in a drop of over $6 per barrel since the beginning of the year, with prices expected to stabilize somewhat over the remainder of 1997.
- **Assuming the return of both heating demand and the size of the corn crop to average levels, fall propane demand in PADD 2 should be well below the record levels seen in 1996; however, PADD 2's demand declines could be tempered by demand increases in PADDs 1 and 3, which experienced warmer-than-normal temperatures this past winter.** PADD 2 demand in October and November 1996 was 23 percent greater than the 5-year average, fueling the strong stock draw that pushed regional prices to historical highs. A presumed return to normal seasonal demand levels would remove a major potential source of regional price pressure. In spite of PADD 2's colder-than-average weather, the U.S. in total experienced a warmer-than-normal winter. Normal weather next winter could result in higher total propane demand than that seen in winter 1996/97, which would keep U.S. average prices from declining as much as the other factors discussed on this page might imply.
- **The significantly higher season-ending propane stock levels in March 1997, compared to the previous spring, should allow for higher beginning stocks this fall than in 1996.** Despite a relatively normal 1996 off-season stockbuild, the low spring stocks carried over to similarly diminished starting inventories for winter 1996/97. Propane stocks ended this winter about 4.4 million barrels higher than the previous year overall, including a 3.3-million-barrel surplus in PADD 2 alone. Assuming a typical summer build, propane inventories could enter the 1997-98 heating season above the 5-year average level both nationally and in the vulnerable PADD 2 region. Thus, even though a return to normal temperatures nationwide may mean higher demand in PADDs 1 and 3 next winter than winter 1996/97, stocks in all areas are likely to be at or above normal levels, and thus able to serve the higher demand adequately.
- **High levels of refinery inputs expected through this spring and summer, in order to meet gasoline demand, will also result in higher domestic propane production.** If refinery runs reach expected levels, as much as 6 thousand barrels per day of additional propane will be produced, further facilitating the summer stockbuild.

In short, with pre-season stocks expected to be above average relative to recent history, and Midwest demand not likely to repeat last winter's early surge, propane markets may be well-supplied during the peak portion of next winter's heating season.

Appendix A. Ethylene Steam Cracker Plant Feedstocks

Company	Location	Total Nameplate Capacity (MTY[1])	Typical Feedstock or Feedstock Mixture On Which Listed Capacity is Based (Percent)					
			Ethane	Propane	Butane	Naphtha	Gas Oil	Other
Amoco Chemical	Chocolate Bayou, TX	1,426,000	40	45		15		
Chevron Chemical	Baytown, TX	680,272	25	50	15	10		
Chevron Chemical	Port Arthur, TX	453,515	70	30				
Condea Vista	Lake Charles, LA	419,501	100					
Dow Chemical	Freeport, TX	884,354	50	50				
Dow Chemical	Plaquamine, LA	1,102,041						
DuPont	Orange, TX	589,569	100					
Eastman Chemical	Longview, TX	657,596	20	74	5	1		
Exxon Chemical	Baton Rouge, LA	850,000						
Exxon Chemical	Baytown, TX	950,000						
Formosa Plastics	Point Comfort, TX	680,000						
BF Goodrich	Calvert City, KY	159,090						
Huntsman Corp	Port Arthur, TX	551,364				60		40 (LPG)
Huntsman Corp	Port Neches, TX	136,364						Ref gas/EP Mix
Javelina	Corpus Christi, TX	90,703						Ref gas
Koch Industries	Corpus Christi, TX	136,364						
Lyondell	Channelview, TX	816,327						
Lyondell	Channelview, TX	818,182						
Mobil Chemical	Beaumont, TX	566,893	60	10	20	10		
Mobil Chemical	Houston, TX	294,785	90	10				
Occidental Chemical	Chocolate Bayou, TX	500,000				75	25	

1 Metric tons per year.

Occidental Chemical	Corpus Christi, TX	772,727	15	30		35	20	
Occidental Chemical	Lake Charles, LA	363,636	50	50				
Phillips Petroleum	Sweeny, TX	1,632,653	80	15	5			
Quantum Chemical	Clinton, IA	435,374	80	20				
Quantum Chemical	LaPorte, TX	680,272	60	40				
Quantum Chemical	Morris, IL	480,726	80	20				
Rexene Products	Odessa, TX	230,000						
Shell Chemical	Deer Park, TX	829,932	10		10	50	30	
Shell Chemical	Norco, LA	371,882	50			50		
Shell Chemical	Norco, LA	743,764				60	40	
Sun Co	Marcus Hook, PA	102,041						
Sun Co	Brandenburg, KY	45,351						
Union Carbide	Seadrift, TX	414,966	60-80	20-40				
Union Carbide	Taft, LA	680,272	0-30	0-50		50-100		
Union Carbide	Texas City, TX	680,272	60-80	20-40				
Union Texas Petrochemicals/GE Petrochemicals/ BASF)	Geismar, LA	545,000	85	15				
Westlake Polymers	Sulphur, LA	454,545						
TOTAL U.S.		22,226,332						

