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The Texas Economy: The Prospects for Natural Gas Substitution

It is now widely appreciated that among the fossil fuels, natural gas pollutes least. Measured in terms of carbon dioxide equivalent per Btu of energy, the air pollution resulting from coal combustion is three times that of natural gas. In the case of oil products, the pollution is one and a half times that of natural gas. It follows that substantial substitution of natural gas for coal and oil products would significantly reduce air pollution. Presumably, a sound environmental policy using market-based instruments would induce some such substitution.

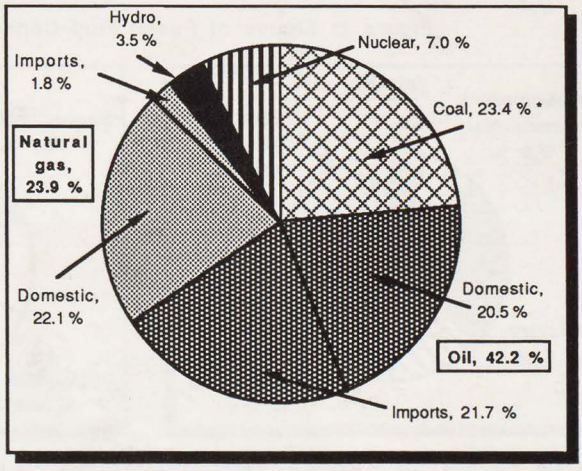
The question then arises: what are the prospects for natural gas substitution? The approach to the answer is in two parts. The first, fully addressed in this article, has to do with the magnitude of coal and oil product use in processes where natural gas is a technical, if not currently an economic, alternative. The second, only partially addressed here, concerns the size and quality of the natural gas resource base, hence the economic feasibility of substantial substitution for other fossil fuels.

In this discussion, we shall be concerned only with primary sources of energy—the fossil fuels (coal, oil, and natural gas), plus nuclear, hydro, solar, and wind power—but especially the fossil fuels. Much of the energy consumed by end users is in the form of electricity. But electricity is a secondary source, generated by one or more primary sources. Thus, it would be double counting to add electricity to the consumption of primary sources. In this connection, it should be noted that the substitution of electricity for a fossil fuel in some end uses—say, in home heating—does not mean a reduction in fossil fuel consumption if the electricity is generated by a fossil fuel. Indeed, the contrary is true because the generation of electricity involves a large heat loss. It requires three Btus of oil, for instance, to generate the equivalent of one Btu of electricity in modern plants.

The following three figures show the percentage distributions of (1) the principal primary sources of energy, (2) the principal uses of the fossil fuels, and (3) the principal primary sources used in electric utilities, transportation, and the remaining sectors as a whole. All of the percentages are for the year 1989, the latest period for which fully comparable data are available. Taken together, these figures provide some indication of the possible scope and industrial location of natural gas substitution.

Starting with figure 1, we see that in 1989 oil supplied the largest percentage of U.S. primary energy. (Solar and wind energy are omitted as negligible.) Only in the case of oil are imports

Figure 1: Sources of Primary Energy Consumption, United States, 1989 (Btu equivalent)



* Domestic production minus exports.
Sources: *Twentieth Century Petroleum Statistics* (Dallas: DeGolyer and MacNaughton, 1990), and DRI, *Energy Review*, 1991.

important, accounting for about half of 1989 oil consumption. Natural gas imports, predominantly by pipeline from Canada, account for only 7 percent of natural gas consumption. All of U.S. coal consumption is domestically produced; indeed, about 12 percent of the nation's coal production is exported.

Figure 2 shows the principal uses of oil, natural gas, and coal in 1989. (Hydro and nuclear power need not be charted here because all of it goes to generate electricity.) Part (a) indicates that transportation consumes more oil than industry, residential and commercial uses, and electric utilities combined. In part (b), we see that industry and residential and commercial establishments are, by far, the largest users of natural gas; electric utilities and transportation claim much smaller percentages. In contrast, electric utilities, as illustrated in part (c), consume most of the coal in the United States. Industry is a distant second, and consumption by residential and commercial establishments and transportation is virtually nonexistent.

Turning to figure 3, we see in part (a) that electric utilities satisfy most of their primary energy demands with coal and nuclear power. Part (b) shows that transportation needs are met with oil, almost to the exclusion of gas. The remaining sectors, represented in part (c), meet about half of their primary energy needs with natural gas; the remainder, with oil and coal.

