Natural Gas Savings to End-users: 2008-2018
A Technical Briefing Paper

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Executive Summary

Since 2008 the U.S. has greatly increased the production of natural gas. Investments made by the natural gas exploration and production industry along with new technologies have made possible substantial increases in supply. In 2017, the U.S. became a net exporter of natural gas. By producing more than Russia, Iran, Qatar, and China, the U.S. is the world's number one producer of natural gas and now reaps the benefits of abundant natural gas energy supplies. Among the benefits are lower domestic end-user prices for customers in the Residential, Commercial, Industrial, and Electric Power Generating sectors. This paper identifies and explores methods of estimation of cost savings that have applied to U.S. end-users of natural gas. Dollar savings are also examined for the Shale Crescent USA region comprised of Ohio, Pennsylvania, and West Virginia. The Shale Crescent is responsible for 85 percent of the net growth in natural gas daily production over the past ten years and now accounts for nearly one-third of U.S. natural gas annual production.

Findings in Brief

End-users have saved $1.1 trillion over the past ten years due to increased natural gas production that has reduced the price of natural gas in the United States. (Table 1) Several methods of calculating the counterfactual scenarios were explored in order to estimate what would have happened in the natural gas markets had the sizable production of shale gas not occurred. A Henry Hub pricing approach was chosen to investigate the effect of additional natural gas production since it is a national pricing point and best approximates the U.S. natural gas market. In addition, Henry Hub[1] prices are net of considerable transmission and distribution costs that occur between producers and end-users. While the use of Citygate[2] prices provides an alternative approach to measure impacts, it is considered second best since it masks production contribution with variable transport and regulatory costs found region by region. Even so, calculating the effect of increased production using Citygate prices yields sizable savings of $887.5 billion to end-users over the past ten years. (Table 1)

Table 1. U.S. Savings: Sum of End-user Ten-year Savings by Counterfactual Method

Method	Sum of End-user Savings
	-- billion 2018$ dollars --
Henry Hub	1,081
Citygate	888

[1] Henry Hub is a natural gas pipeline located in Erath, Louisiana, that serves as the official delivery location for futures contracts on the New York Mercantile Exchange (NYMEX).

[2] A Citygate is a point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system.

The Shale Crescent USA region has realized savings totaling $92 billion since 2009 using the counterfactual Citygate method. (Table 2) In total, Industrial end-users in the Shale Crescent USA saved $24.7 billion in the past ten years due to increased natural gas supplies driving down the cost of natural gas.

Table 2. Shale Crescent USA Savings, 2018$

State	Ten-year Savings
	-- 2018 dollars --
Ohio	45,325,567,530
Pennsylvania	43,933,440,019
West Virginia	3,689,476,685
Sum	92,948,484,234

Calculating household savings using a separate data series, the Consumer Expenditure Survey, further confirms the magnitude of savings. Published annually by the Bureau of Labor Statistics, Consumer Expenditure Survey data reveals that for the average household using natural gas the amount paid annually for natural gas declined by $429 since 2008. Moreover, across household income cohorts a distributional effect is evident. The reduction in natural gas prices represents savings of 2.7% of income for the lowest income quintile. This is equivalent to a raise of 2.7% for the poorest households.

Introduction

In the past ten years, technological innovations in horizontal drilling have led to sustained and record-level production of natural gas in the United States. As a result, prices have fallen substantially throughout the U.S. Natural gas as measured using the average Henry Hub price has declined from a 2008 high of $8.86 to an estimated 2018 price of $3.16. The Shale Crescent USA region comprised of Ohio, Pennsylvania, and West Virginia has benefited end-user consumers and businesses with lower utility bills for natural gas and electricity and has given the region a locational cost advantage for economic development, especially for energy intensive industries.

In this paper, we highlight key factors influencing gas prices and provide first approximations of the savings to end-users in the U.S. and the Shale Crescent USA region. In addition to estimating savings to end-users, we also examine corroborating evidence of lower natural gas prices on after-tax income of households. This paper is best viewed from the cost savings to end-users and not a comprehensive accounting of costs associated with increased natural gas production.

Analyzing Natural Gas Market Dynamics

In economic theory, the law of supply and demand is considered one of the fundamental principles governing how markets operate in an economy. The theory asserts that as supply increases the price will tend to drop or vice versa, and as demand increases the price will tend to increase or vice versa. In an unrestrained market, the forces of supply and demand push the price to an equilibrium level. A reduction in the cost of an input such as natural gas generates a positive supply response for the final good and will cause the supply schedule for the final good to shift to the right. The reduction in natural gas price will lower production costs and increase supply of the final good. Because natural gas consumption and prices are simultaneously determined by the interaction between demand and supply, the theory explains that the lowering of the cost of a good will cause the quantity demanded to rise.