Source: *Oil and Gas Journal*, May 13, 1996, pp 68-69

Appendix B. Quantitative Explanation of Propane Market Price Passthrough

Using industry and EIA data, an analysis was undertaken to begin exploring the speed of price change passthroughs from the spot market to the terminal and resale level and from the resale level to the residential level. The results reported below are preliminary in nature, and were done to form the basis for more formal research on pricing mechanisms in product markets.

Preliminarily we found nearly all of a spot price change is passed through to the terminals in the first 3 weeks, with 60 to 80 percent of the change occurring during the same week of the spot price change. Our results also indicate that the price passthrough from spot to resale level will be complete in two months with about 60 percent of the change occurring in the same month. The adjustment of residential prices to changes in resale prices is also relatively fast, with the majority of the change being passed through during the current month.

The first item of investigation was to determine how fast a change in spot prices will be reflected at pipeline terminals. This econometric investigation used weekly terminal data published by Oil Price Information Service (OPIS) and spot data published by Reuters. The OPIS terminal data is normally published as an average of rack price on the first working day of the week, however some gaps in this data were filled in using data from the previous Thursday. Since the vast majority of the data are a full week apart, the few temporally unequally spaced data should have negligible effects on the validity of the time series methods used in this study. The spot data were taken from the working day prior to the reported rack data.

Prices were used from three major terminals at various locations along the Texas Eastern Transmission (TET) pipeline (a major feeder into PADD 1) in order to determine if there were any differences in the speed of change as a function of distance from the hub (Mont Belvieu). The terminals chosen, and listed in order of increasing distance from the Mont Belvieu were Princeton, IN, Todhunter, OH and Selkirk, NY. Prices from two major terminals in PADD 2 which are fed from the Conway, KS hub were also used: Lemont, IL (ELPC pipeline) and Pine Bend, MN (Mapco pipeline).

The weekly price series used were not a weekly average, but rather daily prices gathered on a particular day of the week. Investigation of the time series properties of the price data was performed in order to assist in specifying the form of the model; for example, data with unit root properties are best analyzed using first differences, whereas stationary series can be estimated in level form. Augmented Dickey-Fuller (ADF) tests indicated that both the Conway spot data series and the PADD 2 prices probably don't have unit roots (test statistic close to the rejection value for 5% level) , whereas the ADF test could not reject units roots (even at the 10% level) for Mont Belvieu spot and TET pipeline prices. Since all series had a strong autoregressive component first differences were used for the regression analysis. For this study we were interested only in the short run dynamics of price changes, so testing for cointegration was not done and error correction models were not used. The basic linear model used to investigate the passthrough of spot price changes to terminals is shown in Equation. B1.

Equation B1

$$\Delta PT_t = C + \sum_{i=0}^{5} \Delta PS_{t-i} + \sum_{i=0}^{2} \Delta HO_{t-i} + U_t$$

Where:

PT_t is the Monday terminal price for week t

PS_t is the Friday spot propane price for the week preceding the Monday terminal price

HO_t is the Friday spot heating oil price for the week preceding the Monday terminal price[1]

U_t is the random error term at time t

Δ Refers to current minus previous prices.

GARCH (Generalized Autoregressive Conditional Heteroskedastic) models were estimated because the variance of the prices was not constant during the time period. (see *The Econometric Modelling of Financial Time Series*, Terence C. Mills, Cambridge University Press, 1993, Chap. 4 & 5, for an introduction into ARCH/GARCH models). The estimation results are shown in Tables B1 and B2. Table B1 shows that the speed of adjustment seems to slow slightly the further the terminal is along the pipeline. Also, the explanatory power of the simple model used decreases as distance from the hub increases. Table B2 shows that the adjustment is more rapid for the terminals in PADD 2. These models provide a good fit both during time of price stability and during times of rapidly changing prices.

An attempt was also made to estimate the speed of adjustment of propane resale and residential prices using monthly EIA data from the Form EIA-782A,"*Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report*" and Form EIA-782B, "*Resellers'/Retailers' Monthly Petroleum Product Sales Report.*" This Resale/Residential data is a monthly average; correspondingly, monthly averages of Mont Belvieu and Conway spot prices were calculated from the daily prices. All these monthly data series were stationary but displayed a strong autoregressive component, actual prices (rather than first differences) were used in the estimation. The simple model used the price at a particular market level being explained as a (linear) function of the next lower level (eg.

