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Representation of LPG Retail Costs
TAFV Model Technical Note
DRAFT

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This note summarizes the treatment of the supply of Liquid Petroleum Gas (LPG or propane) in the Transitional Alternative Fuel Vehicle (TAFV) Model. While there is little dispute over current LPG retail price (1995 as defined here), two competing views of the price of LPG in the future exist. In recognition of this, we have created two different LPG price scenarios, lower LPG cost and higher LPG cost. The lower LPG cost scenario for 2010 tracks the lower plantgate and distribution costs embodied in the AFTM (version 0996) while the higher LPG cost scenario approximates the Annual Energy Outlook 1996. Only conversion and distribution costs differ between the two views. Feedstock, retailing, and taxes are the same for both the low and higher LPG cost views. Section I below details the component costs of LPG for 1995 and 2010 used in the model. Point estimates from the TAFV and other models and sources are presented in Section II.

I. Decomposition of TAFV Model Retail LPG Prices

The LPG retail "supply curves" for the years 1995 and 2010 embodied in the Transition to Alternative Fuels (TAFV) Model are shown in Figures 1 and 2. These estimates exclude state and federal taxes. The TAFV curves are not directly specified in the model as such; rather they are the net result of a variety of processes that lead to the production and delivery of LPG. Specifically retail LPG prices are composed of natural gas feedstock supply costs, conversion costs, distribution costs, retail markup, and retail fuel tax.[1] The separate components are discussed below. Also given in Figures 1 and 2 are point estimates from other models and sources at approximately zero LPG transportation demand.

[1] Excluded here is the effective costs to consumers of limited fuel availability which we treat as a non-price fuel attribute.

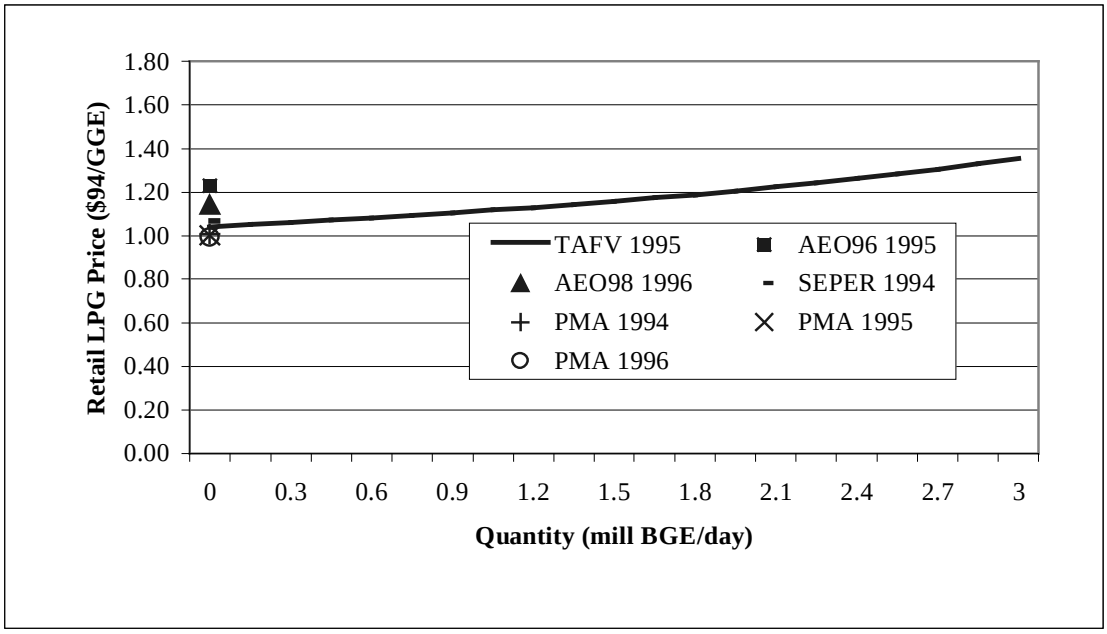

Figure 1: Retail transportation LPG price excluding tax. TAFV supply curve is net of other natural gas and LPG uses. PMA = Petroleum Marketing Annual, SEPER = State Energy Price and Expenditure Report, GGE = Gallons of Gasoline Equivalents, BGE = Barrels of Gasoline. Equivalents.