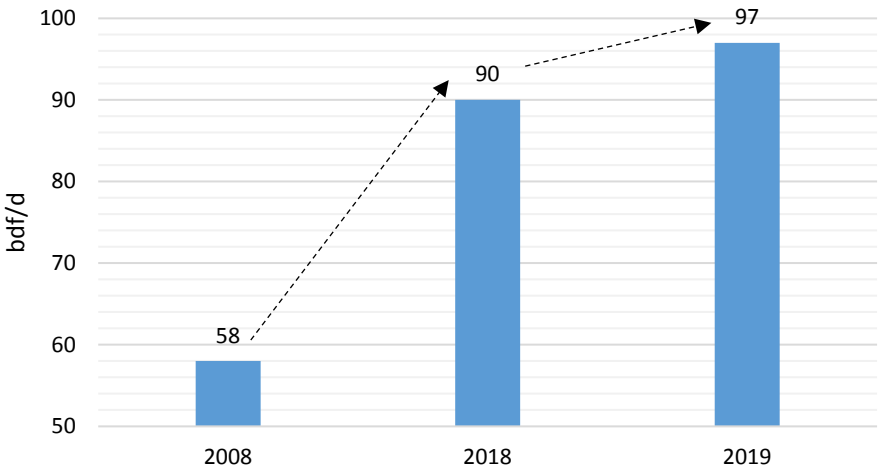
There is little doubt that the supply of natural gas has increased due to new technologies and industry investments made in accessing shale. These production changes are highlighted below. Indeed, economic principles indicate that the supply curve for natural gas shifted to the right and causes a downward price movement at equilibrium. It is important to recognize that changes in weather, international oil supplies, and natural gas demand can also impact natural gas prices and need to be accounted for when isolating the amount of price decrease due to a supply shift.

Production Changes

In 2008, the United States produced an average of 58 billion cubic feet per day (bcf/d) of marketed natural gas production. By 2018, marketed natural gas production had risen to nearly 90 bcf/d and

was projected to rise to over 97.1 bcf/d by December of 2019.[3] (Figure 1) The United States has become the number one natural gas producing country in the world.[4] In 2017 the United States exceeded its previous peak of natural gas production set in 1971 by 39 percent and became a net exporter of natural gas for the first time.[5]

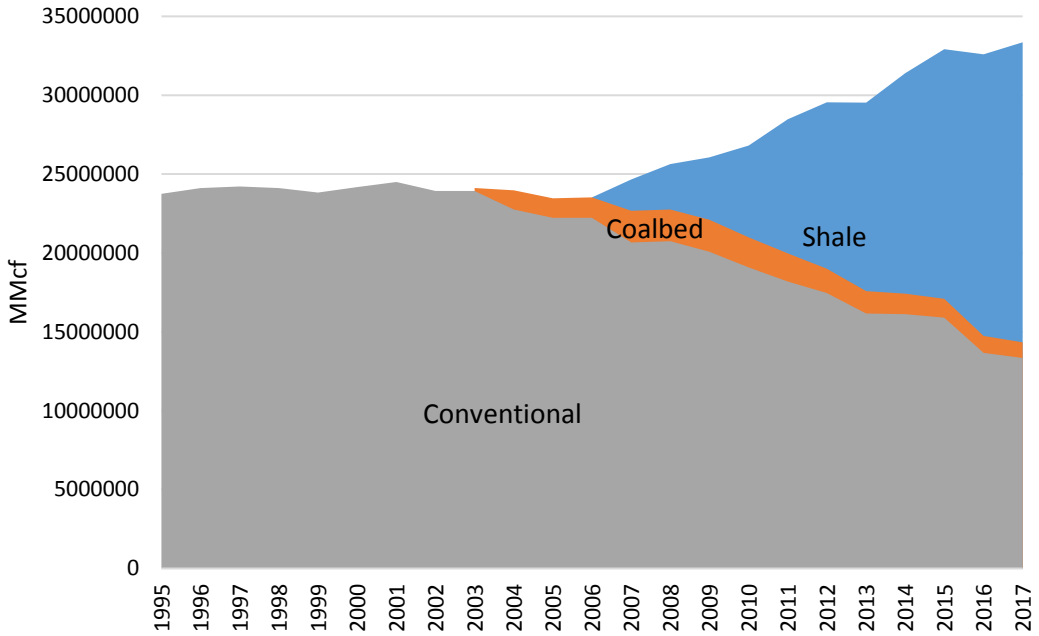
Figure 1. U.S. Daily Marketed Natural Gas Production, Bcf/d



[3] EIA, Short Term Energy Outlook, December 11, 2018. For 2008, natural gas marketed production was divided by 365.
[4] EIA, International Data. https://www.eia.gov/beta/international/data
[5] EIA, Gross Withdrawal data. https://www.eia.gov/dnav/ng/hist/n9010us2A.htm

