



New Industrial Operations Leveraged by Unconventional Natural Gas

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STUDY PURPOSE & ACKNOWLEDGMENTS

Over the past several years, Louisiana has seen considerable unconventional natural gas reserve development that has been nothing short of “revolutionary.” These resources have played, and will continue to play, a significant role in North American and even global energy markets. Several studies have examined the economic benefits of unconventional natural gas reserve development in Louisiana. None, however, have explored the impact that these unconventional resource developments are having on downstream manufacturing capital investments in the state.

The Center for Energy Studies (“CES”) was asked by America’s Natural Gas Alliance (“ANGA”) to examine the potential economic impacts associated with the numerous capital investments that have been recently announced, in large part, due to these newly-found unconventional natural gas reserves. The purpose of the study is to educate stakeholders about the nature and motivations for these manufacturing investments and what they mean for Louisiana’s economy.

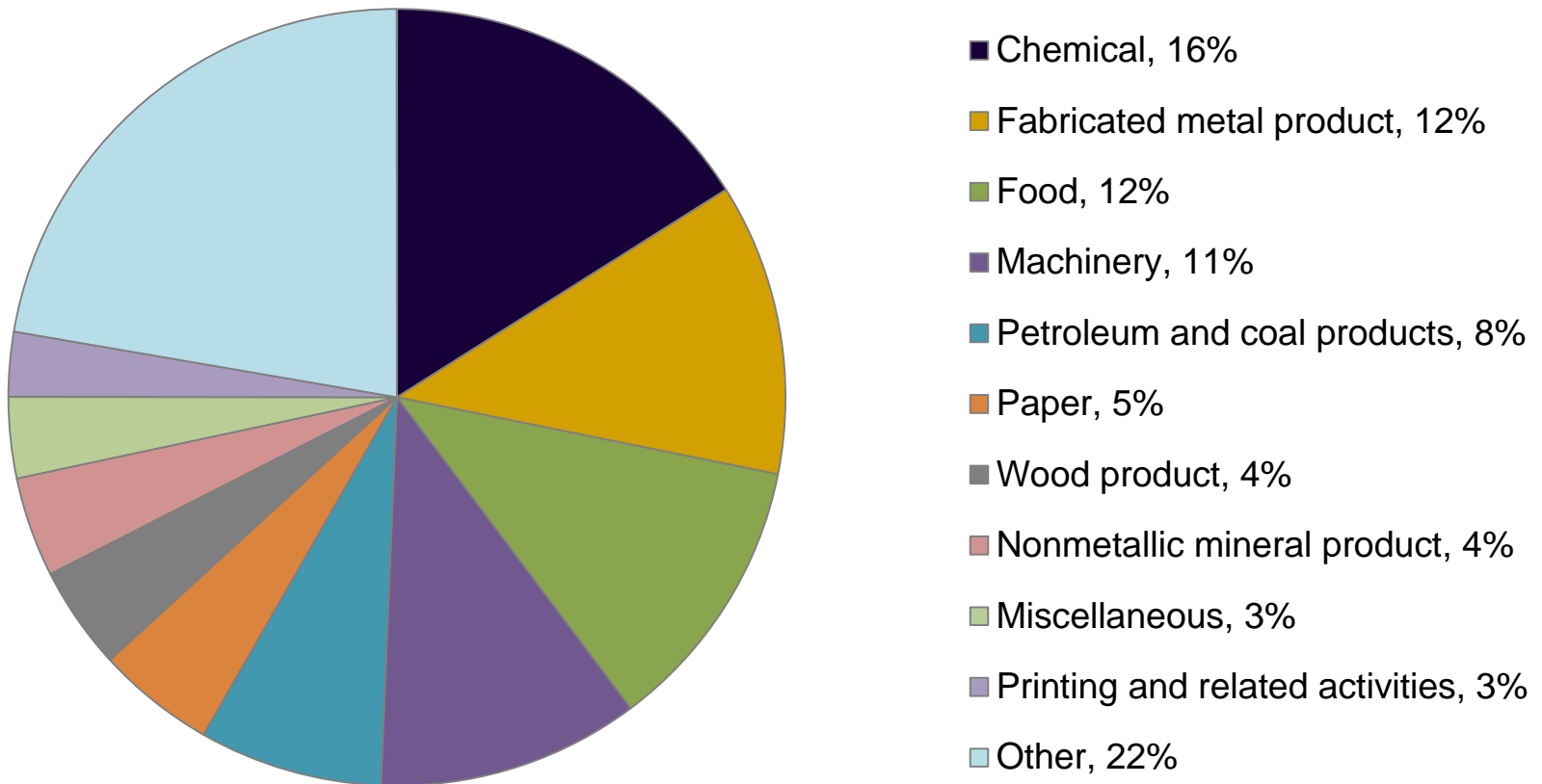
CES appreciates the financial support provided by ANGA to complete this study for Louisiana stakeholders and policy makers.



Section 2: Overview of Louisiana Manufacturing

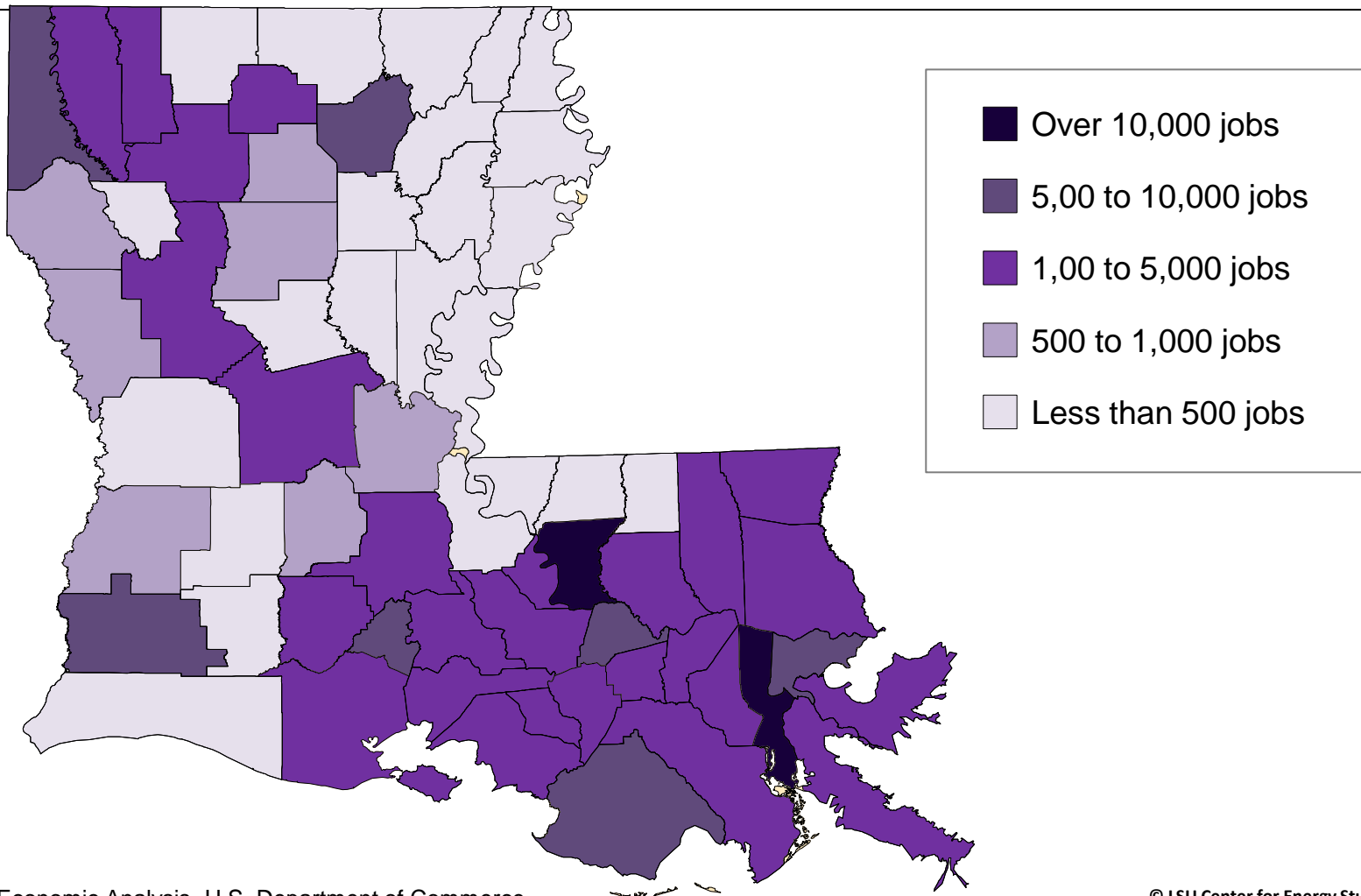
Manufacturing Employment (2011) by Sector and Total State

The manufacturing sector supports 147,177 jobs in Louisiana. The top five categories account for almost 60 percent of manufacturing jobs.



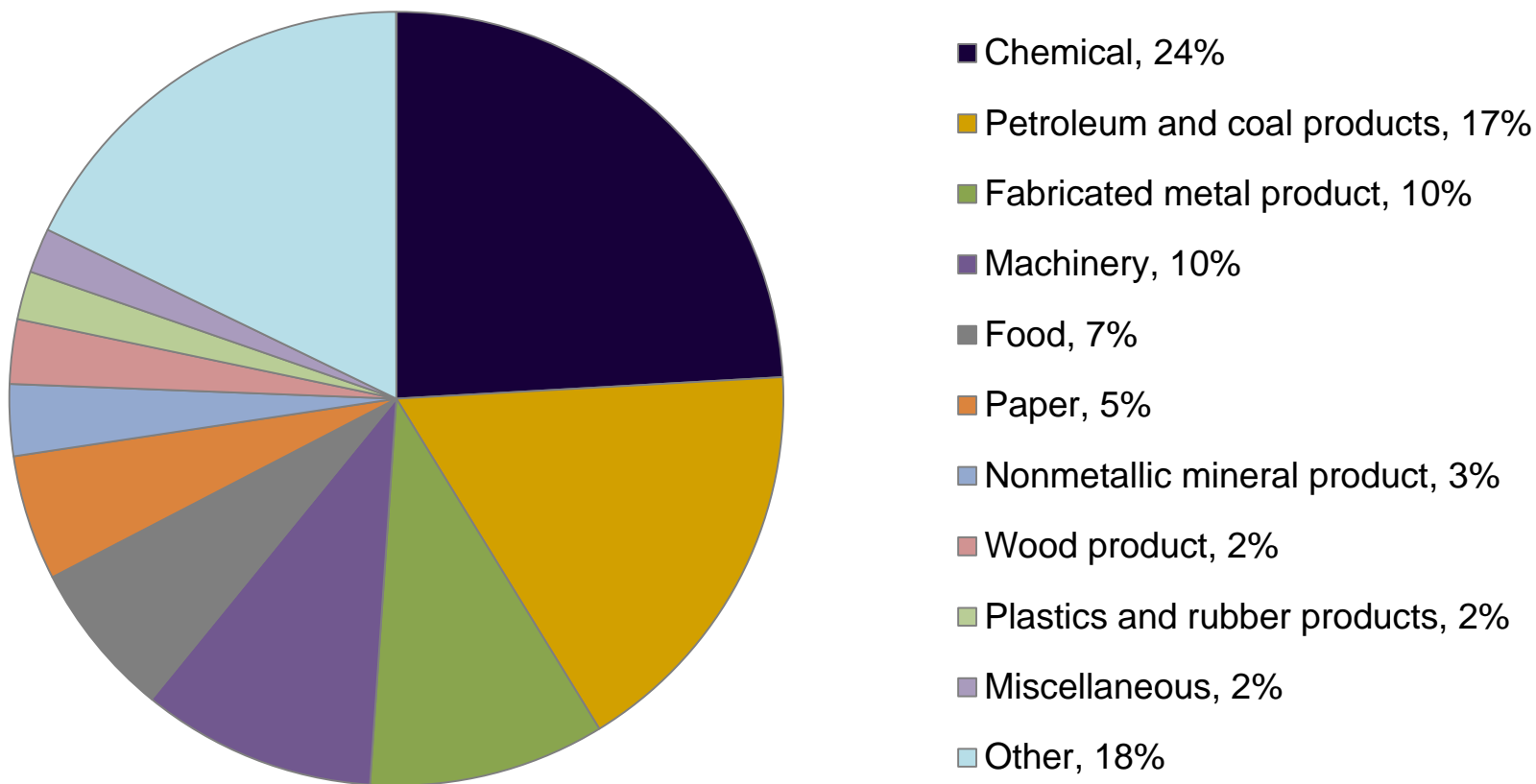
Manufacturing Employment (2010) by Parish (All Sectors)

The majority of manufacturing jobs are located in about 10 parishes the southern portion of the state.