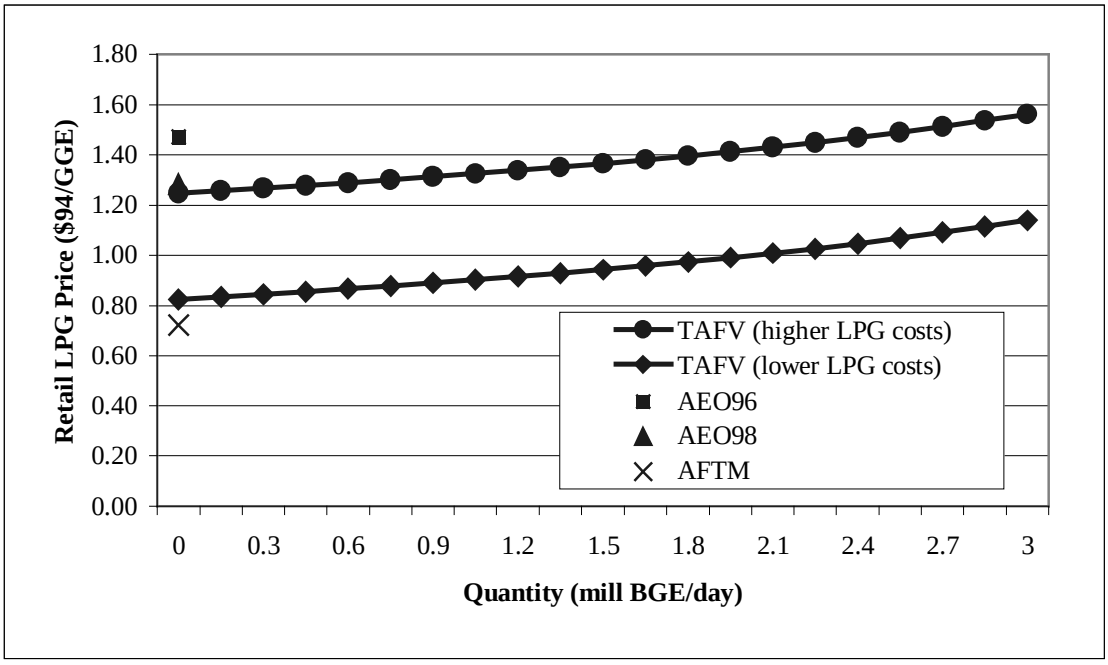

Figure 2: Retail 2010 transportation LPG price excluding tax. TAFV supply curves are net of other natural gas and LPG uses. GGE = Gallons of Gasoline Equivalents. BGE = Barrels of Gasoline Equivalents.

Feedstock Costs

Within the TAFV, LPG is derived from domestic and foreign natural gas. The TAFV uses a net natural gas supply curve (net of non-vehicle natural gas demand) to compute the feedstock costs for fuels derived from natural gas (methanol, CNG, and LPG). The slope or elasticity of the supply curve, for each year, was derived from the AFTM while the intercept reflects AEO projections. The AFTM forecasts 2010 light duty vehicle fuel and vehicle equilibriums based upon available supplies. Using the AFTM, multiple points in the natural gas price-quantity space are derived by changing the reference demands for natural gas vehicle fuel (CNG and LPG). The resulting generic supply curve was then fit to a variable elastic functional form.

The feedstock supply curve is then transformed into multiple annual supply curves by shifting the "generic" supply curve through the AEO's average wellhead and imported natural gas prices and natural gas derived vehicle demands. The resulting supply curves for the years 1995 and 2010 are given in Figure 3 below.