1 Heating oil price is used as a surrogate for other variables (eg. weather, supply/demand balance, etc.) not explicitly included.

retail price = f(resale price)). The equation estimated for resale prices is shown in Equation B2, and the equation estimated for residential prices is shown in Eqation B3.

Equation B2

$$PWHO_t = C + \sum_{i=0}^{1} PS_{t-i} + AR,\ MA\ terms + U_t$$

Where:

$PWHO_t$ is the resale propane price for month t

PS_t is the average spot propane price for month t

AR, MA are autoregressive and moving average terms

U_t is the random error term at time t

Equation B3

$$PRET_t = C + \sum_{i=0}^{1} PWHO_{t-i} + AR,\ MA\ terms + U_t$$

Where

$PRET_t$ is the retail propane price for month t

$PWHO_t$ is the resale propane price for month t

AR, MA are autoregressive and moving average terms

U_t is the random error term at time t

Sufficient autoregressive and moving average terms were used to make the estimation residuals test as random variables (using the correlogram and Q-statistic). Table B.4 displays the results for resale prices and shows that a 10 cent change in spot price will be reflected in resale prices by a 6 cent change in the current month and an additional 3 cent change in the next month. The estimation results are shown in Tables B.3 and B.4. Table B.3 displays the regression results for the retail prices. These results are less reliable; with the autoregressive components indicating that a more elaborate model with additional explanatory variables will be required for more conclusive results. Nonetheless, it appears that between 5 and 9 cents of a 10 cent resale price change will be passed through in the current month.

Table B.1 ARCH Regression Results for Terminal Prices on TET Pipeline
Weekly Prices from October 1, 1993 to March 3, 1997

	Change in Terminal Price (dependent variable)		
Parameter	Princeton, IN	Todhunter, OH	Selkirk, NY
ΔSPOTMB(t)	0.705***	0.629***	0.617***
	(0.026)	(0.020)	(0.024)
ΔSPOTMB(t-1)	0.341***	0.346***	0.363***
	(0.033)	(0.029)	(0.035)
ΔSPOTMB(t-2)	0.125***	0.191***	0.119***
	(0.040)	(0.035)	(0.039)
ΔSPOTMB(t-3)	0.049	0.071*	0.078*
	(0.043)	(0.040)	(0.041)
ΔSPOTMB(t-4)	0.050*	0.092***	0.077***
	(0.027)	(0.023)	(0.029)
ΔSPOTMB(t-5)	0.012	-0.042	-0.004
	(0.036)	(0.030)	(0.039)
ΔSPOTHO(t)	-0.009	-0.012	-0.021
	(0.015)	(0.014)	(0.019)
ΔSPOTHO(t-1)	0.030*	0.041***	0.035*
	(0.017)	(0.014)	(0.020)
ΔSPOTHO(t-2)	-0.027	-0.014	-0.026
	(0.017)	(0.015)	(0.016)
ARCH(1)	0.695***	0.868***	0.778***
	(0.187)	(0.225)	(0.194)
GARCH(1)	0.430***	0.367***	0.402***
	(0.120)	(0.104)	(0.119)
adj. R^2	0.748	0.662	0.463
F-Statistic	44.6	29.7	13.6
D.W. Statistic	2.83	2.69	2.68

The general form of the linear model is shown in Equation B1.
All prices in cents per gallon.
Δ is the weekly change.

SPOTMB is the spot price of propane at Mont Belvieu, TX.
SPOTHO is the spot price of heating oil at N.Y. Harbor.
The (t), (t-1),..., (t-5) refer to current and lagged values.

Standard errors appear in parentheses below parameter estimates.
*** indicates significant at 1% criteria (p-value < 0.01).
* indicates significant at 10% criteria (p-value < 0.10).