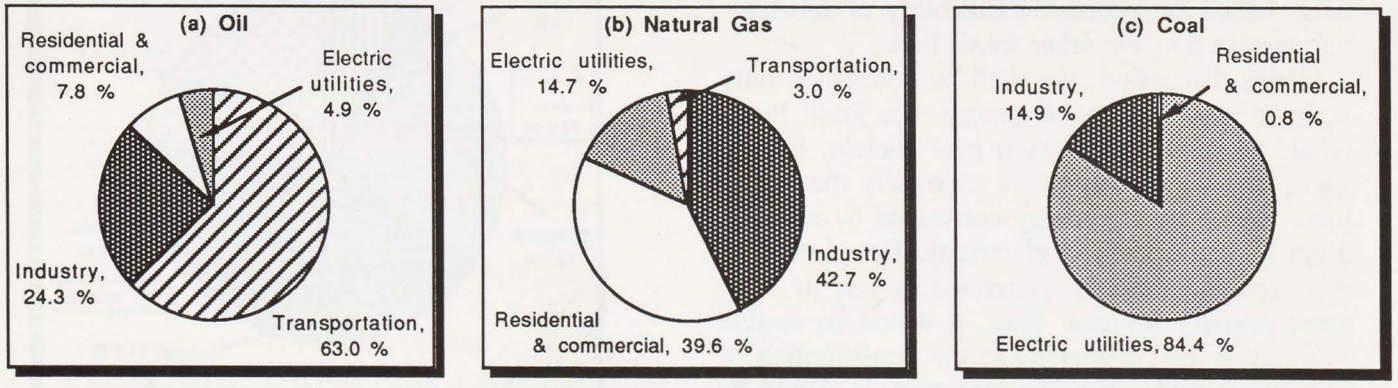
These figures indicate quite clearly that the largest technical scope for natural gas substitution is to be found in two sectors: the generation of electricity, where coal is by far the dominant fossil fuel, and transportation, where oil has a virtual monopoly. If natural gas could be substituted for one-half of the coal used in generating electricity and one-fourth of oil products used in transportation, the share of natural gas in total primary energy consumption would rise from 24 percent to 41 percent. At current rates of total energy consumption, that would mean a 70 percent increase in natural gas consumption, to be supplied by some combination of increased domestic production and imports.

So the next question is: what are the prospects for increased domestic production and imports of natural gas?

Between 1960 and 1989 domestic oil production rose 8 percent while domestic natural gas production rose 43 percent. Since 1986 domestic oil production has been falling and imports now account for about half the nation's consumption. Domestic natural gas production, in contrast, has strengthened somewhat in the same period. While import prices constrain the domestic price of oil, it is primarily domestic coal prices that constrain the domestic price of natural gas. If coal were priced to reflect relative environmental damages, the electric utility demand for natural gas and its price would rise, with major environmental gains. If oil prices reflected the risk attached to imports, the demand for natural gas in transportation would rise also, according both environmental and security benefits.

In any case, the above price and production record suggests that, during the last three decades, there has been less of a quantitative and qualitative domestic resource base constraint on the development of new capacity in natural gas

Figure 2: Shares of Fossil Fuel Consumption by Consuming Sectors, United States, 1989



Source: *Twentieth Century Petroleum Statistics* (Dallas: DeGolyer and MacNaughton, 1990).

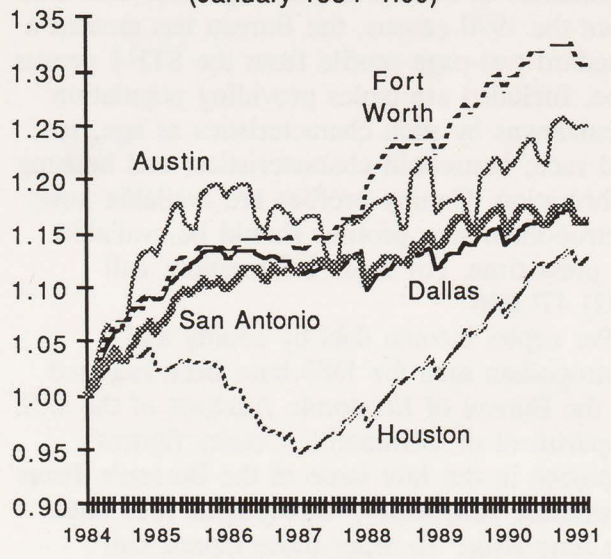
Employment and Unemployment Rate by Metropolitan Area