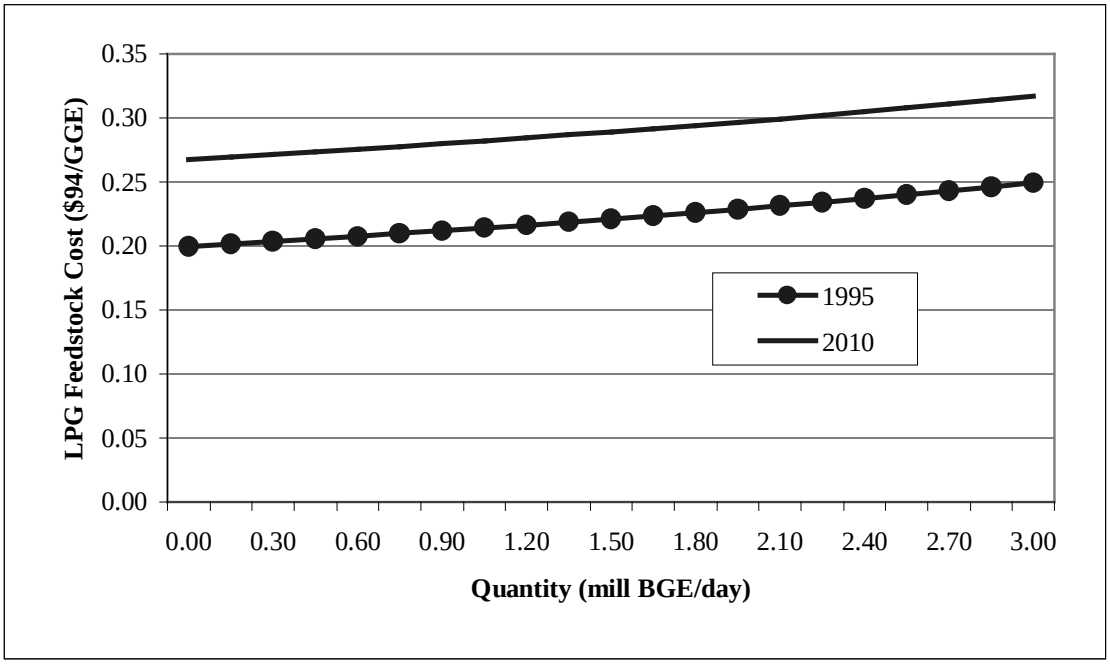

Figure 3: Net natural gas supply curves for the years 1995 and 2010.

Conversion Costs

LPG conversion costs, as defined here, are the cost of producing LPG from natural gas (excluding feedstock costs). The summation of conversion and feedstock costs is what is typically known as the plantgate price. The 2010 TAFV higher LPG costs, and 2010 TAFV lower LPG cost curves for converting natural gas into LPG are given in Figure 4. The 1995 TAFV LPG cost curve is the same for both scenarios, and is also shown in Figure 4. For both scenarios, reference demands for CNG, LPG, and gasoline, within the AFTM, are perbertrated, separately. The differences in well head natural gas and plantgate LPG prices are then tracked and used to form the basic shape or elasticity of the TAFV LPG conversion cost curves. For the 1995 TAFV conversion cost curve the intercept is taken from the Annual Energy Outlook 1996. Though not explicitly given in the AEO, the implied conversion costs were back calculated by subtracting the industrial LPG distribution and marketing costs given in the *Assumptions for the Annual Energy Outlook 1996* (Table 45) and the wellhead natural gas price (AEO 1996, Table 14) from the industrial LPG end-use price excluding tax (AEO 1996, Table 3).[2]

The higher LPG cost scenario continues this trend, benchmarking to the implied conversion costs in the Annual Energy Outlook in five year increments. For the lower LPG cost scenario, 2010 conversion costs are benchmarked to the AFTM. In between years are derived by extrapolating between the TAFV (AEO) 1995 conversion costs and the AFTM 2010 conversion costs.