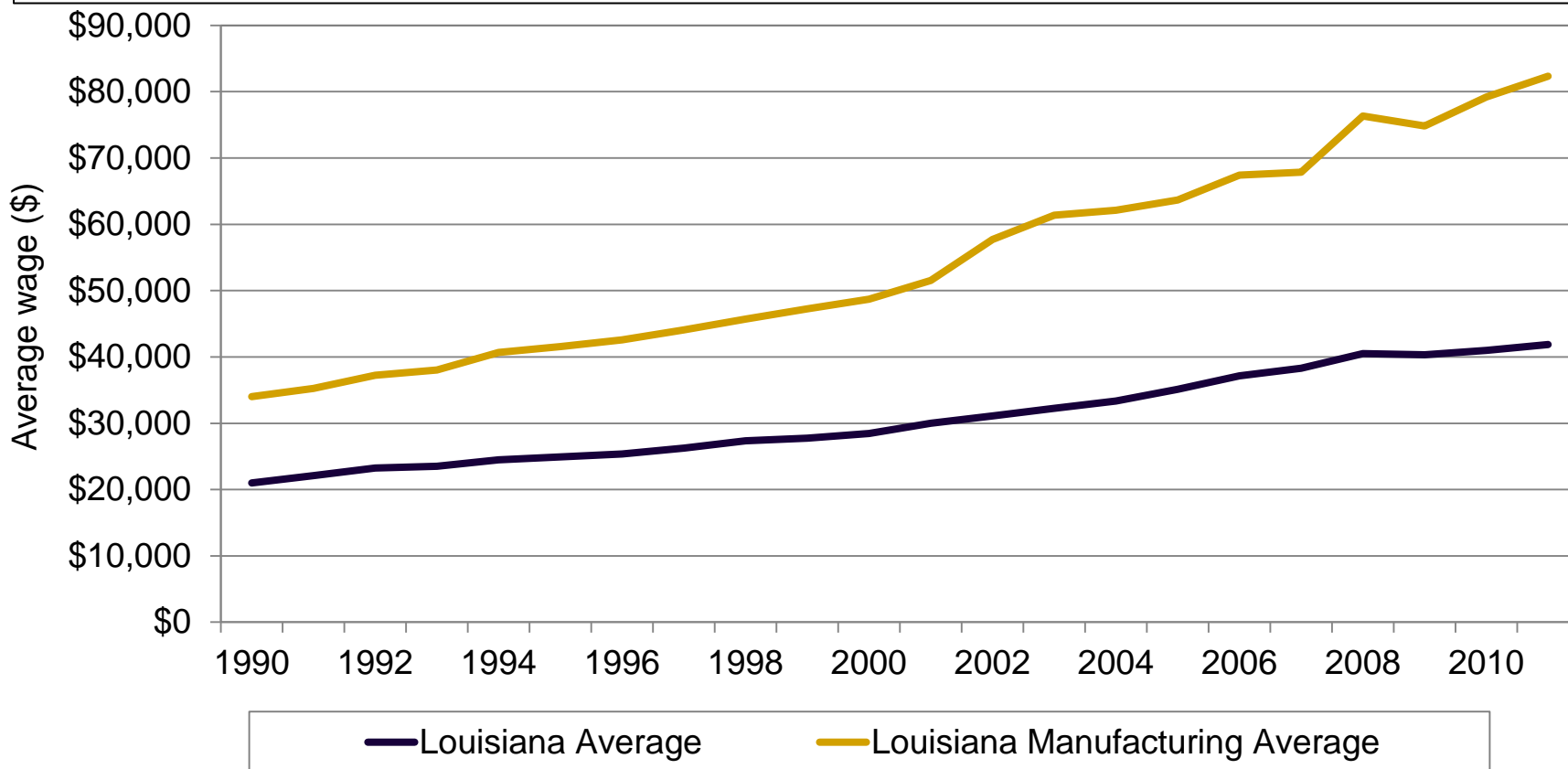
Manufacturing Wages (2011) by Sector and Total State

Manufacturing sector wages in Louisiana totaled \$12.1 billion in 2011. The top five categories account for 68 percent of manufacturing wages.



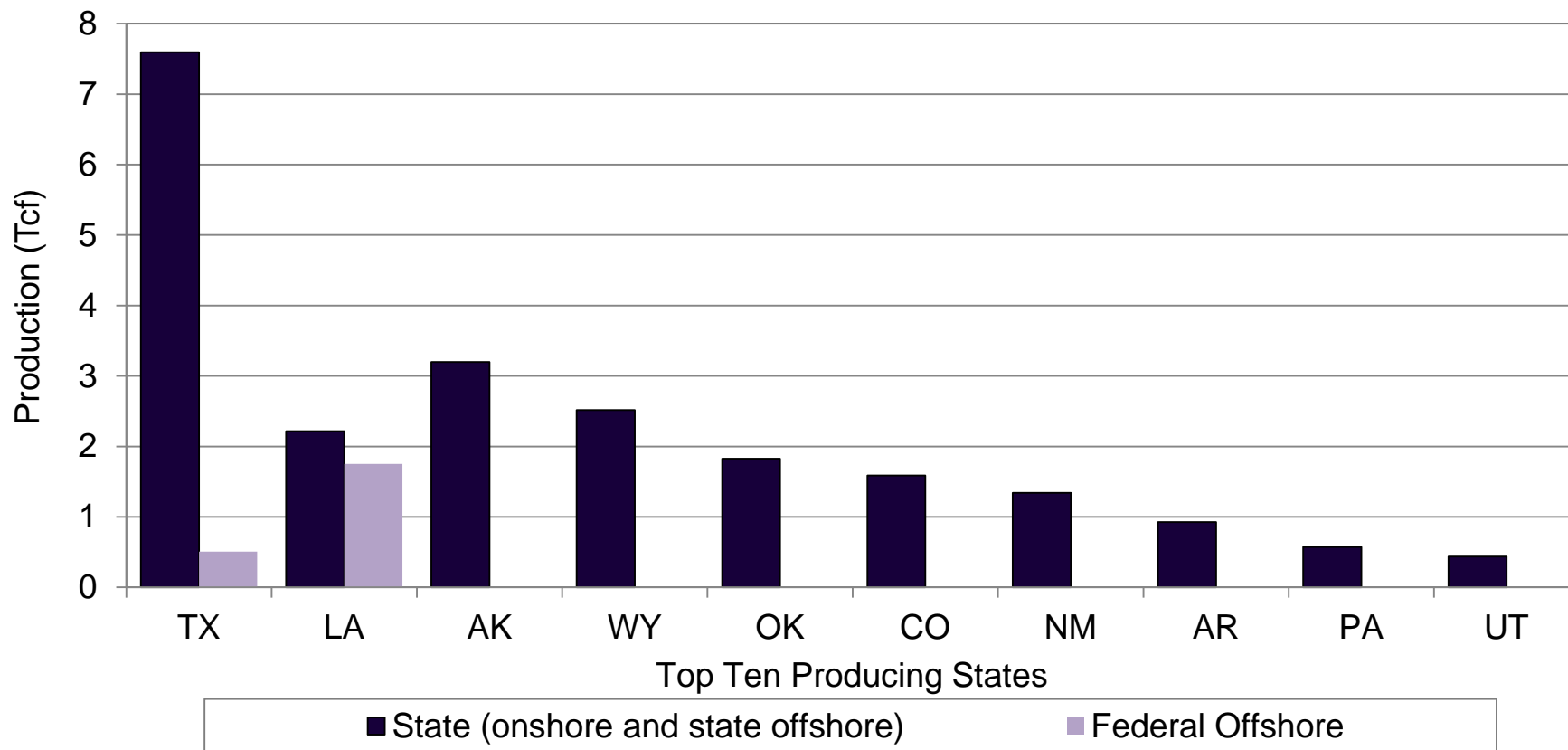
Average Wage Comparison, Manufacturing versus State Average

Average manufacturing wages in Louisiana are significantly higher than the average state wage. In 2011, the average manufacturing wage was double that of the average state wage. Manufacturing wages have also increased at a faster rate, an average annual rate of 4.3 percent (compared to the state average of 3.4 percent)



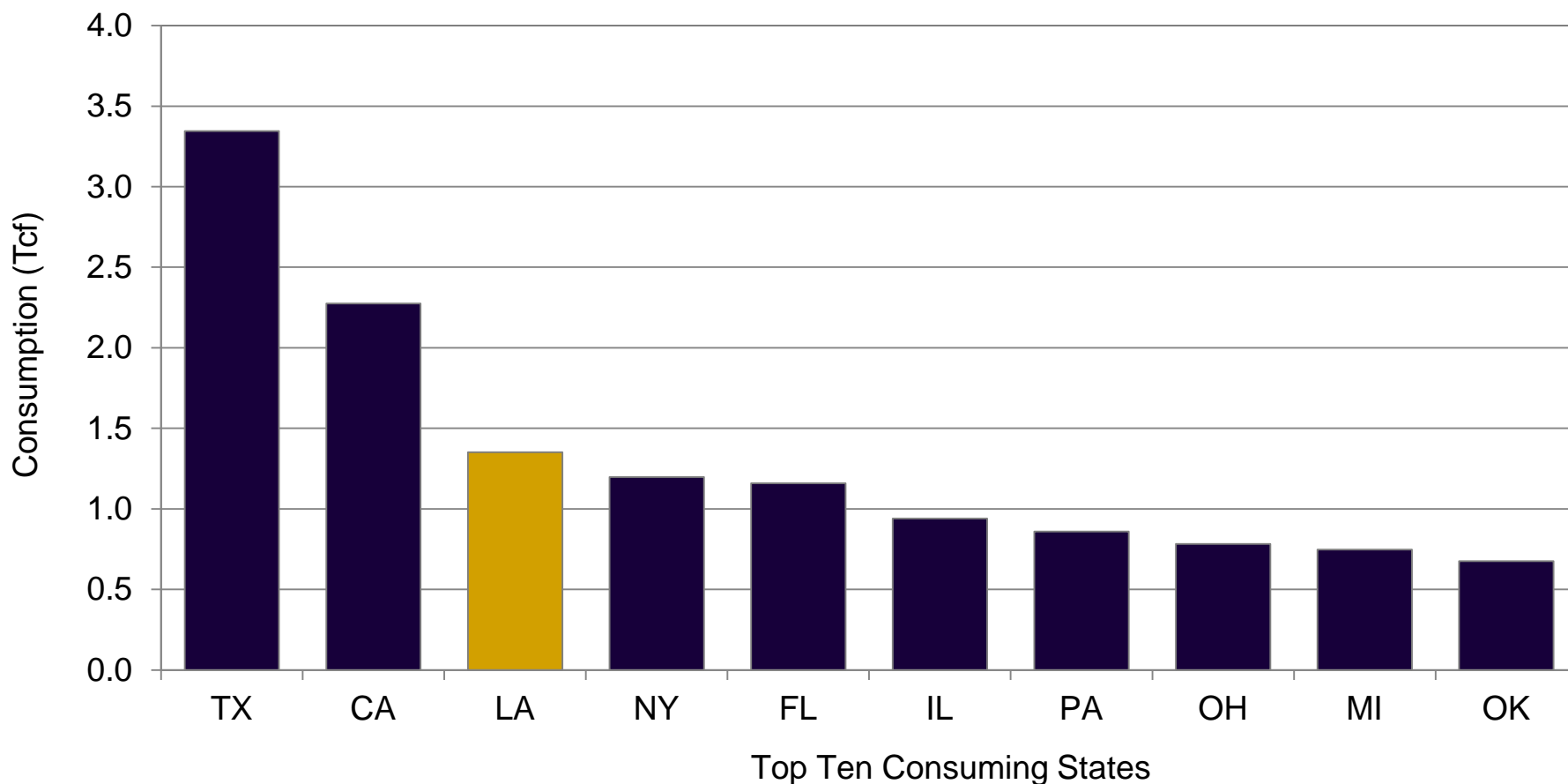
Natural Gas Production in the U.S., 2010

Louisiana is the second largest producer of natural gas in the U.S. and has been historically because of its prolific offshore natural gas reserves. Today, those offshore reserve are supplemented with new on-shore unconventional resources produced primarily in North Louisiana.



Natural Gas Consumption in the U.S., 2010

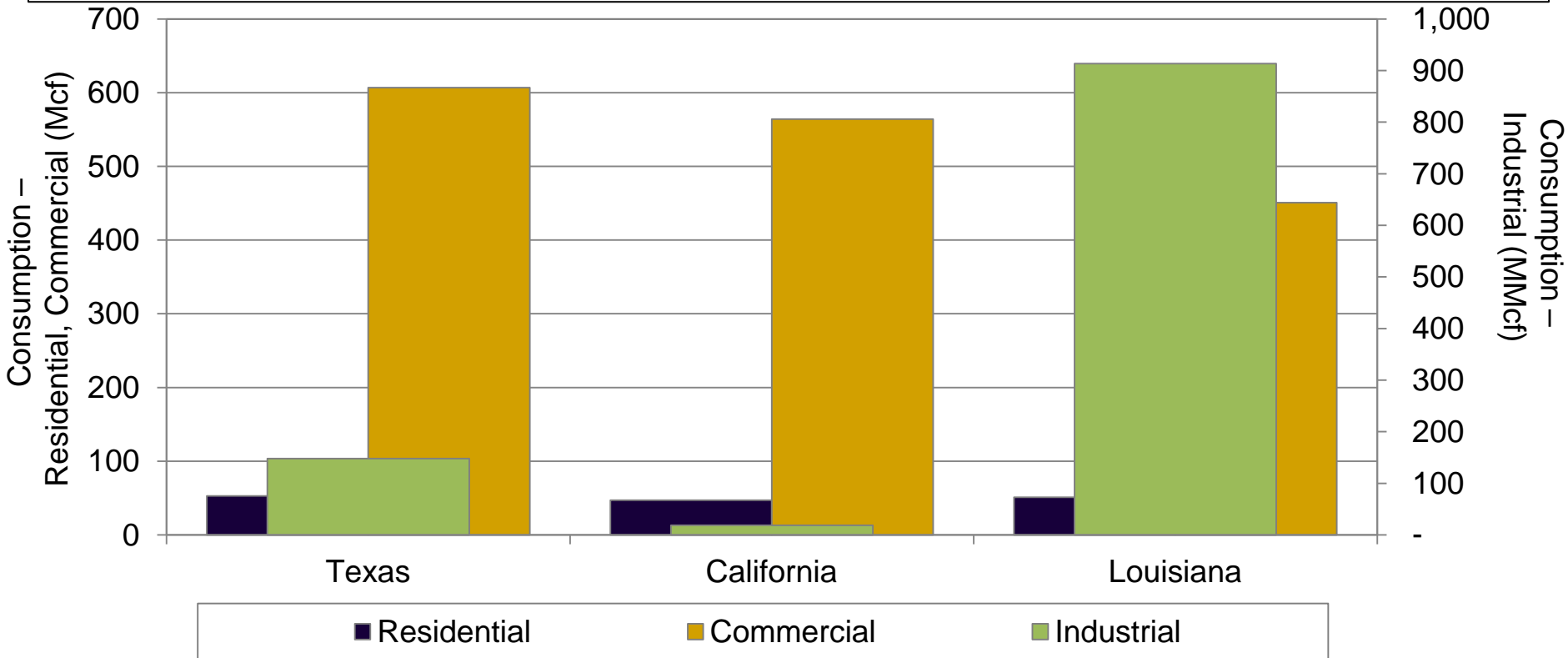
Equally important is the fact that Louisiana is the third largest consumer of natural gas in the U.S. This ranking is entirely a function of the energy-intensive manufacturing located throughout the state.