Area	Total nonagricultural employment (thousands)			Total employment (thousands)			Unemployment rate
	May 1991	May 1990	Percentage change	May 1991	May 1990	Percentage change	May 1991
Abilene	48.6	48.9	-0.6	47.8	48.0	-0.4	5.9
Amarillo	78.2	78.8	-0.8	91.1	91.6	-0.5	4.9
Austin	383.0	378.5	1.2	421.5	415.2	1.5	4.4
Beaumont-Port Arthur	147.6	141.0	4.7	158.5	151.3	4.8	7.0
Brazoria	68.1	66.7	2.1	84.0	82.6	1.7	5.3
Brownsville-Harlingen	78.0	75.4	3.4	96.0	93.0	3.2	12.2
Bryan-College Station	55.4	53.9	2.8	60.6	59.0	2.7	3.7
Corpus Christi	137.8	135.8	1.5	155.8	152.8	2.0	7.4
Dallas	1,376.7	1,373.6	0.2	1,359.7	1,348.8	0.8	5.7
El Paso	211.0	207.8	1.5	227.3	223.5	1.7	10.3
Fort Worth-Arlington	587.0	587.3	-0.1	691.9	688.4	0.5	6.4
Galveston-Texas City	77.1	76.5	0.8	102.8	102.5	0.3	6.9
Houston	1,630.2	1,595.6	2.2	1,663.0	1,623.4	2.4	5.5
Killeen-Temple	73.8	74.4	-0.8	90.2	90.0	0.2	6.5
Laredo	45.1	44.1	2.3	48.0	47.0	2.1	9.1
Longview-Marshall	69.1	70.0	-1.3	73.2	74.2	-1.3	8.0
Lubbock	99.0	98.7	0.3	110.2	109.1	1.0	5.2
McAllen-Edinburg-Mission	103.7	103.8	-0.1	134.7	136.2	-1.1	15.2
Midland	44.7	44.4	0.7	45.6	45.1	1.1	5.2
Odessa	44.6	43.7	2.1	49.2	47.9	2.7	6.3
San Angelo	36.7	36.4	0.8	41.4	41.1	0.7	4.8
San Antonio	521.9	523.6	-0.3	565.7	562.6	0.6	6.5
Sherman-Denison	37.9	38.2	-0.8	44.7	45.0	-0.7	6.5
Texarkana	45.7	47.4	-3.6	52.1	53.0	-1.7	7.9
Tyler	62.4	62.2	0.3	69.2	69.3	-0.1	6.4
Victoria	29.3	28.2	3.9	34.9	34.1	2.3	4.9
Waco	82.4	82.2	0.2	87.4	86.9	0.6	6.4
Wichita Falls	50.1	50.1	0.0	51.8	51.3	1.0	6.8
Total Texas	7,118.4	7,042.5	1.1	7,999.5	7,886.8	1.4	6.3
Total United States	109,195.0	110,721.0	-1.4	116,624.0	118,277.0	-1.4	6.5

Note: Data are not seasonally adjusted. Figures for 1990 have undergone a major revision; previously published 1990 figures should no longer be used. Revised figures are available upon request. All 1991 figures are subject to revision.
Sources: Texas Employment Commission and U.S. Department of Labor, Bureau of Labor Statistics.

Nonagricultural Employment in Five Largest Texas Metropolitan Areas

(January 1984=1.00)



Total Employment in Five Largest Texas Metropolitan Areas

(January 1984=1.00)