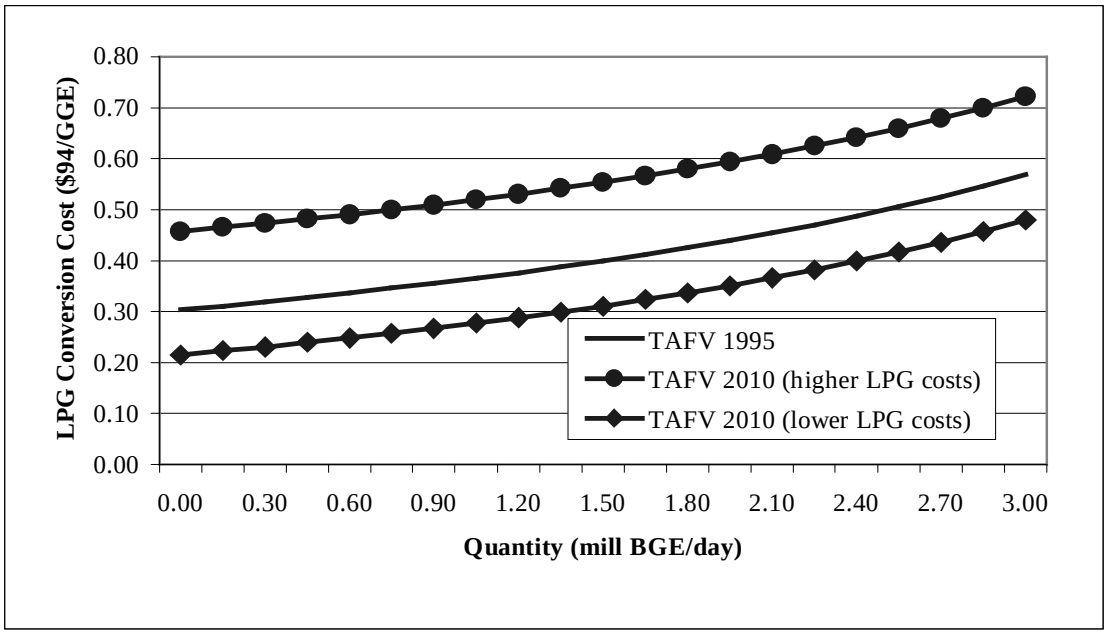

Figure 4: TAFV conversion cost curves for the years 1996.

[2] Industrial LPG prices rather than transportation LPG prices was used since: 1) the AEO96 does not report transportation LPG prices and, 2) plantgate costs and conversion costs of LPG should be roughly the same regardless of the ultimate end user.

Retail Markup

Retail markups for LPG to the transportation sector are derived from the EEA's "Supplement to Methodology for Alternative Fuels Retailing within the Transition Model" (1995). Within the TAFV model, retailing costs vary according to the year and according to the pump share. The pump share or number of pumps relegated to a particular fuel for stations carrying that fuel is a choice variable in the model.

Distribution Costs

Case A: Higher LPG Costs

The 1995 TAFV LPG distribution cost from the plantgate to the retail outlet is taken from the Petroleum Marketing Annual (PMA) 1994 and 1995.[3] Beginning in the 1994 edition (released in August 1995) the Energy Information Administration (EIA) began tracking and disseminating average annual LPG retail prices (excluding tax) for various end-uses categories including "Through Retail Outlets" or on-highway vehicle use (see PMA 1994, page 446 for the definition of retail outlets). Previous editions reported only the average price to all end users. In addition the EIA tracks the "Sale for Resale" or plantgate price. Subtracting the "Sale for Resale" price from the end-use price (and applying the proper conversion factors to convert from physical gallons to GGE's) produces the distribution and marketing costs shown in Table 1 below.[4]

[3] It is thought that distribution cost estimates based upon the PMA are preferred to those based upon the AEO96 since the AEO96 was constructed before the EIA began tracking LPG distribution and marketing costs to the transportation sector.

[4] End-use prices and Sale for Resale prices in the PMA are given in $/gal. These were converted to $/GGE assuming a btu content of 3.837 mmbtu/bbl for LPG to the transportation sector and 5.253 mmbtu/bbl for gasoline.