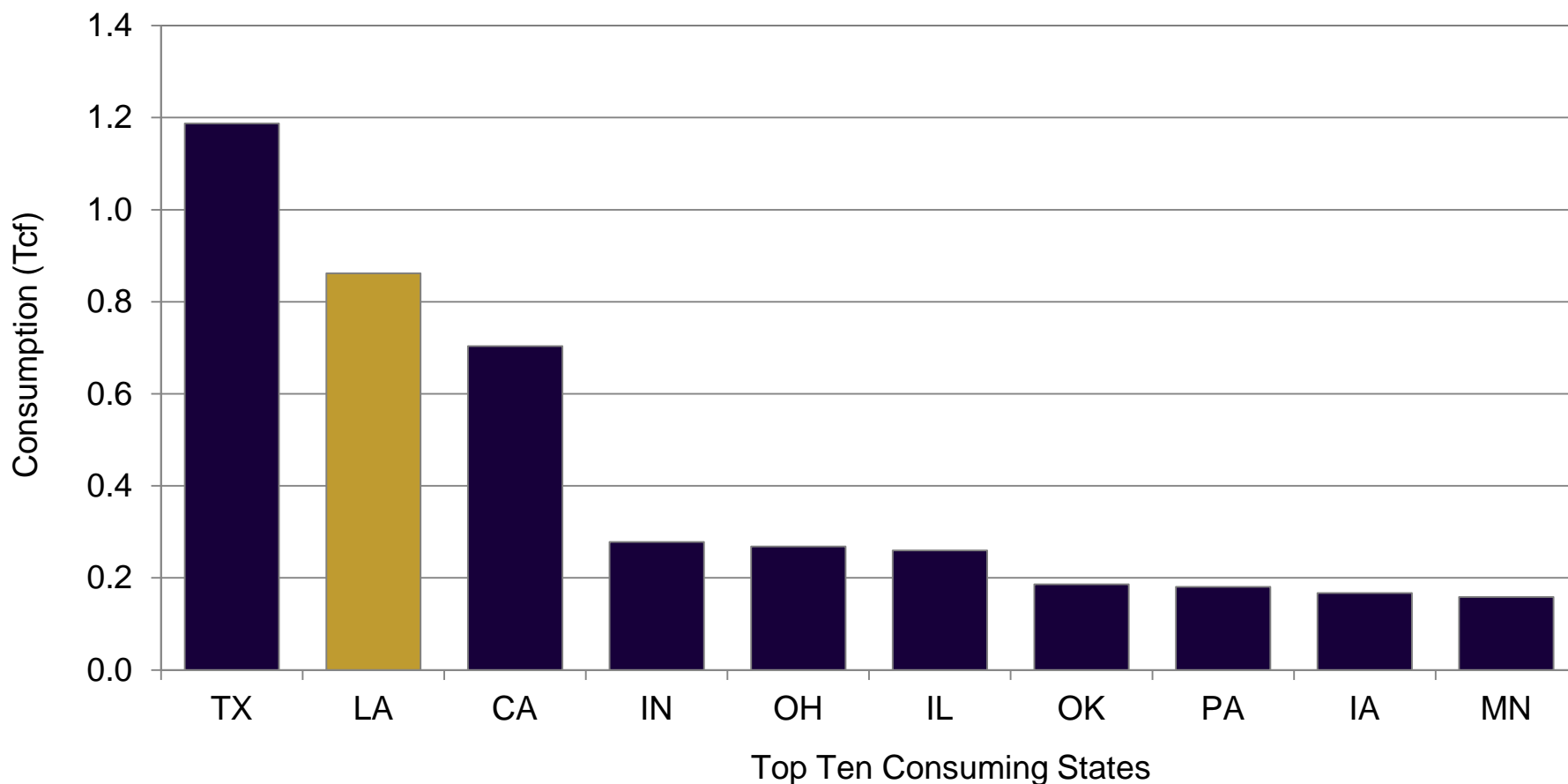
Per Customer Natural Gas Consumption by Sector, 2010

The intensity of Louisiana’s energy use is clearly demonstrated by comparing per customer usage levels between the top three natural gas consuming states. Louisiana’s residential and commercial use per customer are comparable to the other two states. Louisiana’s industrial/manufacturing use per customer is six times higher than Texas and almost 50 times higher than California.



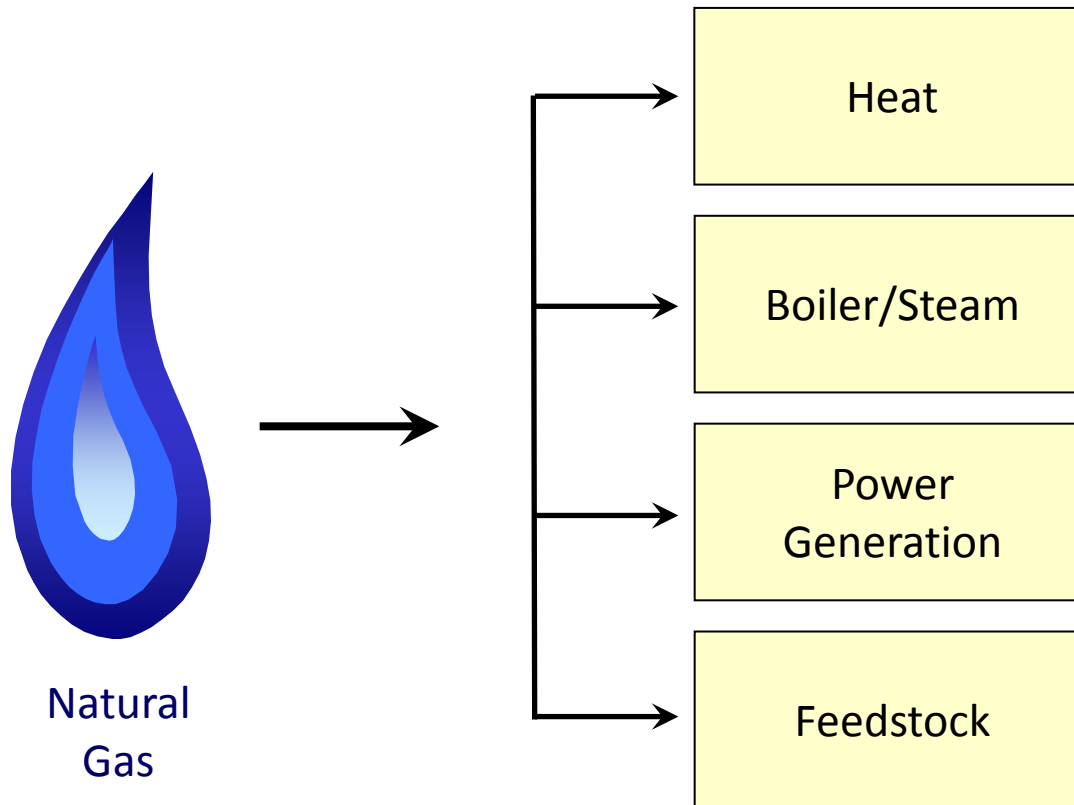
Industrial Natural Gas Consumption, 2010

In fact, Louisiana industrial and manufacturing natural gas usage (not total natural gas usage) ranks second amount the country's ten largest natural gas industrial users.



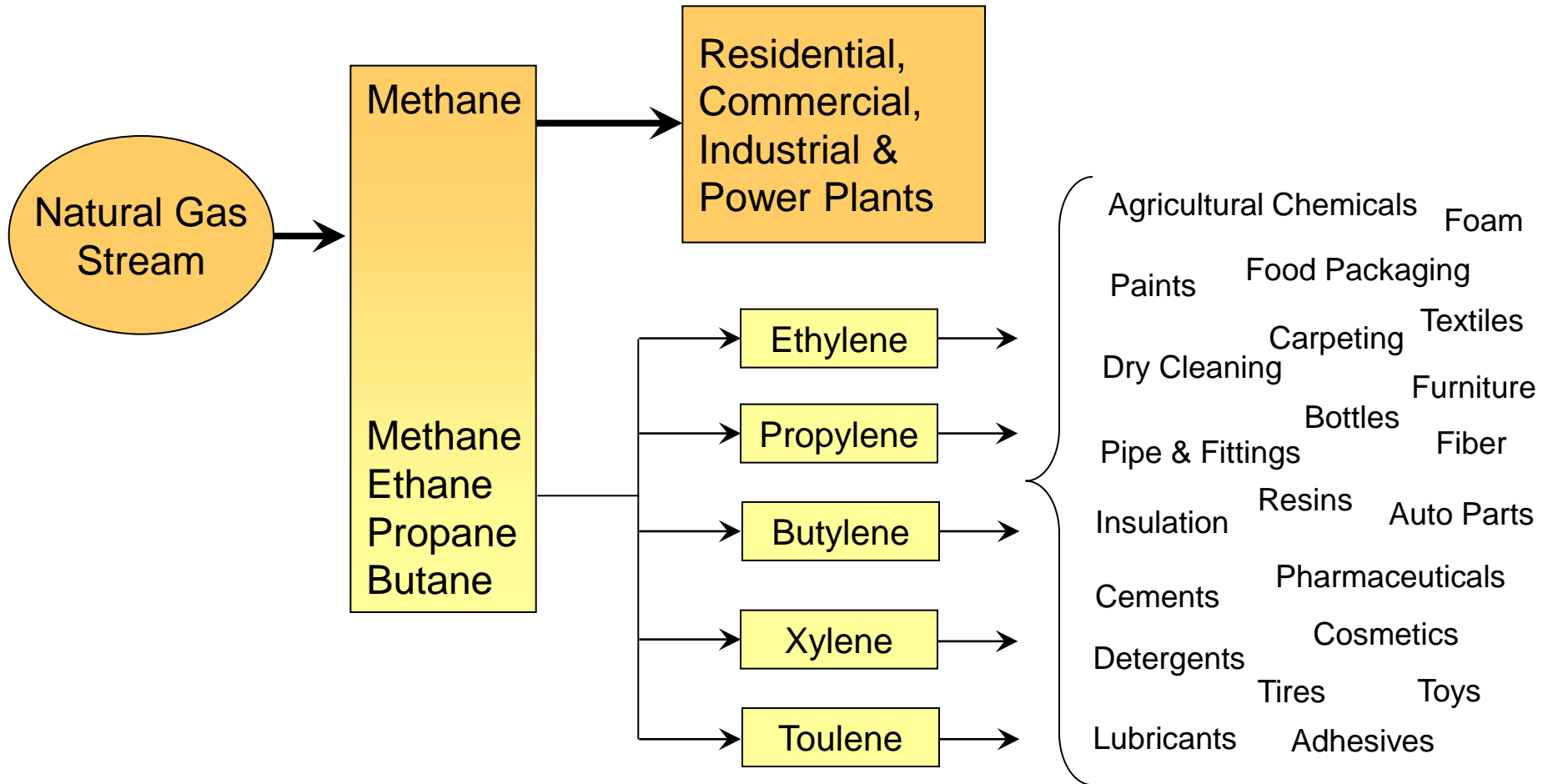
Industrial Natural Gas Usage

Louisiana’s chemical industry, in particular, uses natural gas in a range of applications that include the generation of heat, steam, and power. Feedstock uses are equally important and are the building blocks of modern petrochemical manufacturing.



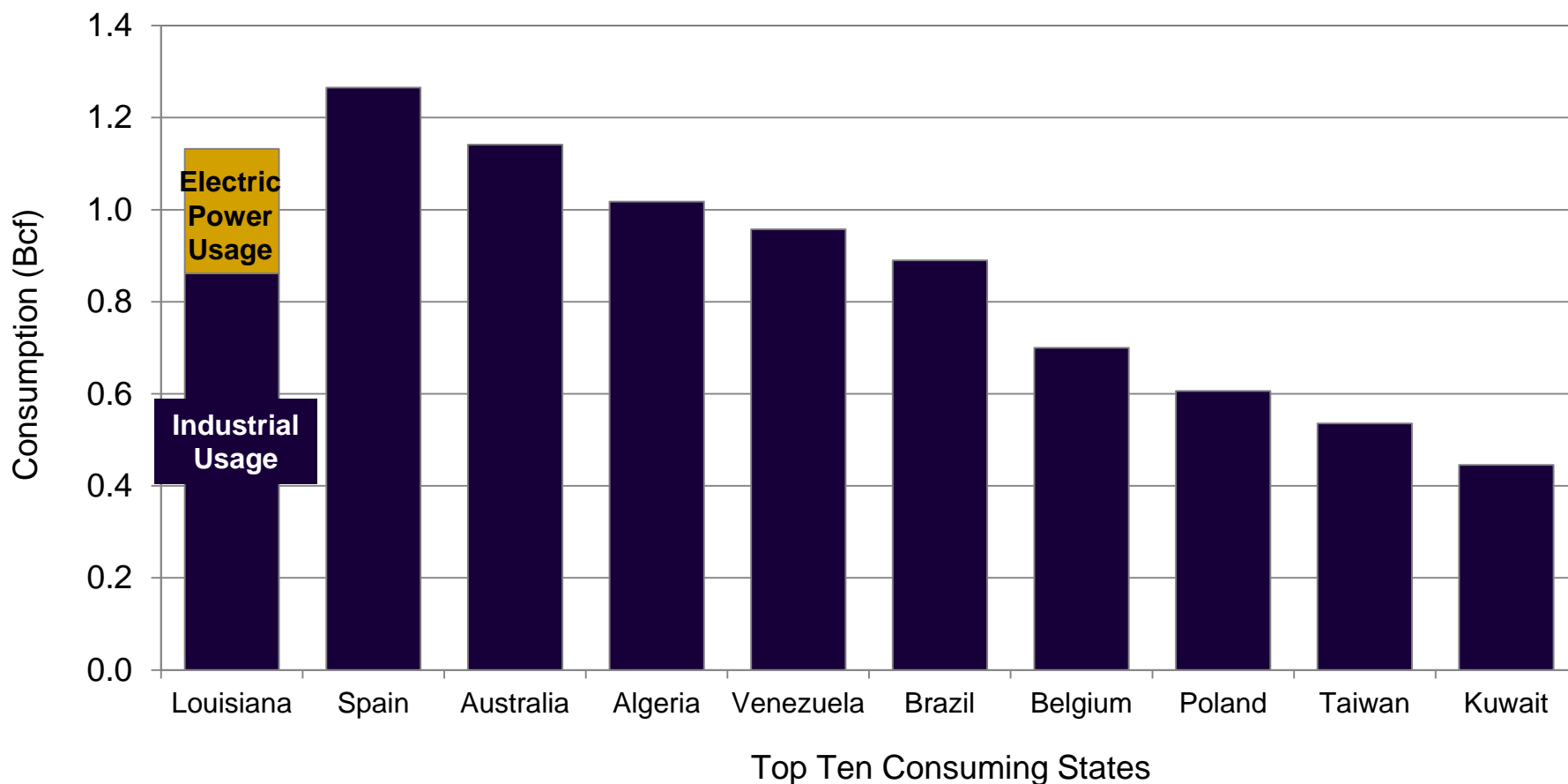
Components of Natural Gas

Natural gas and natural gas liquids, as chemical manufacturing feedstocks, are used to create a variety of products or inputs used to create a variety of products.