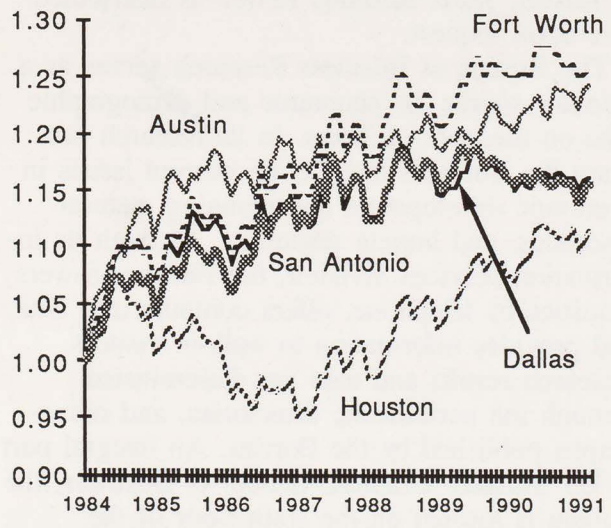
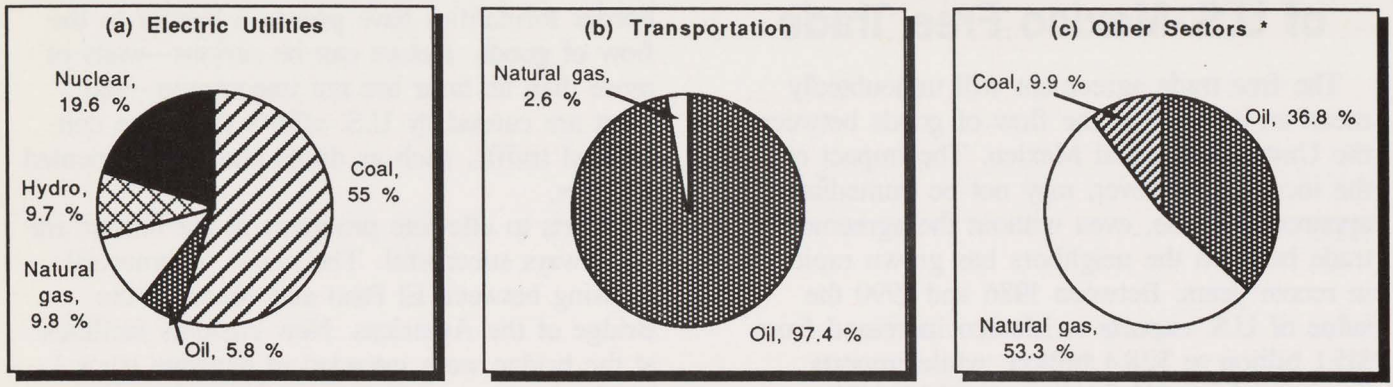


Figure 3: Shares of Primary Energy Consumption by Fuel, United States, 1989 (Btu equivalent)



*Other sectors include industry, residential, and commercial.
Source: *Twentieth Century Petroleum Statistics* (Dallas: DeGolyer and MacNaughton, 1990).

than in oil—that, at a Btu price commensurate with that of oil (roughly $3.00/mcf), domestic natural gas capacity and production could and probably would be much larger. Estimates of the natural gas resource base (the amounts remaining to be discovered and produced with current technology at a given price) are consistent with this inference. The most recent estimate of the natural gas resource base recoverable at $3.00/mcf (Gulf Coast Wellhead price as of this writing: $1.20) *in the lower 48 states alone* is 604 tcf, about 35 times the current annual rate of consumption.[1] There is undoubtedly a large additional base in Alaska awaiting a pipeline through Canada (with its own substantially exportable base) to be evaluated. We lack a comparable estimate of the oil resource base, but one recent estimate, based on a price of $24.00/bbl (West Texas Intermediate price as of this writing: about $20.50) and *including Alaska,* is 120 billion barrels, about 20 times the current annual rate of consumption.[2]

The above analysis leads us to believe that there is substantial scope for the substitution of natural gas for other fossil fuels, especially in the electric utility and transportation sectors. If exploited, this substitution would bring significant environmental benefits and perhaps a bonus of reduced reliance on foreign oil. As yet unanswered questions include: (1) the size of the increase in the real price of natural gas likely to result from a rational market-based environmental program, and (2) the exploration and development response of the domestic natural gas-producing industry to this enhanced incentive. In subsequent articles, we shall try to provide at least approximate answers to these questions.

— *Stephen L. McDonald*
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and
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Notes

1. National Research Council, *Future Directions in Advanced Exploratory Research* (Washington, D.C.: National Academy Press, 1987).
2. Ibid.

Transportation (continued)

clearance limitations. (The Ford facility in Hermosillo, a General Motors plant at Ramos Arizpe near Saltillo, and Chrysler plants near Mexico City are among the automobile plants that have used the double-stack rail service.) Finally, two new crossings are planned in New Mexico just west of El Paso and other locations are undergoing continuing improvements.

Such measures, however, may provide only temporary solutions. Despite the obstacles, international traffic along the border has been increasing. If the free trade agreement materializes, the traffic will only increase further, and with it, the need for more long-term solutions to the transportation problems.

— *Charles Zlatkovich*
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Transportation Impacts of U.S.-Mexico Free Trade

The free trade agreement will undoubtedly mean an increase in the flow of goods between the United States and Mexico. The impact of the increase, however, may not be immediately apparent because, even without the agreement, trade between the neighbors has grown rapidly in recent years. Between 1986 and 1990 the value of U.S. exports to Mexico increased from $15.1 billion to $28.4 billion, while imports increased from $12.6 billion to $30.2 billion.