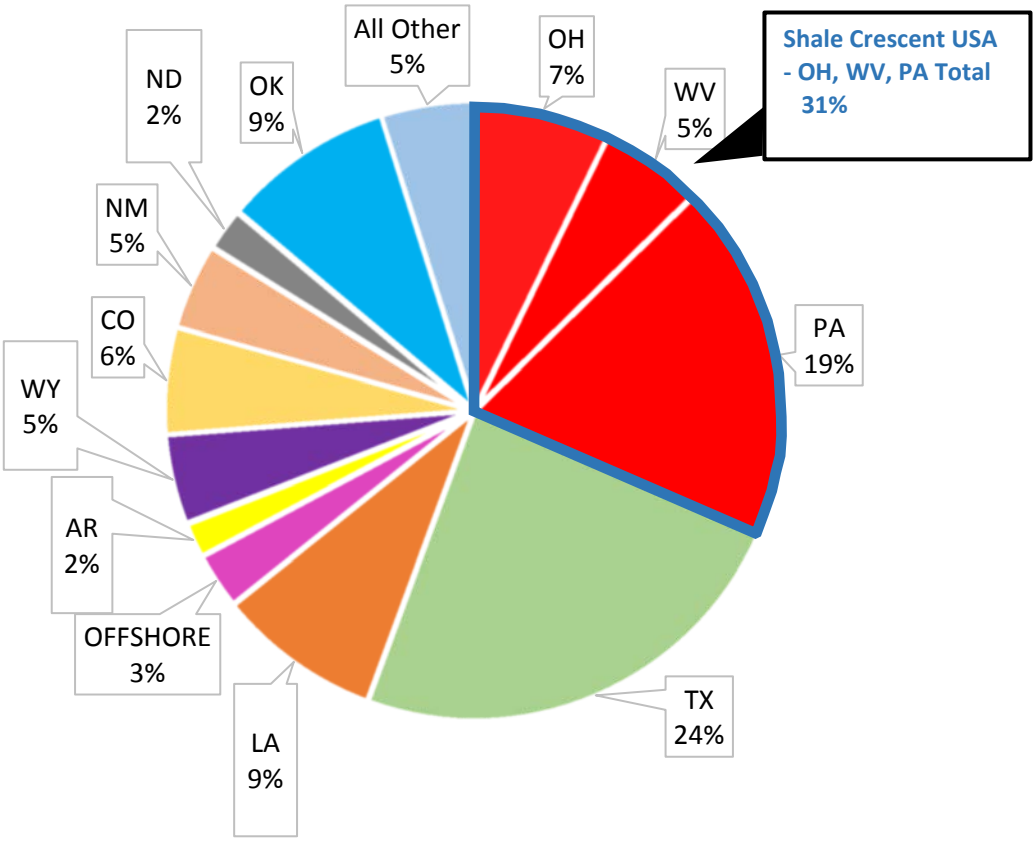
By 2008 widespread application of the technology of horizontal drilling for oil and gas extraction from within shale gas formations had been put in place. (Figure 2) This technological advancement led to dramatic increases of oil and natural gas supplies which in turn led to reduced natural gas prices in the United States.

Figure 2. Advent of Shale



Historically, one thinks of large natural gas supplies originating from areas such as the Gulf of Mexico, Louisiana, Texas, and the Rockies. However, nearly all the growth of natural gas production since 2008 has come from the Shale Crescent USA region of Ohio, Pennsylvania, and West Virginia. By 2017, the Shale Crescent USA region accounted for 31 percent of overall natural gas production. (Figure 3)

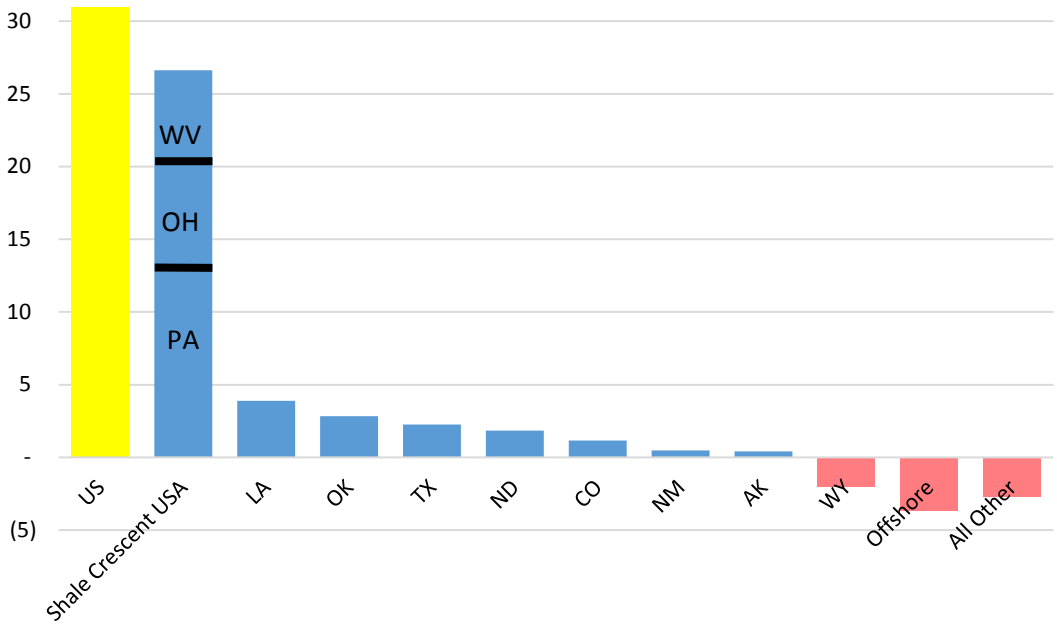
Figure 3. Share of Natural Gas Production, 2017



Source: EIA

In 2008, the three states produced a combined 1.5 billion cubic feet of natural gas production per day (bcf/d) accounting for 3 percent of the nation's production. Over the past ten years, the three states have increased production by nearly 20-fold. In 2018, Ohio, Pennsylvania, and West Virginia produced 28.0 bcf/d, accounting for nearly one third of U.S. natural gas production. The production increase for the three states from 2008 to 2018 equals 26.5 bcf/d. (Figure 4) Pennsylvania grew 16.2 bcf/d, Ohio grew 6.1 bcf/d, and West Virginia grew 4.2 bcf/d. Overall, the entire U.S. production increased from an annual average of 58.0 bcf/d to nearly 90.0 bcf/d during the same time period. The entire U.S. increased its production nearly 31.0 bcf/d during the ten-year period.