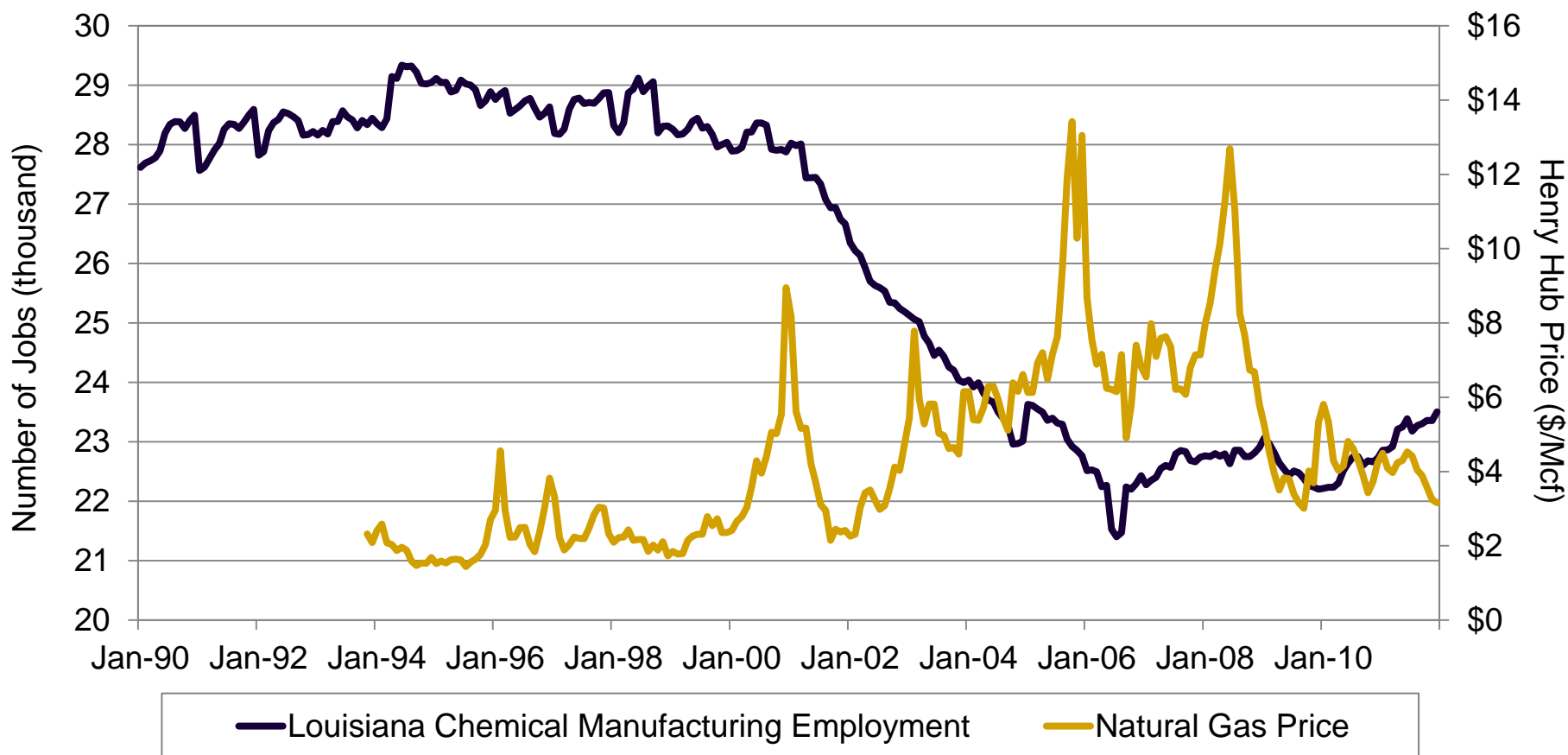
Natural Gas Consumption, Louisiana and World Comparison

Louisiana’s industrial, manufacturing, and power generation use of natural gas is larger than a number of countries.



Louisiana Chemical Industry Employment and Henry Hub Spot Price

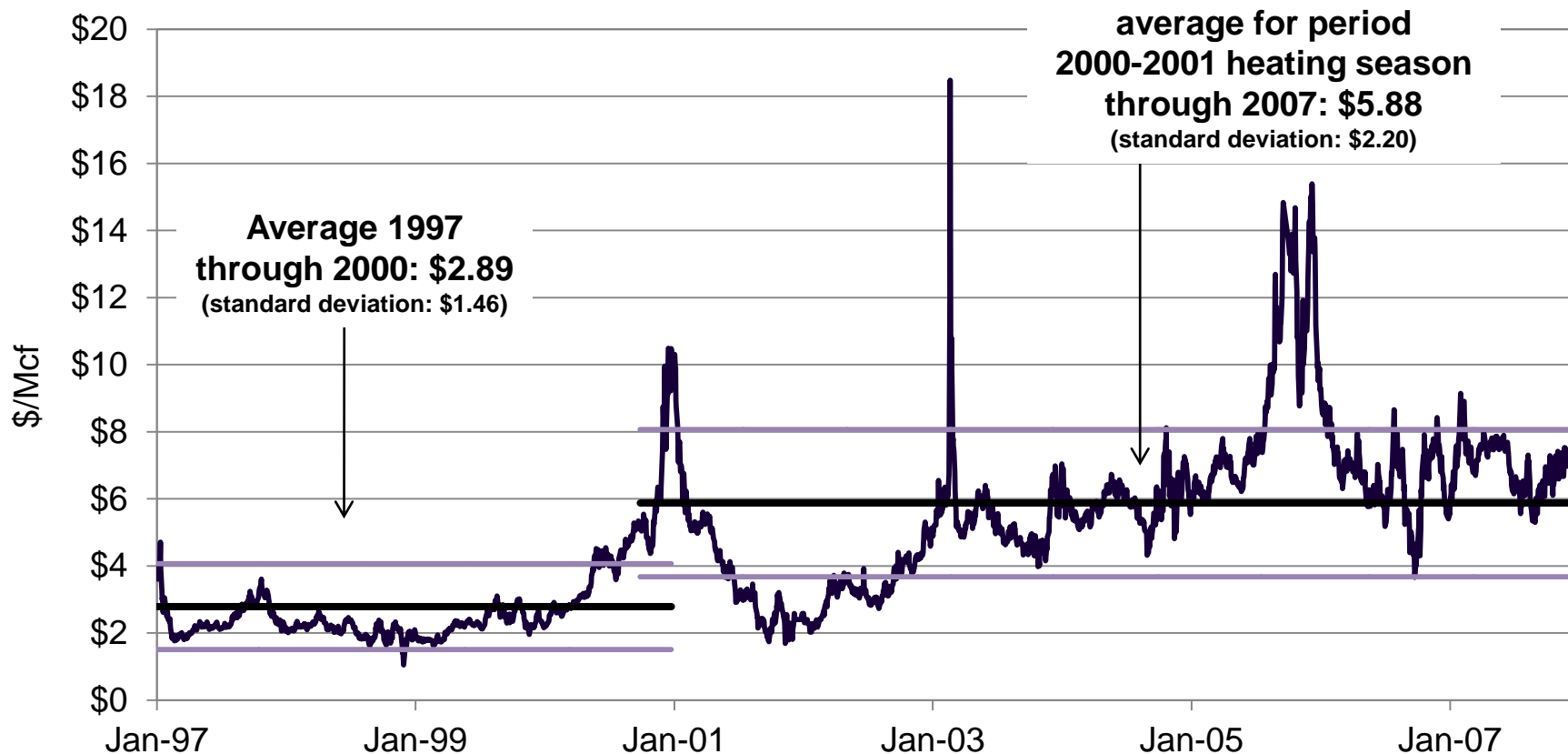
Louisiana’s chemical industry is particularly sensitive to changes in natural gas prices. As natural gas prices increase, chemical industry employment (and output) tends to decrease.



**Section 3:
The Impact of the 2001 Natural Gas Crisis on
Louisiana Manufacturing**

Natural Gas Price Trends, 1997 through 2008

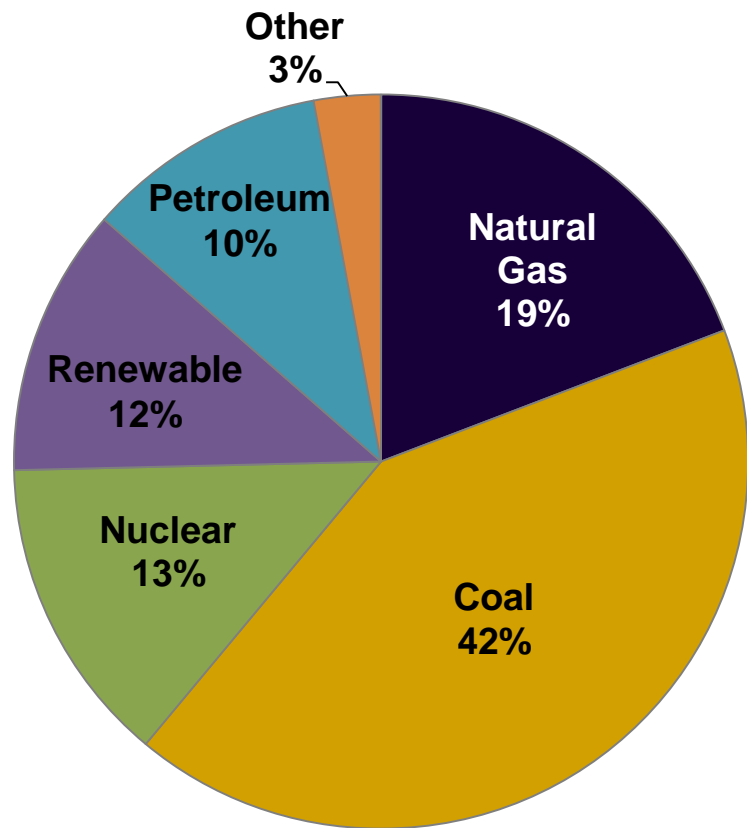
Starting in 2000, the natural gas price begins to increase and becomes much more volatile increasing costs and uncertainty for Louisiana manufacturing.



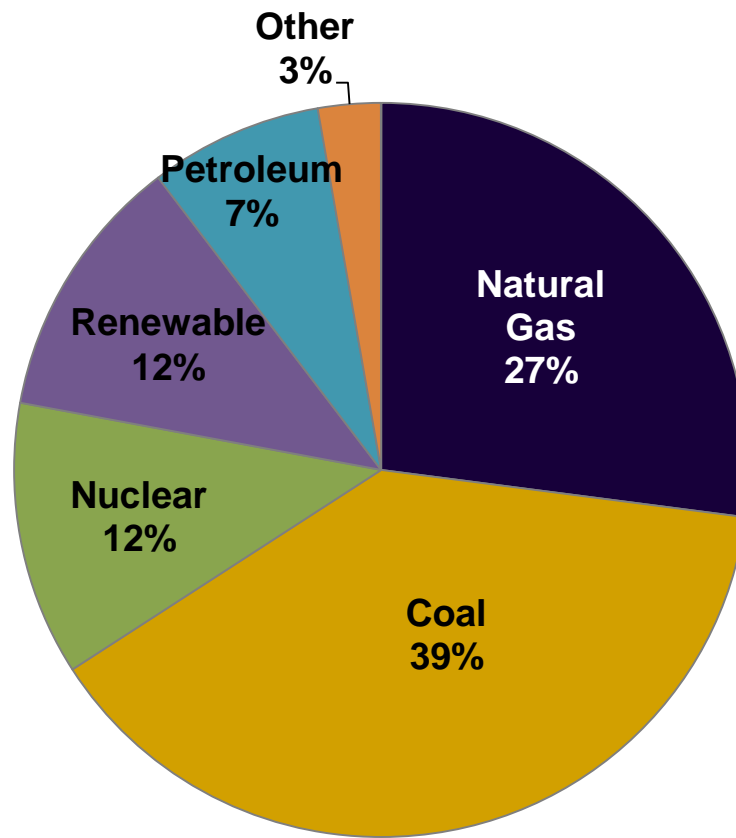
Cause of the Crisis: New Gas End Uses (Power Generation Capacity)

From a consumption perspective, natural gas-fired generation capacity in the U.S. increased from 140 GW in 1990 to almost 220 GW in 2000, an increase of 56 percent.