Table B.2 ARCH Regression Results for Selected Pipeline Terminal Prices
(Weekly Prices from October 1, 1993 to March 3, 1997)

Parameter	Change in Terminal Price (dependent variable) Lemont, IL	Pine Bend, MN
ΔSPOTCON(t)	0.837***	0.818***
	(0.013)	(0.008)
ΔSPOTCON(t-1)	0.114***	0.128***
	(0.016)	(0.011)
ΔSPOTCON(t-2)	0.104***	0.043**
	(0.029)	(0.021)
ΔSPOTCON(t-3)	-0.019	0.081***
	(0.031)	(0.023)
ΔSPOTCON(t-4)	0.058**	0.085***
	(0.026)	(0.015)
ΔSPOTCON(t-5)	-0.070**	0.015
	(0.027)	(0.018)
ΔSPOTHO(t)	-0.019	-0.001
	(0.014)	(0.011)
ΔSPOTHO(t-1)	0.051***	0.010
	(0.015)	(0.011)
ΔSPOTHO(t-2)	0.006	0.027**
	(0.013)	(0.011)
AR(1)	-0.479***	-0.288***
	(0.073)	(0.069)
ARCH(1)	0.770***	1.658***
	(0.190)	(0.346)
GARCH(1)	0.362***	0.120
	(0.115)	(0.078)
adj. R^2	0.895	0.879
F-Statistic	116.2	98.4
D.W. Statistic	2.51	2.32

The general form of the linear model is shown in Eqation. B1.
All prices in cents per gallon.
Δ is the weekly change.

SPOTCON is the spot price of propane at Conway, KS.
SPOTHO is the spot price of heating oil at N.Y. Harbor.
The (t), (t-1),..., (t-5) refer to current and lagged values.

Standard errors appear in parentheses below parameter estimates.
*** indicates significant at 1% criteria (p-value < 0.01).
** indicates significant at 5% criteria (p-value < 0.05).

Table B.3 Regression Results for Price Passthrough to the Resale Level
(Monthly Prices from October, 1993 to December 1996)

Parameter	Resale Price (dependent variable) PADD 1	PADD 2	U.S.
CONSTANT	9.187*	6.286***	5.785*
	(4.678)	(2.272)	(2.726)
SPOTMB(t)	0.657***		0.618***
	(0.117)		(0.056)
SPOTMB(t-1)	0.363**		0.315***
	(0.146)		(0.075)
SPOTCON(t)		0.633***	
		(0.050)	
SPOTCON(t-1)		0.273***	
		(0.067)	
DIFCONMB(t)	0.089	-0.142	0.284***
	(0.117)	(0.094)	(0.065)
AR(1)	0.558***	0.276	0.583***
	(0.183)	(0.181)	(0.163)
MA(1)	0.518**	0.849***	0.726***
	(0.193)	(0.095)	(0.156)
adj. R^2	0.95	0.987	0.987
F-Statistic	140.6	581.3	552.5
D.W. Statistic	1.91	1.95	1.98

The general form of the linear model is shown in Eqation. B2.
All prices in cents per gallon.
SPOTMB and SPOTCON are the spot prices of propane at Mont Belvieu and Conway, respectively.
DIFCONMB is the price difference between Conway and Mont Belvieu.
The (t) and (t-1) refer to current and lagged values.

Standard errors appear in parentheses below parameter estimates.
*** indicates significant at 1% criteria (p-value < 0.01).
** indicates significant at 5% criteria (p-value < 0.05).
* indicates significant at 10% criteria (p-value < 0.10).

Table B.4 Regression Results for Price Passthrough to the Residential Level
(Monthly Prices from October, 1993 to December, 1996)

	Residential Price (dependent variable)		
Parameter	PADD 1	PADD 2	U.S.
CONSTANT	85.676***	36.169***	47.644***
	(4.552)	(4.247)	(7.225)
P!RESALE(t)	0.467***		
	(0.110)		
P!RESALE(t-1)	0.140		
	(0.129)		
P2RESALE(t)		0.833***	
		(0.111)	
P2RESALE(t-1)		0.230	
		(0.149)	
USRESALE(t)			0.578***
			(0.187)
USRESALE(t-1)			0.560**
			(0.240)
AR(1)	1.533***	1.375***	1.202***
	(0.149)	(0.167)	(0.236)
AR(2)	-0.838***	-0.692***	-0.542**
	(0.125)	(0.162)	(0.228)
MA(1)	-0.439*	0.070	0.229
	(0.234)	(0.252)	(0.276)
adj. R^2	0.874	0.969	0.919
F-Statistic	49.6	223	80.1
D.W. Statistic	2.09	1.98	1.94

The general form of the linear model is shown in Eqation. B3.
All prices in cents per gallon.
P!RESALE, P2RESALE, and USRESALE refer to the resale price of propane for PADD 1, PADD 2, and U.S., respectively.
The (t) and (t-1) refer to current and lagged values.

Standard errors appear in parentheses below parameter estimates.
*** indicates significant at 1% criteria (p-value < 0.01).
** indicates significant at 5% criteria (p-value < 0.05).
* indicates significant at 10% criteria (p-value < 0.10).