Figure 4. Change in Natural Gas Marketed Production (Bcf/d), 2008-2018

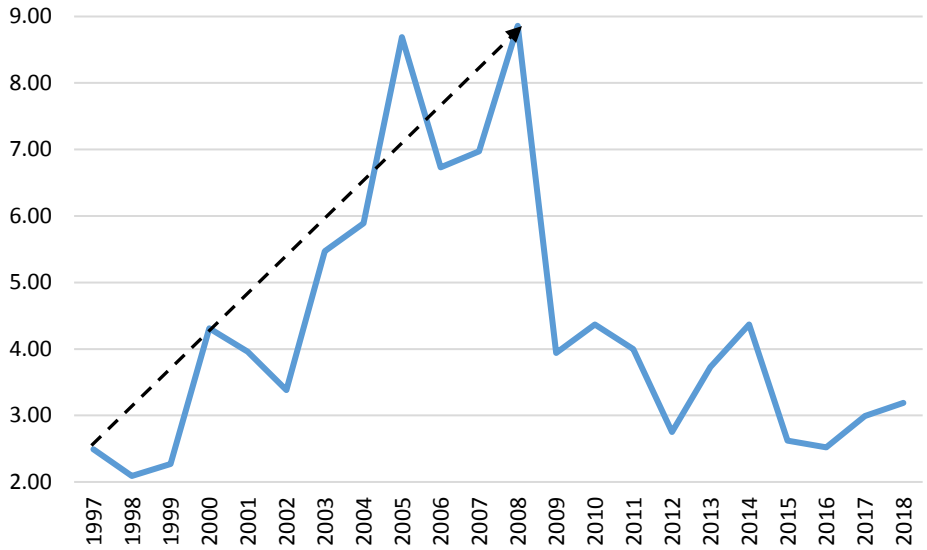


Source: EIA

Price Changes

For the ten-year period prior to 2008, natural gas spot prices were on the rise. (Figure 5) In 2009, the price dropped to approximately $4 per million cubic feet per day (mcf/d) and has remained between $2.50 and $4.50 for the past ten years. These price declines were due to the new natural gas production brought to market starting in 2008.

Figure 5. Henry Hub Natural Gas Spot Price: 1997-2018, Nominal $



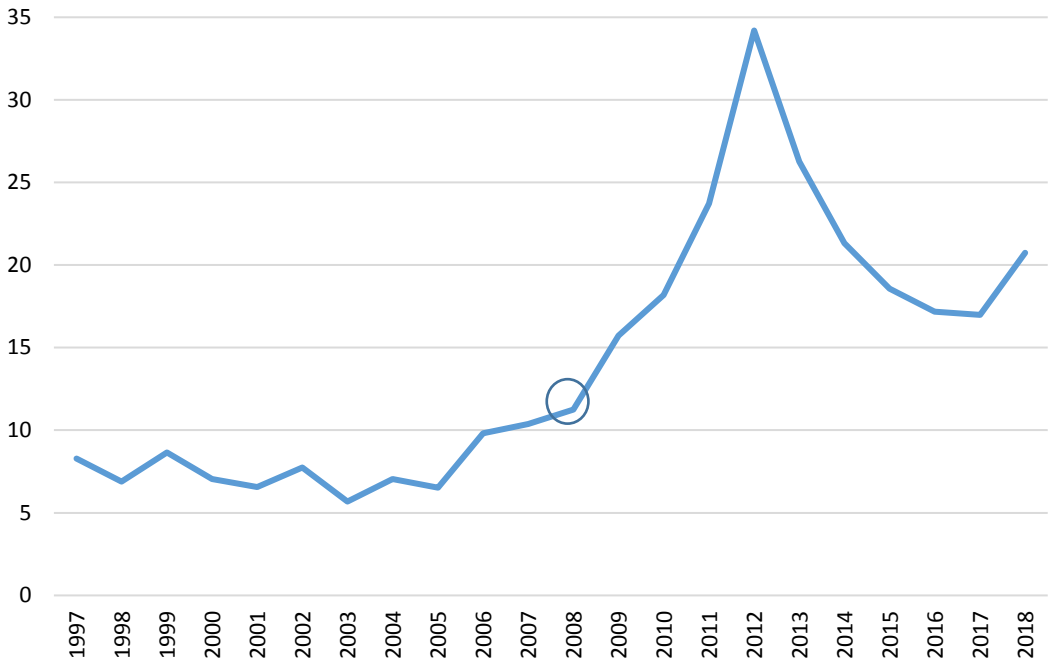
The increased supply of natural gas in the U.S. structurally changed the historical relationship between oil and natural gas prices. Crude oil and natural gas are both energy commodities that trade on commodity markets and have a common use as fuels for heating. Traders refer to the price relationship as an inter-commodity spread, measured by comparing the per-barrel price of crude oil to 1 million British Thermal Units (MMBtu) of natural gas. From 1997 to 2007, the price of oil to natural gas averaged 7:1, meaning when oil was at $50 a barrel, natural gas would be approximately $7 per MMBtu. (Figure 6) The higher the oil price to natural gas ratio, the greater the demand for oil. If the ratio declines, then the difference in the prices of the two commodities narrows. Since 2007, the ratio has been over 10:1.[6] The run up to the ratio's peak in 2012 was caused by the combination of warmer-than-normal temperatures, ample natural gas in storage, and growing production as well as a 19 percent increase in spot oil price occurring over a six month period.[7]

[6] For further discussion see: The Relationship Between Crude Oil and Natural Gas Prices, Jose Villar and Frederick Joutz, EIA Office of Oil and Gas 2006. Also, "With the Benefit of Hindsight: The Impact of the 2014-2016 Oil Price Collapse" in Global Economic Prospects, January 2018.