1990



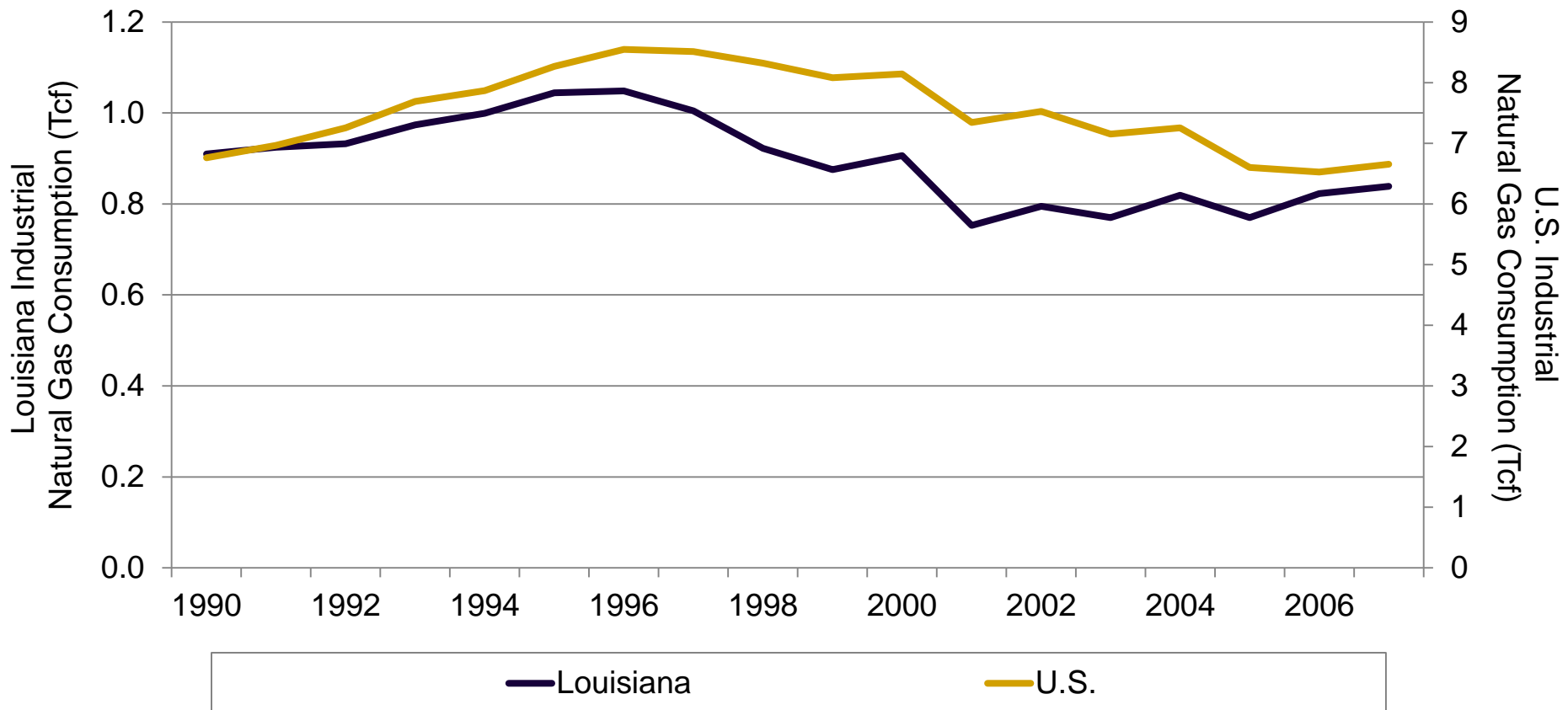
2000





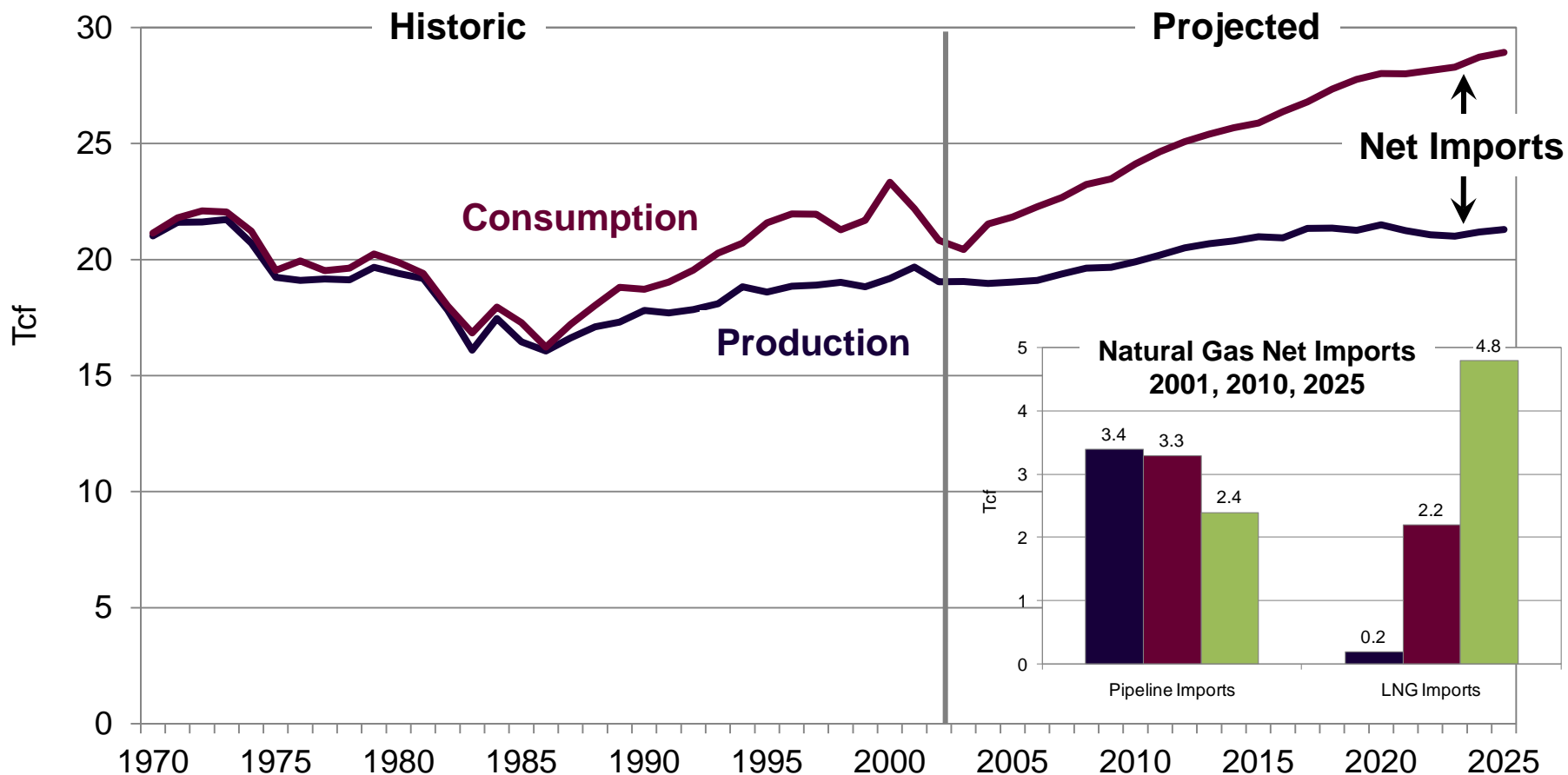
Natural Gas Demand Impacts: Industrial Demand Destruction

Increasing and volatile natural gas prices lead to reduced industrial natural gas consumption in both Louisiana and the U.S. This reduction in usage is another measure of industry contraction during this period.



Policy Crisis Response: Forecasted Natural Gas Imports (LNG)

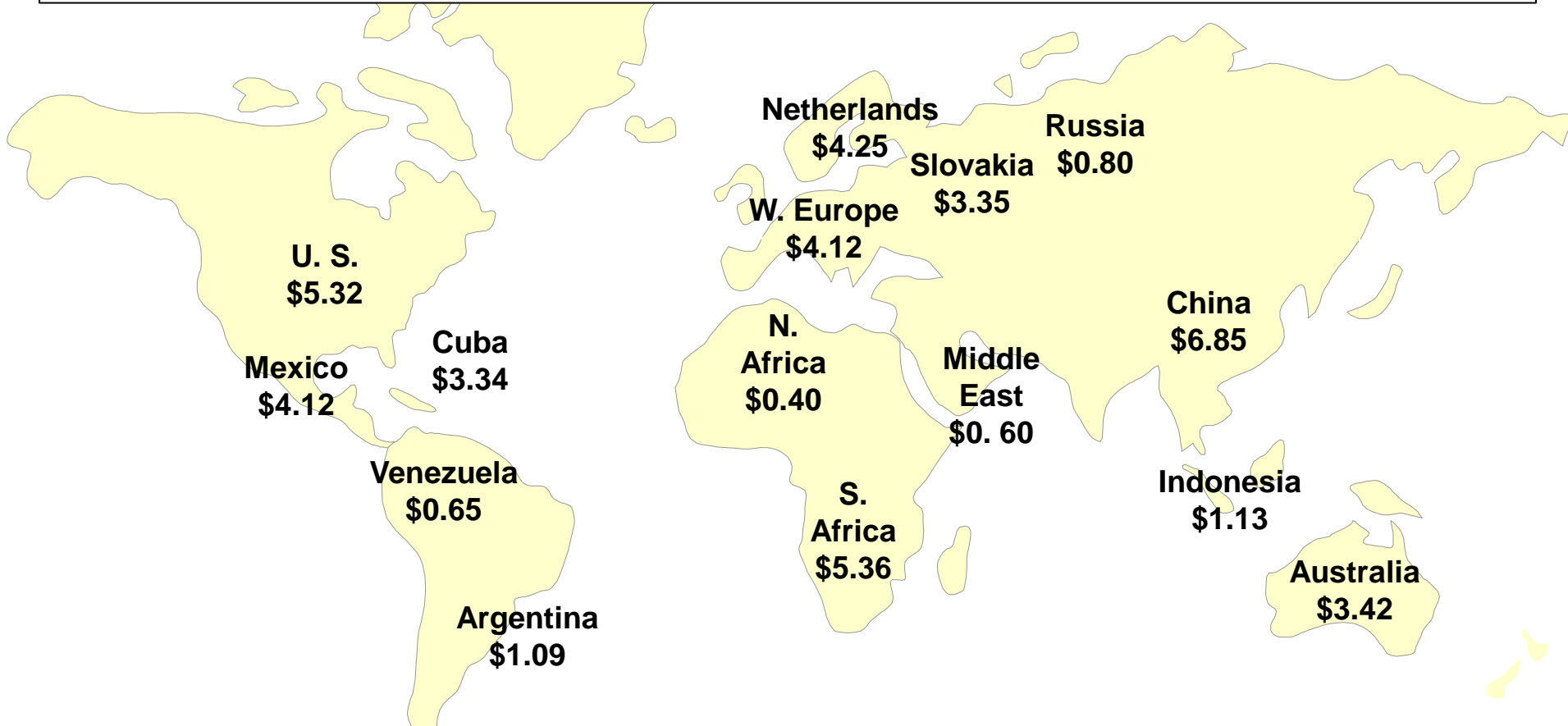
By 2004 LNG was forecasted to be an important component of natural gas supply.





World Natural Gas Prices for Industry (\$/MMBtu), 2002

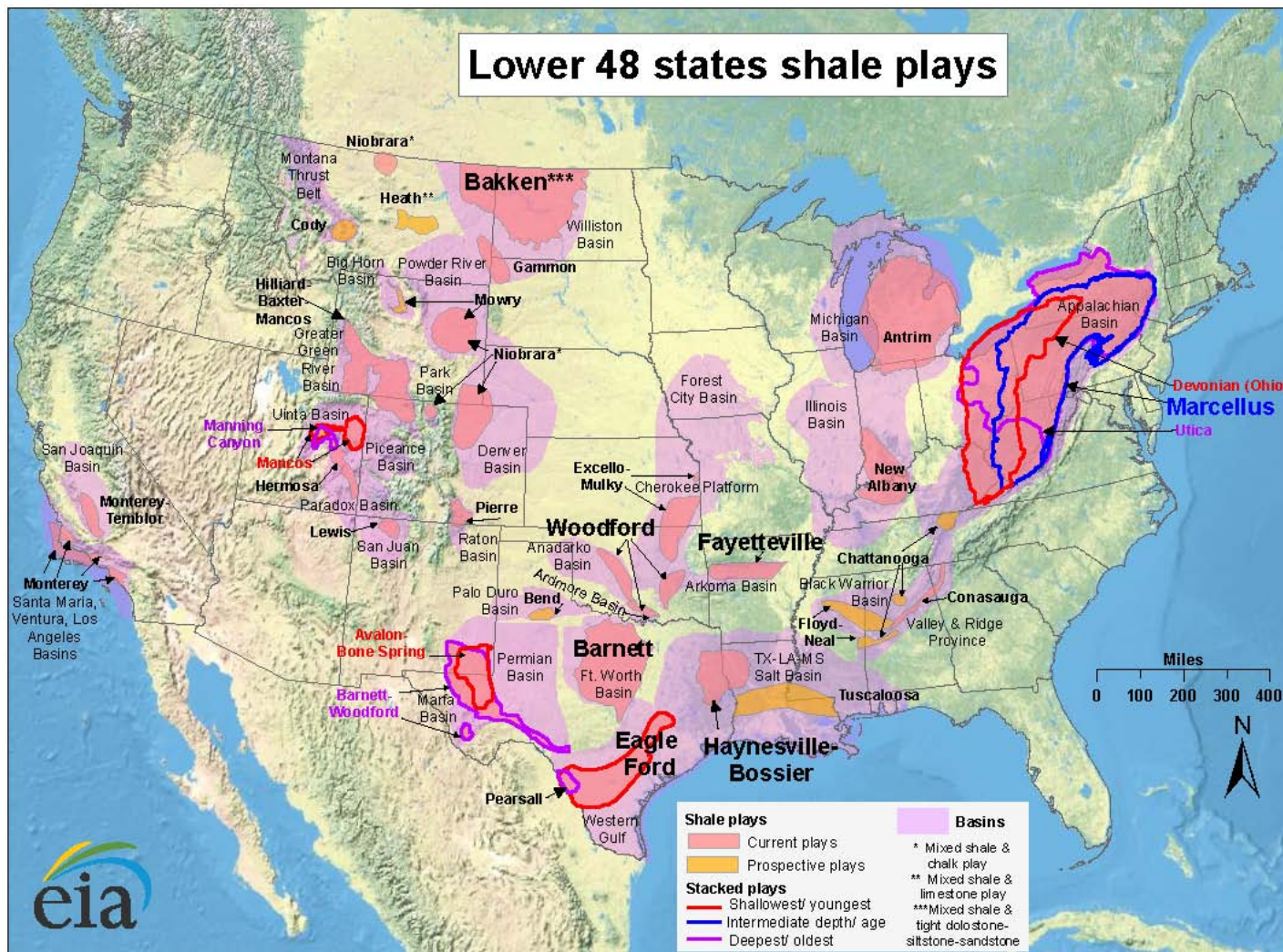
During this time period, US. natural gas prices were considerably higher than many other places in the world creating considerable competitiveness issues and incentives for offshoring and re-directing new incremental investments away from the Gulf of Mexico region.