Mexico ranks third, behind Canada and Japan, among U.S. trading partners, representing 7 percent of U.S. exports and 6 percent of imports. On the other side of the border, the United States dominates Mexico's trade, claiming about 73 percent of Mexican exports and 68 percent of Mexican imports. Much of the trade is associated with the in-bond manufacturing (maquiladora) industry. More than 90 percent of the total in-bond employment is concentrated in the border states of Chihuahua, Baja California Norte, Tamaulipas, Sonora, and Coahuila.

Tariff barriers have been dropping in recent years. The average U.S. tariff on Mexican goods is now less than 4 percent, while the average Mexican tariff on U.S. goods is about 10 percent. For those items on which tariffs remain as high as 70 percent or more, trade volumes are almost certain to increase as a result of the free trade agreement.

The most noticeable impact of the agreement, however, will be on the transportation system between the two nations, particularly at the border and to the south. The volume of traffic is already high, with most commercial traffic concentrated at a handful of points along the 2,000-mile border. From east to west, the major commercial crossings are located at Brownsville, Hidalgo, Laredo, Eagle Pass, El Paso, Nogales, Calexico, and San Ysidro. The interstate highway system reaches the border at Laredo, El Paso, Nogales, and San Ysidro, and active rail gateways with connections to the interior of Mexico can be found at the major commercial crossings (except Hidalgo and San Ysidro) and at Presidio and Douglas.

Two of the biggest obstacles to increased trade are likely to be the border crossings and transportation conditions within Mexico. Although adequate traffic capacity exists on the U.S. side, border formalities have proven a barrier to the flow of goods. Delays can be serious—waits of more than an hour are not uncommon—and most are caused by U.S. efforts to reduce contraband traffic, such as drugs and undocumented workers.

Efforts to alleviate problems at the border are not always successful. The major commercial crossing between El Paso and Juarez is the Bridge of the Americas. New customs facilities at the bridge were intended to expedite truck traffic. Unfortunately, just as the new facilities were nearing completion, it was discovered that structural deterioration of the bridge would necessitate restricting its use to smaller, lighter trucks. Large commercial trucks are to be diverted to the Zaragosa bridge, but customs facilities at the newly rebuilt bridge are not yet finished.

Transportation conditions within Mexico are another source of frustration. For example, traffic is especially heavy at the San Ysidro-Tijuana crossing, and a number of maquiladora plants are located in the Tijuana area, but the commercial importance of the crossing is limited by the absence of direct rail and highway connections to the interior of Mexico. (Curiously, the only highway in northern Mexico extends from Tijuana to the resort community of Ensenada—a boon to tourists but of limited commercial significance.)

While rail service is at least comparable to that available in the United States, highway conditions in Mexico are in need of improvement. With the exception of the Ensenada toll road and the highway between Nogales and Hermosillo, two-lane roads between the border and interior points are the rule. Highway routes through cities and towns are usually slow and congested. Northern Mexico is definitely not a trucker's paradise.

Some relief is on the way. One answer to border delays has been the run-through container train with special customs inspection arrangements. Recent improvements on several Mexican rail lines have enabled the new double-stack container cars to operate across the border at Laredo, Eagle Pass, El Paso, and Nogales. Double-stack container cars carry standard freight containers stacked two high, but cannot operate on all rail lines because of vertical

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The Bureau of Business Research serves as a primary source for economic and demographic data on the state of Texas. In its research program the Bureau's focus is on current issues in economic development and planning, natural resources, and human resources. Through its information services division, the Bureau answers inquiries by telephone, offers computerized data, and provides information to walk-in visitors. Research results and data are disseminated through the periodicals, directories, and monographs published by the Bureau. An integral part of UT Austin's Graduate School of Business, the Bureau is located on the sixth floor of the College of Business Administration building.

Announcements

In order to serve those who need to have summaries of county and metropolitan area data from the 1990 census, the Bureau has created a standard two-page profile from the STF-1 census tape. Included are tables providing population breakdowns by such characteristics as age, sex, and race; household characteristics; and housing information. County profiles are available now; metropolitan area profiles should be available by press time. For more information, call (512) 471-1616.

Per capita income data by county and metropolitan area for 1989 have been released by the Bureau of Economic Analysis of the U.S. Department of Commerce. County figures appeared in the July issue of the Bureau's **Texas Economic Indicators;** metropolitan area data, the June issue. To order those issues, call (512) 471-1616.