[7] eia.gov/todayinenergy/detail.php?id=5830, April 13, 2012, EIA.

The ratio declined in 2012 due to return of normal weather temperatures as well as increased oil production on the world market. That is, normal weather activity firmed up natural gas prices, while oil production activity reduced oil prices. As such, it could be argued that a significant part of the reduced gas prices from 2011 to 2012 is due to weather rather than natural gas supply. However, work completed by Hausman and Kellogg (2015) controlled for the impact of weather on gas prices and still showed savings due to supply increases.

Figure 6. Price Ratio of Natural Gas Relative to Oil



An argument could be made that the demand for natural gas softened during the 2008-09 recession, therefore leading to reduced natural gas prices even without the advent of shale gas production. A leveling off of natural gas consumption between 2008 and 2009 did occur, but by January 2010 consumption had regained and even surpassed its 2008 level. (Figures 7 and 8) Growth in demand for natural gas came from end-users including the Commercial, Industrial, Electric Power Generation, and Export sectors. Housman and Kellogg estimated that average Residential sector bills between 2007 and 2013 declined by $19 billion per year: $13 billion due to the supply shift and $6 billion due to reduced demand.[8] It appears that even in the face of increased demand for natural gas, prices of natural gas have remained low.

[8] Housman, Catherine and Ryan Kellogg, University of Michigan, "Welfare and Distributional Implications of Shale Gas", Brookings Papers on Economic Activity, April 2015.pp.19-20.

Another key question to be examined is "Would the counterfactual prices (being greater than the actual witnessed prices) have led to dampened consumption volumes?" Housman and Kellogg examined data (including weather) covering the period 2007 to 2013 and estimated price elasticities of demand for Residential natural gas consumed to be -0.11. (Table 3) This means that for every 1 percent increase in price there would be an expected 0.11 percent decrease in quantity demanded. Such an inelastic demand makes for very little change in quantities of gas consumed as would be expected for the Residential sector. Other estimated elasticities included: Commercial consumption, -0.09; Industrial consumption, -0.16; and Electric Power Generation consumption, -0.15.[9]

Netting out the shift in demand, the researchers show that the increase in supply of natural gas between 2007 and 2013 reduced wholesale prices of natural gas by $3.45 per mcf. Housman and Kellogg report the range of savings is therefore between $2.19 and $4.16 per mcf depending upon the elasticities employed. As a side note, these researchers provided a discussion on a manufacturing renaissance and claim that the most energy intensive manufacturing sectors have expanded by 30 percent due to reduced gas prices.

Table 3. Demand Elasticities by Sector, 2013$

Demand	Elasticity
Residential	-0.11
Commercial	-0.09
Industrial	-0.16
Electric Power Generation	-0.15

Source: Housman et al., 2015

Finally, reductions in demand for natural gas could also be attributed to ongoing efficiencies. For example, in the Energy Information Association's (EIA) 2008 Annual Energy outlook, several legislative activities were incorporated into the forecasts: The National Appliance Energy Conservation Act of 1987 and the Energy Independence and Security Act of 2007, which includes residential and commercial buildings as well as the Industrial sector. The Alliance to Save Energy reports of increasing gas appliance efficiency as well as on going industrial efficiency programs.[10]

[9] Housman and Kellogg, April 2005, pp14-16.
[10] Alliance to Save Energy, "History of Energy Efficiency," January 2013.

Figure 7. U.S. Natural Gas Monthly Marketed Production (MMcf)