**Section 4:
The Rise of Unconventional
Resources and Louisiana
Manufacturing Recovery**

Domestic Shale Basins and Plays

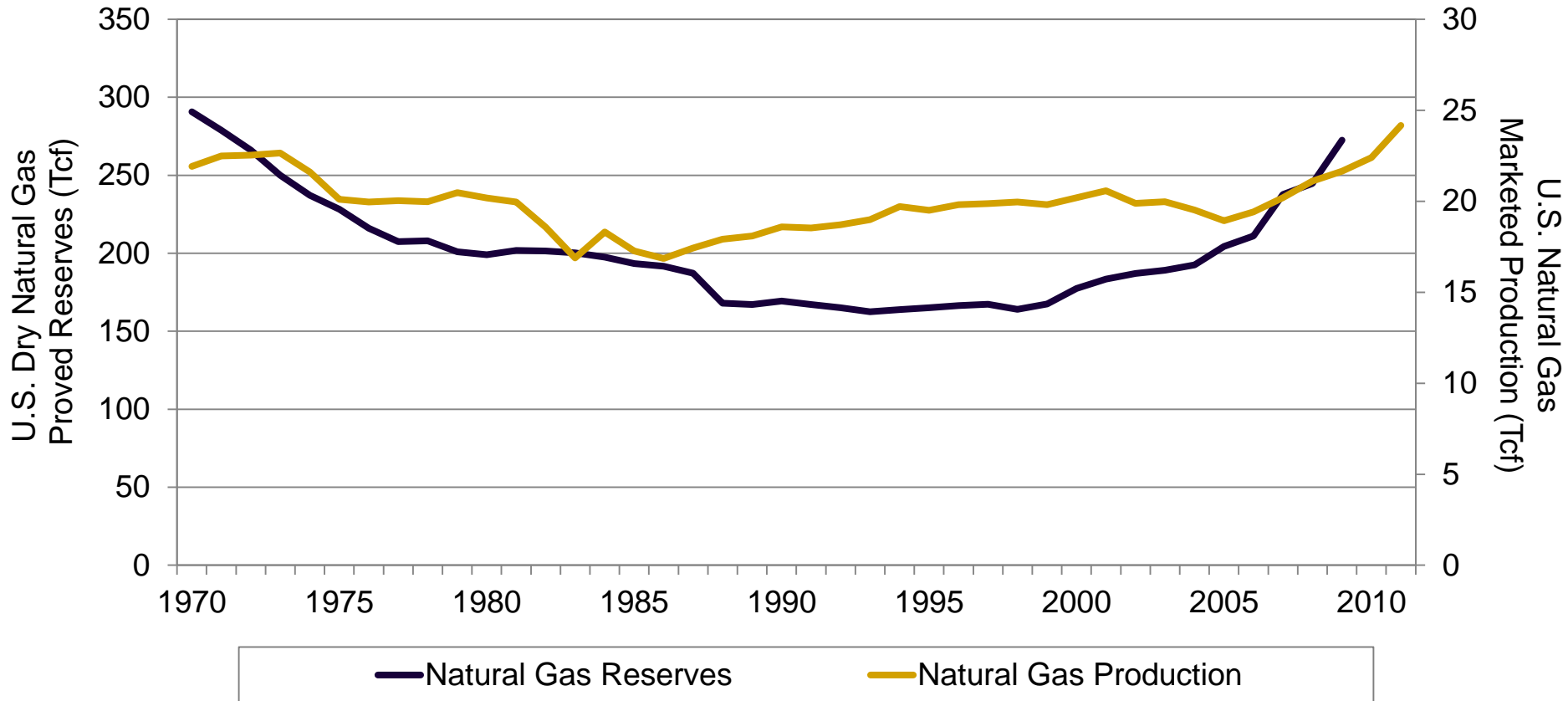
Unlike conventional resources, shale plays (natural gas, liquids, and crudes) are located throughout the U.S. and are the primary reason for the decrease in overall and regional natural gas prices.





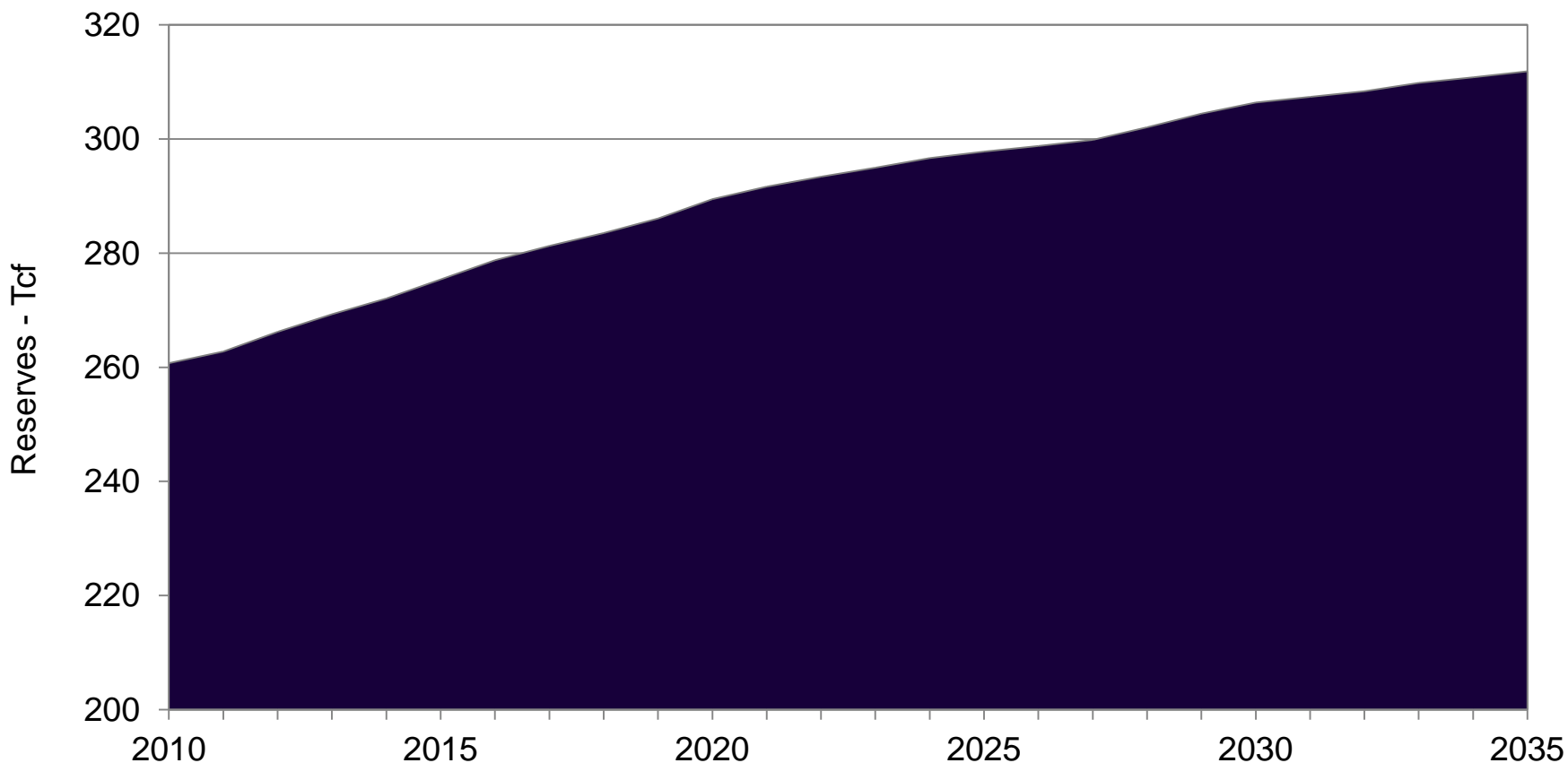
Changes in Reserves and Production

Natural gas production and reserves are at levels not seen since the 1970s. U.S. natural gas production is now at an all time recorded peak. These consistent increases should lead to a steady feedstock supply that does not impinge on other domestic natural gas uses.



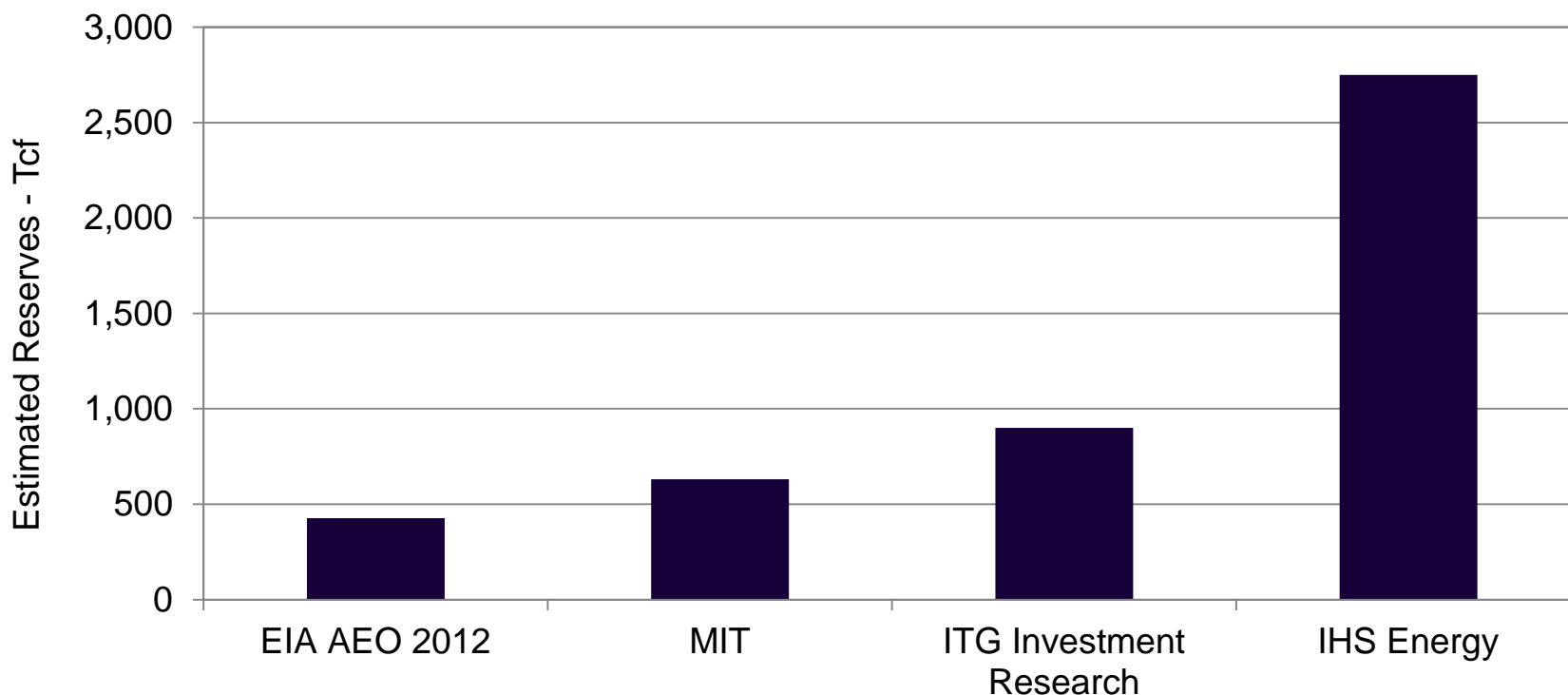
Annual Energy Outlook, Natural Gas Reserves

Unconventional resources are not a “flash in the pan” and are anticipated to continue to increase over the next two decades or more.



Alternative Natural Gas Reserves

There are a wide range of unconventional shale gas reserve estimates that are as low as 436 Tcf to as high as 2,750 Tcf. This represents a range of between 18 years and over 100 years of available natural gas resources based upon current consumption levels.*

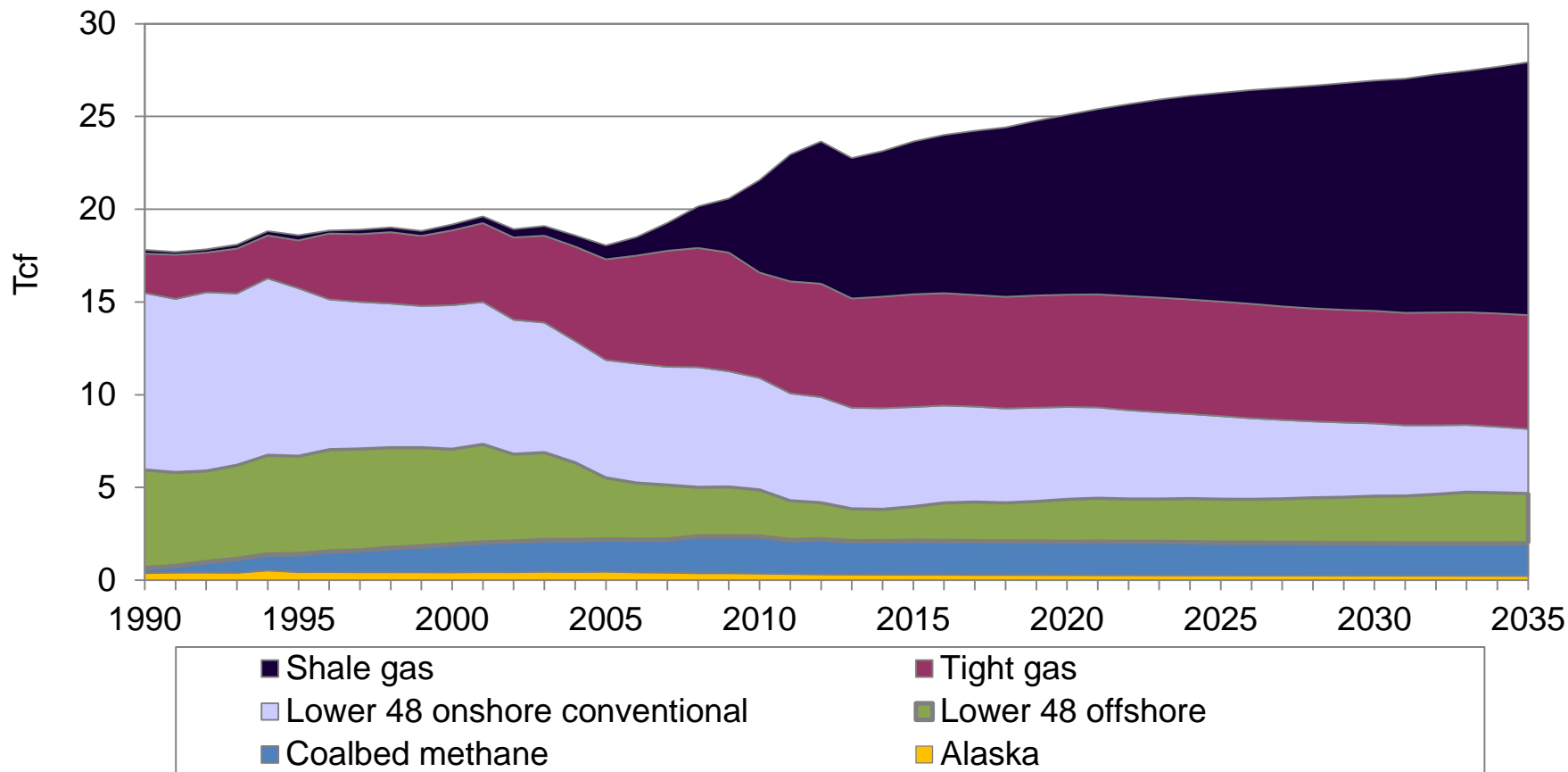


Note: *Assumes an annual consumption level of 24.3 Tcf.