Table 1: Distribution and Retailing Costs (Price minus Sale for Resale Price excluding tax)

1994 Distribution and Retailing Costs ($94/GGE)

PADD	Residential	Commercial and Institutional	Industrial	Through Retail Outlets	Petro-Chemical	Other End Users	Average
1A	1.00	0.55	NA	NA	NA	0.69	0.80
1B	1.13	0.73	0.39	0.47	NA	0.56	0.93
1C	0.90	0.54	0.41	0.39	NA	0.38	0.70
2	0.58	0.50	0.52	0.58	-0.05	0.34	0.52
3	0.78	0.59	0.31	0.53	0.00	0.44	0.47
4	0.65	0.58	0.33	0.46	NA	0.52	0.59
5	0.93	0.69	0.51	0.56	NA	0.85	0.82
U.S.	0.77	0.62	0.46	0.55	-0.04	0.43	0.64

1995 Distribution and Retailing Costs ($94/GGE)

PADD[5]	Residential	Commercial and Institutional	Industrial	Through Retail Outlets	Petro-Chemical	Other End Users	Average
1A	0.95	0.56	0.14	0.31	NA	0.70	0.73
1B	1.06	0.68	0.29	0.40	NA	0.69	0.86
1C	0.87	0.53	0.40	0.39	NA	0.36	0.67
2	0.54	0.45	0.52	0.57	NA	0.33	0.50
3	0.75	0.59	0.32	0.52	-0.01	0.47	0.40
4	0.57	0.51	0.24	0.41	NA	0.52	0.52
5	0.84	0.67	0.37	0.55	NA	0.84	0.73
U.S.	0.73	0.60	0.41	0.53	-0.04	0.44	0.58

Historic Average (1994 and 1995) Distribution and Retailing Costs ($94/GGE)

PADD	Residential	Commercial and Institutional	Industrial	Through Retail Outlets	Petro-Chemical	Other End Users	Average
1A	0.97	0.56	NA	NA	NA	0.70	0.77
1B	1.10	0.70	0.34	0.43	NA	0.63	0.90
1C	0.88	0.54	0.41	0.39	NA	0.37	0.68
2	0.56	0.47	0.52	0.57	NA	0.33	0.51
3	0.76	0.59	0.32	0.53	0.00	0.45	0.44
4	0.61	0.54	0.28	0.44	NA	0.52	0.55
5	0.88	0.68	0.44	0.55	NA	0.84	0.77
U.S.	0.75	0.61	0.44	0.54	-0.04	0.43	0.61

[5] PADD 1A: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
PADD 1B: Delaware, District of Columbia, Maryland, New Jersey, New York, and Pennsylvania.
PADD 1C: Florida, Georgia, North Carolina, South Carolina, Virginia, and West Virginia.
PADD 2: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin.
PADD 3: Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas.
PADD 4: Colorado, Idaho, Montana, Utah, and Wyoming.
PADD 5: Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

The 1995 TAFV LPG distribution cost of 0.38 $94/GGE[6] is derived from the historic end-use price to retail outlets *less* the sale for resale price *less* the "current" retailing cost based on engineering estimates by EEA.[7] Under the higher LPG cost scenario, it is assumed that the distribution costs are held constant across the time horizon at 0.38 $94/GGE. This same format is used by the AEO which also assumes a constant markup (albeit higher) across the time horizon.

Case B: Lower LPG Costs

Under the lower LPG cost scenario, 1995 distribution costs are also set at 0.38 $94/GGE and linearly descend towards an adjusted AFTM estimate of 0.20 $94/GGE in 2010. Within the AFTM, distribution costs were estimated using a bottom-up approach documented in the background paper *Assessment of LPG Infrastructure for Transportation Use* (1992). Assuming an overall LPG transportation demand in 2010 of 13.7 billion gallons, PADD level consumption and production estimates were constructed based upon current LPG consumption shares and availability of excess production capacity in each PADD. All PADDs were considered self sufficient except for PADD 1 which imported LPG from PADD 3. LPG was transported from the production site (either refineries of natural gas plants) to bulk terminals using a least cost combination of pipelines, barges, and rail assuming a straight line distance between the production centroid and the consumption centroid for each PADD. Trucks were then used to haul the LPG from the bulk terminal to the bulk plant and on to the retail station. The combined effects of the LPG distribution network resulted in a 0.10 $94/GGE charge.