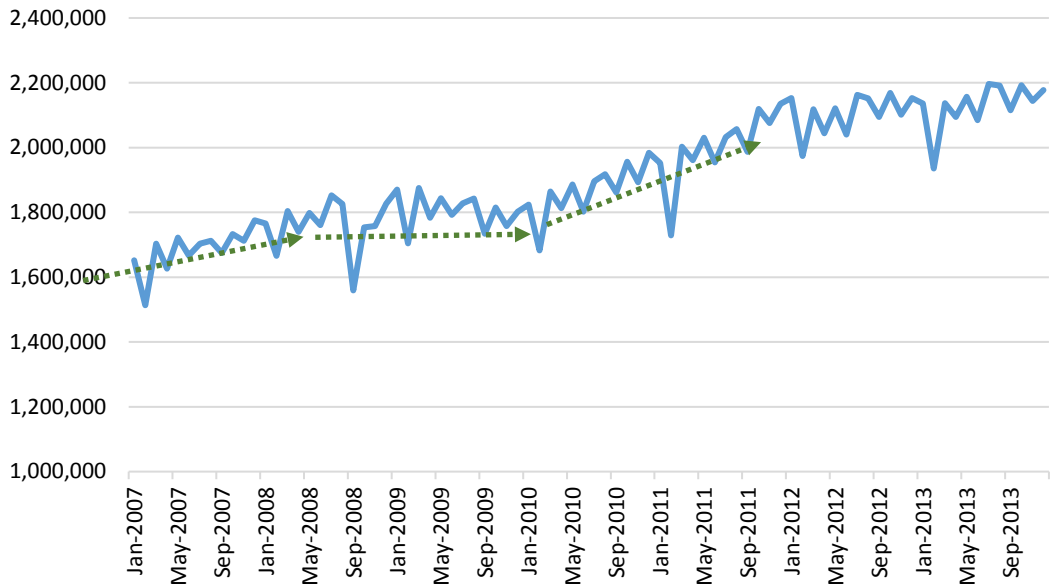
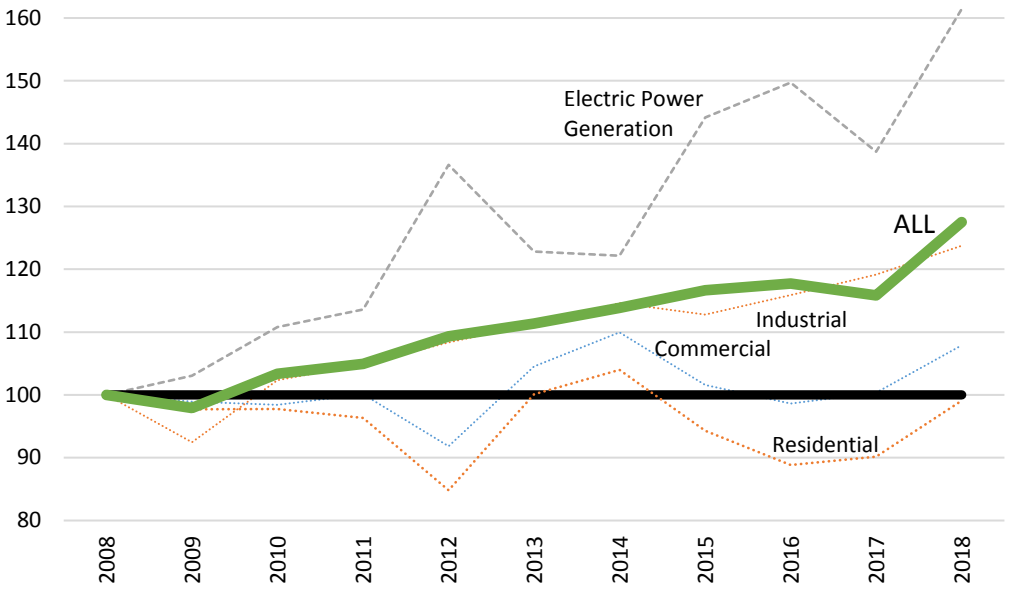


Figure 8. U.S. End-user Natural Gas Consumption Indices



Methods for Estimating the Savings

Solving for End-of-Year Values

To calculate annual cost savings through 2018, the consumption and price of natural gas by end-users had to be forecasted through December of 2018. This required forecasting natural gas usage for the months of October, November, and December. Our data source for consumption data and prices was the EIA and included monthly data through August of 2018. Several forecasting methods to estimate October, November, and December of 2018 were considered. The selected method employed a standard ARIMA estimation using E-views software calculations.[11] This approach accounted for multi-year monthly data through September 2018 and incorporated seasonality patterns. The ARIMA results were found to be nearly identical to using an historic ratio of the past three months to the first nine months of the year. The ARIMA forecast does however take advantage of historic, recent, and seasonal aspects of the series.

The forecasted 2018 U.S. Residential usage is estimated to be 10 percent greater than that of 2017. Usage of natural gas in 2018 by the Commercial, Industrial, and Electric Power Generating

[11] ARIMA: Auto Regressive Integrated Moving Average forecasting temporal data technique best used for short term forecasts. It incorporates differencing to keep the series stationary, regresses on its lagged self, and takes into account residual errors across moving averages.

sectors is forecasted to be 8, 4, and 16 percent greater than 2017 usage. Similar estimates were calculated for Ohio, West Virginia, and Pennsylvania natural gas consumption.

At the time of our calculations, Henry Hub price data was available through December 24, 2018. Consequently, to compute the 2018 annual average Henry Hub price, we calculated December as the average of the available daily prices. Citygate price data was available through September 2018 and we employed ARIMA price estimates for the final three months to compute a 2018 Citygate average price.

The Bureau of Labor Statistics Consumer Price Index (CPI) was used to convert historical prices into 2018 dollars. The CPI for 2018 was estimated as the average of the monthly index through November.

Calculating Counterfactual Prices 2009 to the Present Without Shale Production

If natural gas production from shale had not begun to dramatically increase in 2008, then natural gas supplies would have been tighter and presumably equilibrium prices greater between 2009 and today. Thus, we seek to answer the question counterfactual "What would prices have been from 2009 onward had shale gas not been produced?" We do so by calculating counterfactual gas prices for four scenarios. The first approach uses the historic WTI-to-Henry Hub ratio (oil price-to-gas-price ratio). For that analysis, the Henry Hub price is forecast using WTI as the independent variable. Once estimated, an ARIMA model is used to forecast Henry Hub prices for 2009 to 2018.

The second approach employs a similar WTI-to-Citygate price ratio that can be used at the national level, and critically at the state level, to forecast 2009 to 2018 prices barring the advent of shale gas. As with the Henry Hub method, WTI is regressed on Citygate prices to arrive at an estimated Citygate price which is used in conjunction with an ARIMA forecast. The third national forecast method uses EIA's own price forecast for 2009 through 2018 released in 2008. The fourth method allows 2008 prices to be held constant from 2009 to current.