The MIT study reached a mean estimate of technically recoverable resources of 631 Tcf with an 80 percent confidence interval of 418 to 871 Tcf. The ITG estimates of recoverable resources is for 10 overlapping plays, totaling 900 Tcf. These are the same 10 plays as estimated by the EIA's AEO (resulting in 426 Tcf). IHS Energy estimates show that total recoverable shale in the U.S. could be as high as 2,750 Tcf, significantly higher than their estimate of 1,268 in 2010.

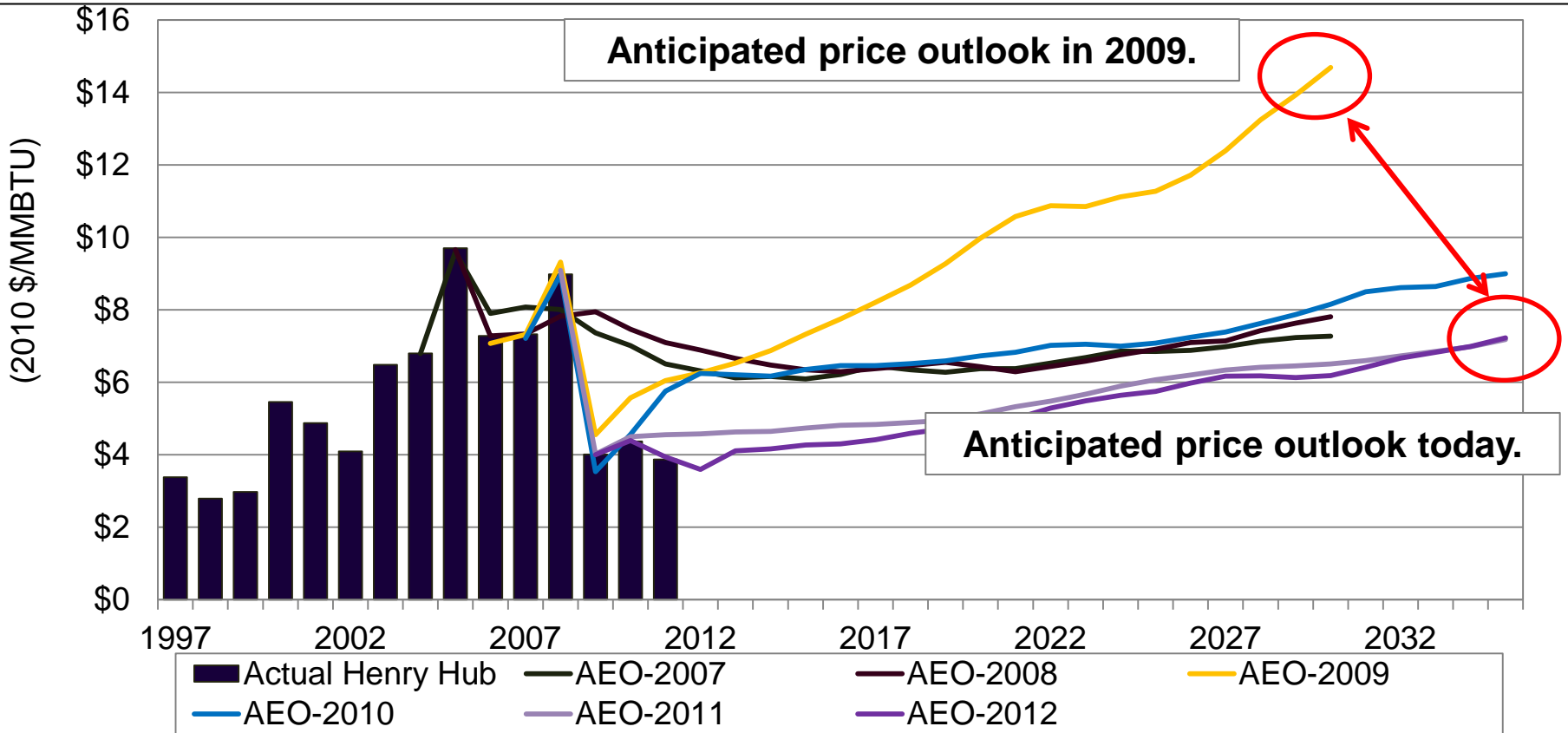
U.S. Natural Gas Production Growth Forecast

Shale availability is driving U.S. natural gas supply and will likely account for over half of U.S. natural gas production in the 2025-2035 time period.



Natural Gas Price Outlook – Annual Energy Outlook (“AEO”)

Shale reserves have a significant impact on future price outlook. Abundant supplies should keep prices from increasing back to levels seen as recently as 2009. The current AEO forecasts natural gas prices in 2030 at \$6.29/Mcf (40 percent less than the 2009 AEO forecast).



**Section 5:
Unconventional Resources and Louisiana's
Manufacturing Renaissance**

Proposed Projects

Project Type / Project	Company	Parish	New or Existing Facility	Estimated Investment (million \$)	Anticipated Online Date
LNG Export					
Sabine Pass LNG Terminal	Cheniere	Cameron	Existing	\$ 6,000	2015
Cameron LNG Export Terminal	Sempra Energy	Cameron	Existing	\$ 6,000	2016
Trunkline Lake Charles LNG Export Terminal	Trunkline LNG Company (Energy Transfer Equity, L.P.)	Calcasieu	Existing	\$ 7,500	2018
GTL					
Westlake GTL Project ¹	Sasol	Calcasieu	New	\$ 12,500	2018
Gulf Coast GTL Project	Shell	n.a.	New	\$ 10,000	2019
Methanol/Ammonia					
Waggaman Facility Expansion	Dyno Nobel International	Jefferson	Existing	\$ 800	2015
Chile-to-US Relocation/Expansion	Methanex	Ascension	New	\$ 550	2014
South Louisiana Methanol	ZEEP	Southern Region	New	\$ 1,018	2015
Mosaic Ammonia	Mosaic Company	St. James	New	\$ 700	2016
Cracker/Polymer					
Dow Olefins Expansion	Dow Chemical	St. Charles	Existing	\$ 4,000	2012
Dow Olefins Expansion	Dow Chemical	Iberville	Existing	\$ 4,000	2014
Huntsman MDI Plant	Huntsman Corp.	Ascension	Existing	n.a.	2018
Garyville Expansion	Nalco Company	St. John the Baptist	Existing	\$ 19	2012
Sasol Calcasieu Expansion	Sasol	Calcasieu	Existing	\$ 175	2013
Sasol Calcasieu Expansion	Sasol	Calcasieu	Existing	\$ 6,000	2018
Lake Charles Expansion	Westlake Chemical	Calcasieu	Existing	\$ 128	2012
Lake Charles Expansion	Westlake Chemical	Calcasieu	Existing	\$ 128	2014
Williams Olefins Expansion	Williams	Ascension	Existing	\$ 375	2013
Other					
Natural Gas Power Plant	Entergy	Jefferson	Existing	\$ 721	2015
Project Sundrop	Sundrop Fuels	Rapides	New	\$ 450	2014
Geismer Plant	Avalon Rare Metals, Inc	Ascension	New	\$ 300	2016
Steel Mill	Benteler Steel/Tube	Caddo	New	\$ 900	2015
TOTAL				\$ 62,262	

Note: The Westlake GTL Project is estimated to cost between \$11 and \$14 billion.

Project Type: LNG Export

- **With an abundance of natural gas supply, a number of companies have applied for a license to export LNG.**
- **Eighteen project sponsors have applied to DOE for authorization to export domestically produced LNG to free trade agreement (FTA) and non-free trade agreement (non-FTA) countries, totaling 27.4 Bcf/d of capacity.**
- **Of these applications, 14 project sponsors totaling 25.1 Bcf/d, are located on the Gulf Coast.**
- **Project sponsors must also seek Federal Energy Regulatory Commission (FERC) approval to construct liquefaction facilities to liquefy natural gas for exports**



Project Type: Gas-to-Liquids (“GTL”)

- **“Gas-to-liquids” refers to technologies designed to convert natural gas to liquid fuels, as an alternative to the traditional refining of crude oil.**
- **Typical outputs for a GTL process include ultra-clean diesel fuel, naphtha and LPGs, lubes and waxes. Prime markets for GTL products are the transportation fuel market and the chemical feedstock market depressed gas prices.**
- **Growing interest in GTL development stems from several factors:**
 - **Strong demand for diesel fuel for transportation (Europe, Asia);**
 - **Stringent environmental specifications for diesel fuel;**
 - **Need to monetize conventional natural gas in locations where gas markets are small or there are value-added manufacturing opportunities; and**
 - **Affordably-priced natural gas makes GTL economically viable since the energy-adjusted differential between gas and crude are significant and anticipated to remain high even if natural gas prices moderately recover.**



Project Type: Methanol/Ammonia

- Because of its many uses, ammonia is one of the most highly-produced inorganic chemicals.
- Most of the ammonia produced is used for fertilizing agricultural crops.
- Ammonia is also used for the production of refrigerant in household, commercial and industrial refrigeration systems, plastics, fibers, explosives, cleaning solutions, pharmaceuticals and intermediates for dyes.
- A typical modern ammonia-producing plant first converts natural gas or LPG into gaseous hydrogen. The method for producing hydrogen from hydrocarbons is referred to as “steam reforming“. The hydrogen is then combined with nitrogen to produce ammonia.



Project Type: Ethylene Cracker/Polymer

- **An ethylene cracker is a petrochemical plant that uses a feed of gas hydrocarbons (dry gas, propane, butane), and heats it (to about 850 °C) to "crack" the molecules into smaller ones.**
- **After being heated, the product becomes a mixture of different gases and some liquids. These are then separated (refined) into different products. The primary product is ethylene.**
- **Most ethylene crackers also have a hydrogenation section. This is a series of reactors which hydrogenate (add hydrogen) and acetylene turning it into ethylene. This increases the ethylene yield.**
- **Ethylene is a major building block of alcohol- and plastic-based products, such as solvents, surfactants and polymers.**



Project Type: Other Investment Types

Other facilities under development include:

A natural gas-fired generation unit. The proposal would add an additional natural gas-fired generation unit at an existing generating facility.

A biofuels plant. The proposed biofuels plant will salvage wood waste for use as a feedstock. It would also extract hydrogen from natural gas, combining it with carbon extracted with the woodwaste, to create a renewable “green gasoline”.

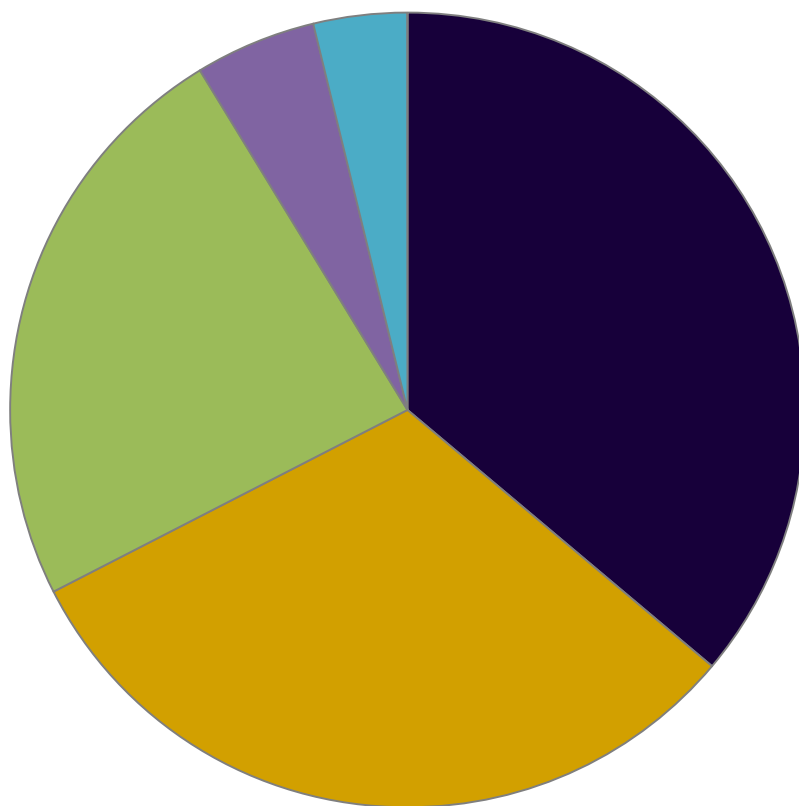
A rare earth separation plant that would isolate and refine the individual light and heavy rare earth oxides and chlorides and produce a mixed rare earth concentrate.

A steel mill that would produce seamless steel tubing.



Total Capital Expenditures by Sector

Of the proposed facility expansions in Louisiana, gas-to-liquids and LNG export comprise the majority of proposed capital spending.