Unfortunately, however, the distribution cost used in AFTM underreported the actual assumed cost due to three factors. First, although capital costs were derived, the per barrel distribution cost used in the AFTM (3.58 $90/BGE or $0.10 $94/GGE) did not include the amortized cost of building the distribution network. Secondly either the operations cost of hauling LPG to the bulk plant (50 miles) or to the retail station (50 miles) was included in the final calculation, but not both. Thus half of the per barrel truck operations costs was excluded from the average per barrel distribution costs. Thirdly, an assumed LPG btu content of 4.011 per barrel was used. Later additions of the AFTM notably the 0996 version changed this estimate to 3.825 mmbtu/bbl reflecting the higher propane content in transportation LPG. The combined effect of these slight discrepancies result in an additional 0.10 $94/GGE charge for distributing LPG and a final value for the lower LPG cost scenario of 0.20 $94/GGE in 2010.

Thus the 2010 higher LPG cost of 0.38 $94/GGE uses a more status quo, top-down approach based upon observed historical data while the lower cost scenario uses a more bottom-up, least cost approach. Part of the difference in the two estimates may

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[6] The $0.38 distribution cost is equal to the observed $0.54 total retailing and distribution costs minus the endogenously determined retail cost of $0.16, i.e. $0.54-0.16- $0.38)

[7] In particular, we assume that one in every six gasoline pumps at retail stations that carry LPG are converted to LPG. This yields a "current" or 1995 retail cost estimates of 0.16 $94/GGE and a LPG distribution cost to the transportation sector of 0.38 $94/GGE.

be attributable to scale economies; larger trucks and more pipelines may be prevalent in a high transportation LPG demand world. However, part of the difference in the two estimates maybe a result of inefficiencies and realities which do not lend themselves to the least cost approach. Depending upon the degree to which a perfect world drives the results, the lower (corrected) AFTM distribution costs should be considered at best a realistic estimate and at worst an extreme lower bound.

Retail Fuel Tax

Retail federal fuel taxes in the TAFV have been updated to conform with the latest tax law given in the Taxpayer Relief Act of 1997. State taxes are based on a sales weighted average shown in the *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. transportation Sector* (1996).

II. Point Estimates from Various Sources

Table 2: Comparison of Various Sources of Retail LPG Price to the Transportation Sector at Approximately Zero LPG Transportation Consumption Level for the Year 1995 ($94/GGE)

Source		TAFV	AEO96	AEO98	SEPER	PMA94	PMA95
Year		1995	1995	1996	1994	1994	1995
Plantgate	Feedstock Costs	0.20	0.20[8]	0.26[9]	NA	NA	NA
	Conversion Costs	0.30	0.30[10]	0.23[11]	NA	NA	NA
	Total	0.50	0.50[12]	0.50[13]	NA	0.46[14]	0.48[15]
Distribution & Retailing	Distribution Costs	0.38	NA	NA	NA	NA	NA
	Retailing Costs	0.16	NA	NA	NA	NA	NA
	Total	0.54	0.73[16]	0.64[17]	NA	0.55	0.53
Retail Price (excluding Tax)	Total	1.04	1.23	1.14	1.07[18]	1.01[19]	1.00[20]
Tax	Total	0.38	0.41[21]	0.37[22]	NA	NA	NA
Retail Price	Total	1.42	1.64[23]	1.51[24]	NA	NA	NA

[8] Calculated as the average wellhead and import price of natural gas (AEO 1996, Table 14). The price was converted from $94/mcf to $94/GGE assuming a heating value for natural gas of 1 mmbtu/mcf and a heating value of gasoline of 5.253 mmbtu/bbl.

[9] Calculated as the average wellhead and import price of natural gas (AEO 1998, Table 14). The price was converted from $96/mcf to $94/GGE assuming a heating value for natural gas of 1 mmbtu/mcf and a heating value of gasoline of 5.253 mmbtu/bbl and using the appropriate GDP deflators.

[10] The implied AEO96 conversion cost was calculated by subtracting the feedstock cost from the calculated plantgate price of LPG.

[11] The implied AEO98 conversion cost was calculated by subtracting the feedstock cost from the calculated plantgate price of LPG.

[12] The implied AEO plantgate costs are derived by subtracting the AEO's Distribution and Marketing Costs from the Delivered Industrial LPG Price (excluding tax) (AEO 1996, Table 3). The delivered industrial LPG price was converted from $94/mmbtu to $94/GGE assuming a gasoline heating value of 5.253 mmbtu/bbl.