To arrive at four different estimates of savings to end-users, actual end-user prices were subtracted from the forecasted counterfactual prices. All prices are stated in 2018$ unless noted otherwise.

Assumptions and Caveats

To capture the price effect of end-user savings we held volumes to their actual historical levels and assumed that the reduction in prices played no role in the increased volumes consumed in the past ten years. In other words, without shale production arguably driving down the price of natural gas, the price of natural gas might have risen and resulted in a reduction in quantity demanded. This assumption might hold true for the relatively inelastic sectors such as Residential, Commercial, and Industrial end-users where in the short term there are only small responses in quantity demanded when there are price changes in natural gas. The assumption

does not hold in the case of the Electric Power Generation sector where the increased usage of natural gas has been largely attributable to its lowered cost.

We do not control for weather in our estimates but recognize that weather impacts may have had a softening impact on price. In the previously discussed study by Housman and Kellogg (2015), it was illustrated that there are Consumer savings due to shale production even after accounting for price-softening weather conditions.

We assume that calculated Henry Hub and Citygate price savings are passed along to end-users uniformly. Meanwhile, negotiating power combined with regulations at the utility level are assumed to not affect the pass-through of calculated cost savings to end-users.

Results

Price Savings

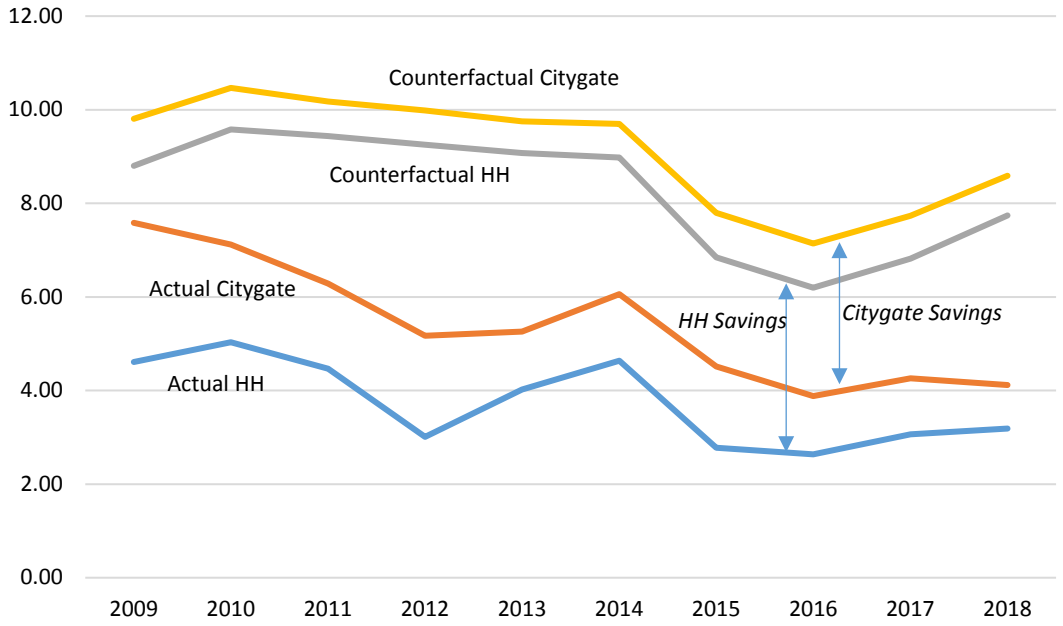
Calculating the price savings by using either the Henry Hub or Citygate counterfactual price methods yield similar results. The savings measured at the Henry Hub are greater than those measured at the Citygate. (Table 4) Henry Hub prices are set in a highly competitive market, largely domestically driven, and linked to world markets. Meanwhile, Citygate prices are set at regional locations where large transmission pipelines enter a metropolitan area to deliver natural gas to a utility which in turn delivers to end-users. There are Citygate price differences due to transportation and storage costs, regulatory practices, and market power outcomes witnessed at, and after, the Citygate from where utilities take over the function of delivering natural gas to various end-users. For the Henry Hub counterfactual pricing, an average annual price savings of $4.53 is calculated. For the Citygate counterfactual pricing, an average of $3.69 is calculated.

Table 4. Price Savings: Henry Hub and Citygate, 2018$

	Counterfactual HH Price	Actual HH	Savings	Counterfactual Citygate	Actual Citygate	Savings
2009	8.80	4.61	4.19	9.81	7.58	2.22
2010	9.58	5.03	4.55	10.47	7.12	3.35
2011	9.44	4.47	4.97	10.17	6.29	3.89
2012	9.26	3.01	6.25	9.98	5.17	4.81
2013	9.08	4.02	5.06	9.75	5.26	4.49
2014	8.98	4.64	4.35	9.69	6.06	3.64
2015	6.85	2.78	4.07	7.80	4.51	3.28
2016	6.20	2.64	3.56	7.14	3.88	3.26
2017	6.82	3.06	3.76	7.73	4.26	3.47
2018	7.74	3.19	4.55	8.59	4.12	4.47
Average			4.53			3.69

The estimated price savings are measured as the distance between the counterfactual and the actual price lines. (Figure 9) The most savings for either scenario appear in 2012 when actual natural gas prices dipped.