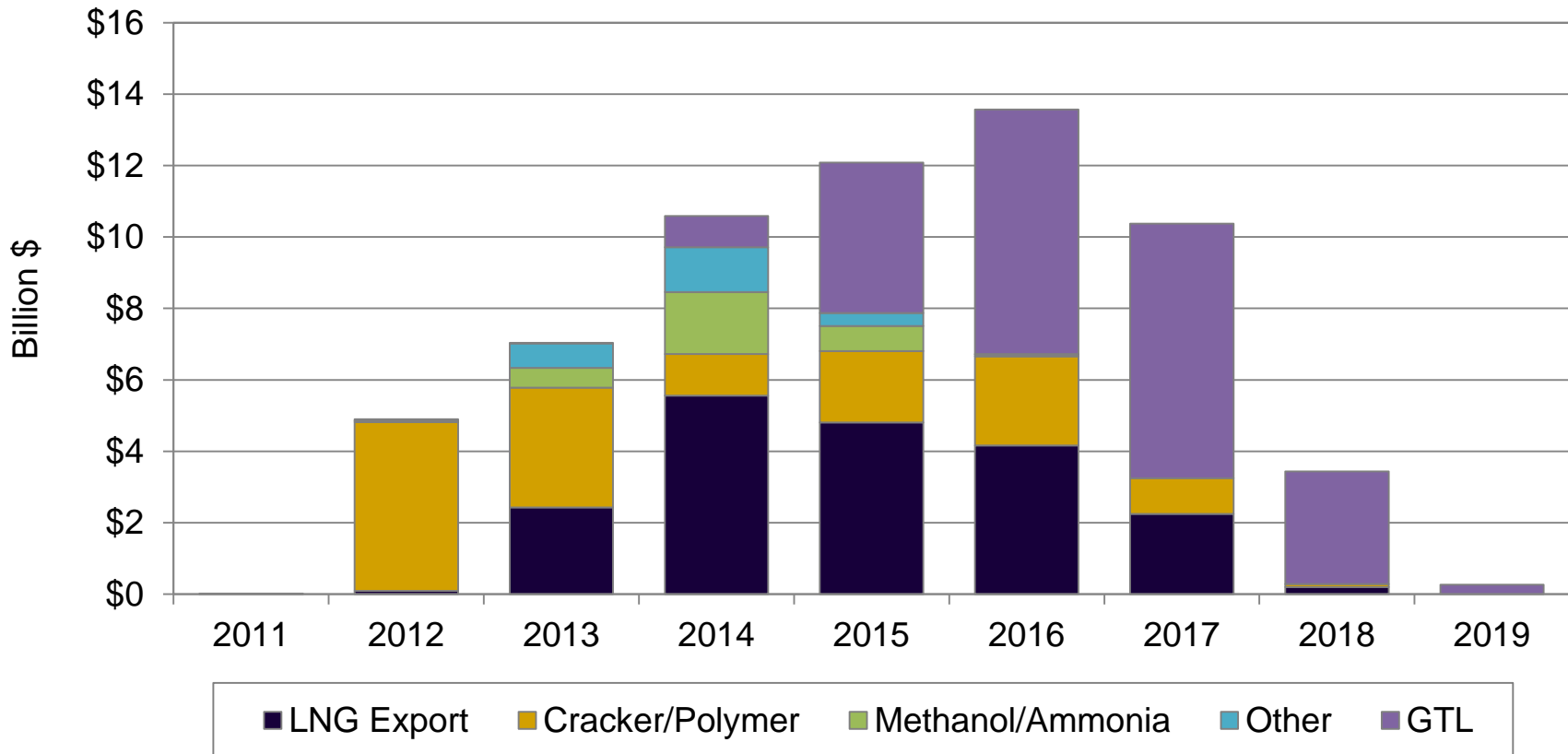


- GTL, \$22.5 billion, 36%
- LNG Export, \$19.5 billion, 31%
- Cracker/Polymer, \$14.8 billion, 24%
- Methanol/Ammonia, \$3.1 billion, 5%
- Other, \$2.4 billion, 4%



Total Capital Expenditures by Sector

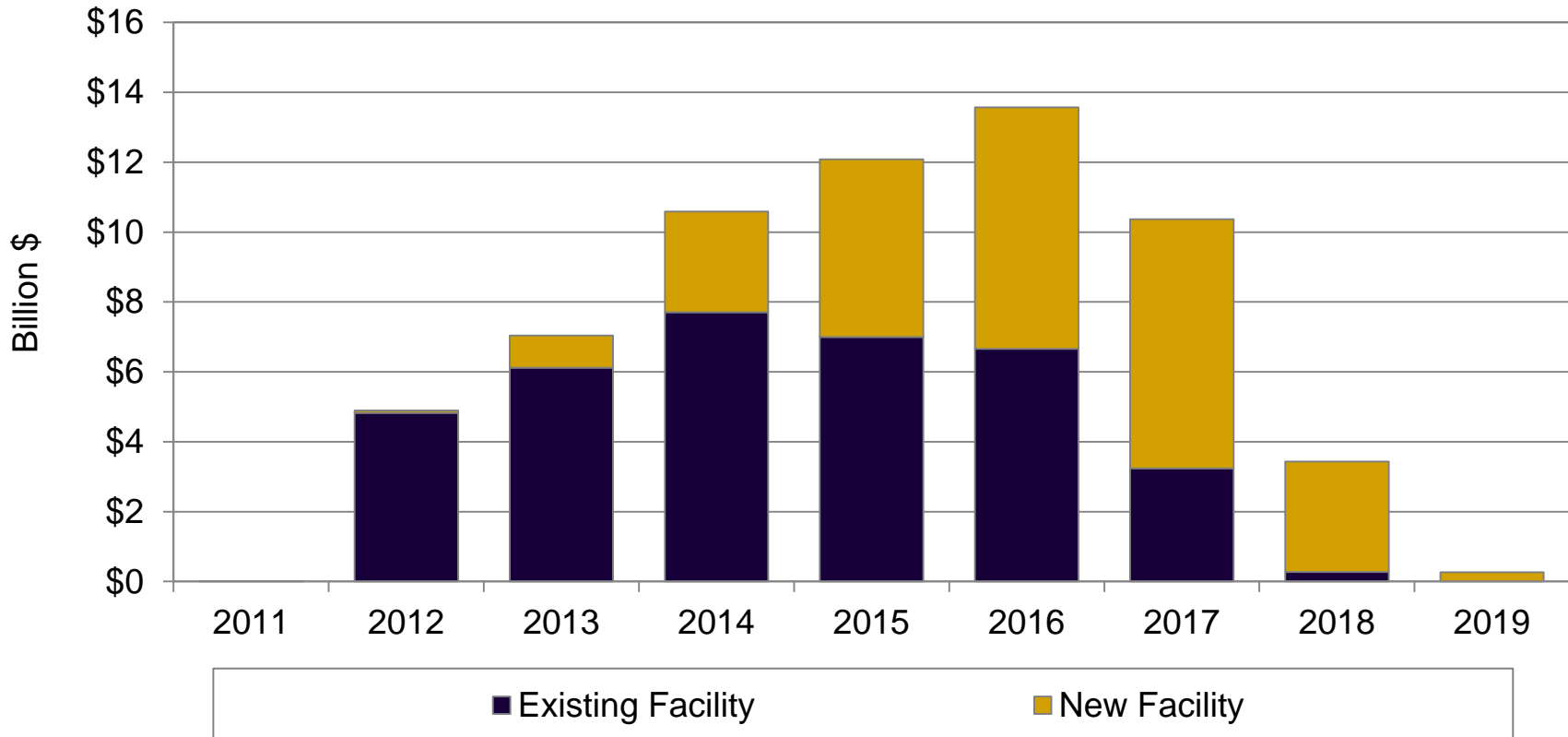
The total capital investment associated with all announced natural gas-driven manufacturing investments in Louisiana totals over \$62 billion. Most of the investment is anticipated to occur between 2014 and 2017.





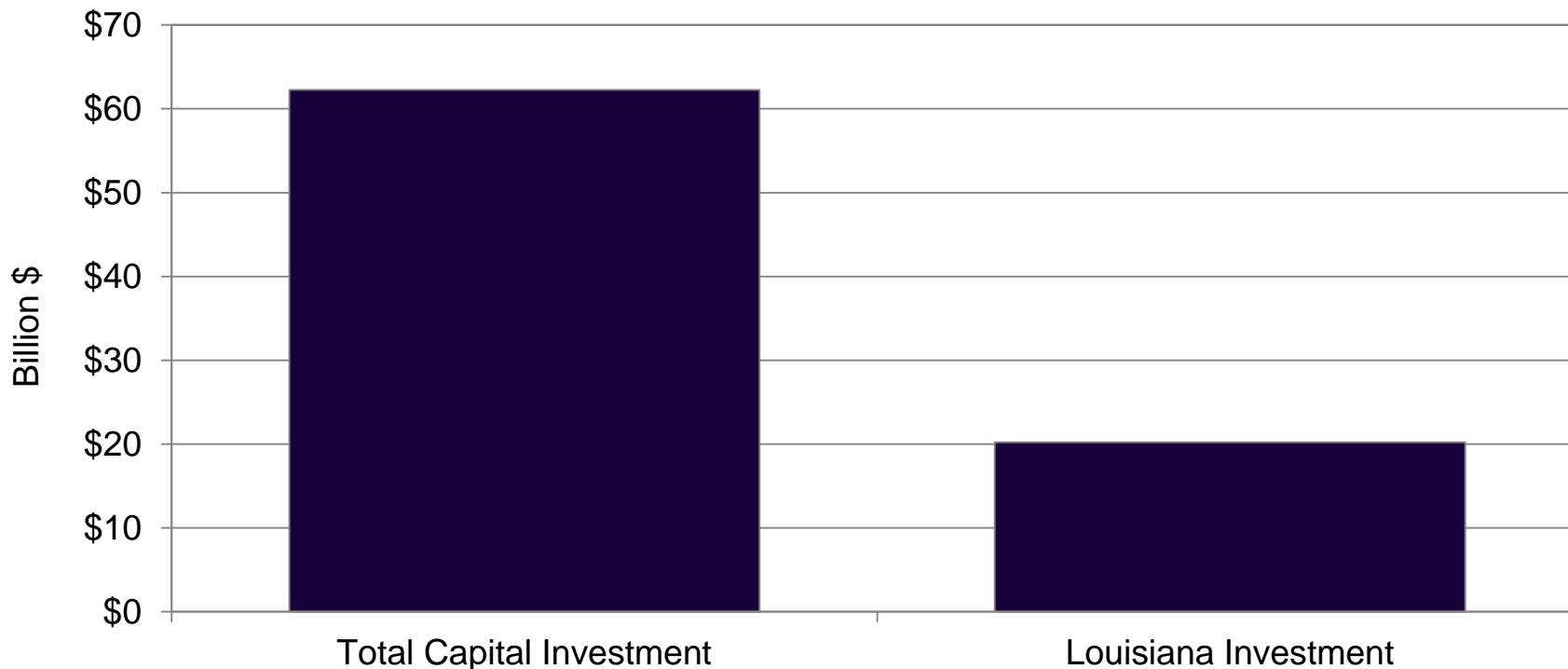
Total Capital Expenditures by Facility Status (Existing, New)

Investments at existing facilities comprise approximately 58 percent of total investment. New facility investments will take longer to materialize and occur in the 2015-2017 time period.



In-State Expenditures

Not all of the total capital investment associated with the natural gas driven manufacturing expansions will occur in Louisiana since a large amount of materials and equipment will be purchased out of state. However, despite this “leakage” there is still an anticipated \$20.2 billion that will be spent in Louisiana over the several years representing one of the largest, most concentrated levels of capital expenditures in the state’s history.



Potential Economic Impacts/Benefit: Construction, State

If developed, all Louisiana natural gas driven project investments will result in a total state-wide economic impact of some \$29.7 billion, the creation of over to 214,000 employment opportunities, and \$9.3 billion in new wages.

	Construction Impacts									
	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019
Output (million \$)										
Direct	\$ 20,205.2	\$ 4.4	\$ 1,715.4	\$ 2,461.9	\$ 3,630.9	\$ 3,907.5	\$ 4,255.9	\$ 3,150.0	\$ 1,002.5	\$ 76.8
Indirect	\$ 3,243.9	\$ 0.7	\$ 275.4	\$ 395.2	\$ 582.9	\$ 627.3	\$ 683.3	\$ 505.7	\$ 160.9	\$ 12.3
Induced	\$ 6,287.8	\$ 1.4	\$ 533.8	\$ 766.1	\$ 1,129.9	\$ 1,216.0	\$ 1,324.4	\$ 980.3	\$ 312.0	\$ 23.9
Total	\$ 29,736.8	\$ 6.4	\$ 2,524.6	\$ 3,623.2	\$ 5,343.7	\$ 5,750.8	\$ 6,263.6	\$ 4,636.0	\$ 1,475.4	\$ 113.0
Employment (jobs)										
Direct	136,900	30	11,623	16,680	24,601	26,475	28,836	21,343	6,792	520
Indirect	21,885	5	1,858	2,667	3,933	4,232	4,610	3,412	1,086	83
Induced	55,885	12	4,745	6,809	10,043	10,807	11,771	8,712	2,773	212
Total	214,670	47	18,225	26,156	38,576	41,515	45,217	33,467	10,651	816
Wages (million \$)										
Direct	\$ 6,585.1	\$ 1.4	\$ 559.1	\$ 802.3	\$ 1,183.3	\$ 1,273.5	\$ 1,387.1	\$ 1,026.6	\$ 326.7	\$ 25.0
Indirect	\$ 952.0	\$ 0.2	\$ 80.8	\$ 116.0	\$ 171.1	\$ 184.1	\$ 200.5	\$ 148.4	\$ 47.2	\$ 3.6
Induced	\$ 1,766.3	\$ 0.4	\$ 150.0	\$ 215.2	\$ 317.4	\$ 341.6	\$ 372.0	\$ 275.4	\$ 87.6	\$ 6.7
Total	\$ 9,303.4	\$ 2.0	\$ 789.8	\$ 1,133.5	\$ 1,671.8	\$ 1,799.2	\$ 1,959.6	\$ 1,450.4	\$ 461.6	\$ 35.4

Section 6: Conclusions

Conclusions

- The natural gas (and crude oil) revolution are having, and are likely to have, considerable positive economic impacts on U.S. manufacturing/industrial development.
- All of this development is **resource-specific** and **policy dependent**.
- There are some doubters and nay-sayers. There are also plenty of opponents (although none locally/regionally).
- Louisiana, and the Gulf Coast generally, will be **the prime beneficiaries** of this early part of this broader U.S. manufacturing renaissance – the mid-west will likely be another beneficiary, although not to the same extent as the GOM, at least not for the next few years.



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