[13] The implied AEO plantgate costs are derived by subtracting the AEO's Distribution and Marketing Costs and Taxes from the Delivered Transportation LPG Price (AEO 1998, Table 3). The delivered transportation LPG price was converted from $96/mmbtu to $94/GGE assuming a gasoline heating value of 5.253 mmbtu/bbl and using the appropriate GDP deflators.

[14] Consumer Grade Propane Sale for Resale Price, Petroleum Marketing Annual 1994, Table 38.

[15] Consumer Grade Propane Sale for Resale Price, Petroleum Marketing Annual 1995, Table 38.

[16] Assumptions for the Annual Energy Outlook 1996, Table 45. Converted from $94/gal to $94/GGE using the heating values of 3.625 mmbtu/bbl for LPG and 5.253 mmbtu/bbl for gasoline.

[17] Assumptions for the Annual Energy Outlook 1998, Table 59. Converted from $96/gal to $94/GGE using the heating values of 3.625 mmbtu/bbl for LPG and 5.253 mmbtu/bbl for gasoline and using the appropriate GDP deflators.

[18] State Energy Price and Expenditure Report 1994, Table 9.

[19] Consumer grade propane sold through retail outlets (on-highway vehicle use), PMA 1994, Table 38

[20] Consumer grade propane sold through retail outlets (on-highway vehicle use), PMA 1995, Table 38

[21] Assumptions for the Annual Energy Outlook 1996, page 74. Converted from $94/gal to $94/GGE using the heating values of 3.625 mmbtu/bbl for LPG and 5.253 mmbtu/bbl for gasoline.

[22] Assumptions for the Annual Energy Outlook 1998, page 99. Converted from $96/gal to $94/GGE using the heating values of 3.625 mmbtu/bbl for LPG and 5.253 mmbtu/bbl for gasoline and using the appropriate GDP deflators.

[23] Though not explicitly given or tracked in the AEO 1996, the retail price of LPG to the transportation sector can be calculated as the sum of plantgate costs plus distribution and markup plus taxes.

[24] Annual Energy Outlook 1998, Table 3

Table 3: Comparison of Various Sources of Retail LPG Price to the Transportation Sector at Approximately Zero LPG Transportation Consumption Level for the Year 2010 ($94/GGE)

		TAFV (higher LPG costs)	TAFV (lower LPG costs)	AEO96	AEO98	AFTM[25]
Plantgate	Feedstock Costs	0.27	0.27	0.27	0.28	0.27[26]
	Conversion Costs	0.46	0.22	0.46	0.34	0.22[27]
	Total	0.73	0.48	0.73	0.62	0.49[28]
Distribution & Retailing	Distribution Costs	0.38	0.20	NA	NA	0.10[29]
	Retailing Costs	0.15	0.15	NA	NA	0.14[30]
	Total	0.52	0.34	0.74	0.66	0.24
Retail Price (excluding Tax)	Total	1.25	0.83	1.47	1.28	0.72
Tax	Total	0.38	0.38	0.31	0.31	0.45[31]
Retail Price	Total	1.62	1.20	1.78	1.59	1.17

[25] AFTM version 0996, base case scenario, current taxes.

[26] Variable WNATGAS (wellhead natural gas) in AFTM version 0996.

[27] Though not explicitly given in AFTM, conversion costs were calculated as plantgate LPG costs less natural gas feedstock costs.

[28] The plantgate price of natural gas is drawn from the AFTM's base case plantgate price of LPG (variable WLPG). WLPG was then converted from $90/physical unit to $94/GGE by applying the appropriate price deflators and converting the price from physical units (3.837 mmbtu/bbl) to GGE (5.253 mmbtu/bbl).

[29] *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector*, 1996, DOE/PO-0042, page 51. Converted from $90 to $94 using the appropriate GDP deflators.

[30] *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector*, 1996, DOE/PO-0042, page 51. Converted from $90 to $94 using the appropriate GDP deflators.

[31] *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector*, 1996, DOE/PO-0042, page 52. Converted from $90 to $94 using the appropriate GDP deflators.

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