Figure 9. Citygate and HH Counterfactual Price Estimates vs. Actual, 2009-2018

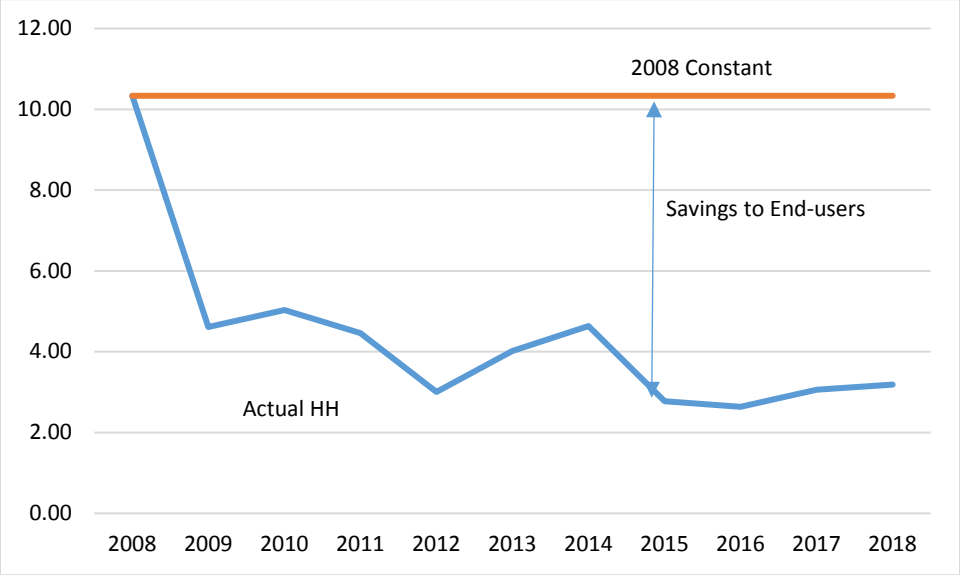


An alternative counterfactual analysis assumes that the 2008 price of natural gas would have remained in place through 2018. There is reason to accept the 2008 price as the trend price since the prior ten-year period showed increasing natural gas prices. (Figure 5) Using a 2008 constant price method, large savings result to end-users relative to other counterfactual estimation methods. (Table 5) By adopting this method, there is an annual average savings of $6.59. This approach does not take into account, however, price-affecting variables such as weather, the underlying energy-equivalency link between oil and natural gas price, or other supply/demand issues arising between 2009 and 2018.

Table 5. Price Savings: 2008 Constant Price Counterfactual

	Actual HH	Counterfactual 2008 Constant Price Savings
2009	4.61	5.72
2010	5.03	5.30
2011	4.47	5.87
2012	3.01	7.33
2013	4.02	6.31
2014	4.64	5.70
2015	2.78	7.56
2016	2.64	7.70
2017	3.06	7.27
2018	3.19	7.15
Average		6.59

Figure 10. 2008 Constant Counterfactual Price Estimates vs. Actual: 2009-2018



When examining the 2008 EIA forecasts of natural gas prices, several production increases had been incorporated into their computations due to shale development. The EIA's Annual Energy Outlook for 2008 referenced the production of unconventional natural gas to increase: "Onshore production of unconventional natural gas is expected to be a key contributor to the growth in U.S. supply, increasing from 8.5 trillion cubic feet in 2006 to a peak of 9.6 trillion cubic feet in

2018 and generally holding at about that level through 2030."[12] Consequently, average price savings from the four methods range from $3.69 to $6.59 (Tables 4 and 5) to $1.25 to $2.57 (Table 6) By using the EIA forecast, lower savings would result than would have otherwise been the case.

Table 6. Price Savings: EIA Counterfactual, 2018$

	Counterfactual Price				Actual Price				Savings			
	EIA Res.	EIA Comm.	EIA Indust.	EIA Electric Power	Res.	Comm.	Indust.	Electric Power	Savings Res.	Savings Comm.	Savings Indust.	Savings Electric Power
2009	15.40	13.57	9.25	8.99	14.34	11.89	6.30	5.82	1.06	1.69	2.95	3.16
2010	14.55	12.69	8.64	8.32	13.24	11.01	6.38	6.13	1.31	1.68	2.25	2.20
2011	13.77	11.97	8.00	7.71	12.43	10.04	5.78	5.51	1.34	1.93	2.22	2.20
2012	13.27	11.53	7.61	7.37	11.76	8.94	4.28	3.91	1.51	2.59	3.32	3.46
2013	12.85	11.13	7.24	6.99	11.23	8.79	5.05	4.89	1.62	2.33	2.19	2.10
2014	12.47	10.78	6.92	6.67	11.75	9.53	6.02	5.56	0.72	1.25	0.90	1.11
2015	12.34	10.66	6.78	6.52	11.10	8.46	4.20	3.62	1.24	2.20	2.57	2.91
2016	12.16	10.51	6.64	6.39	10.62	7.69	3.71	3.16	1.54	2.82	2.93	3.23
2017	12.02	10.40	6.56	6.31	11.28	8.15	4.24	3.64	0.73	2.25	2.32	2.67
2018	11.73	10.17	6.42	6.15	10.33	7.73	4.04	3.51	1.39	2.43	2.37	2.64
								Average	1.25	2.12	2.40	2.57

Summary of Price Savings

Of the four counterfactual price methods examined, the Citygate and Henry Hub scenarios provide median savings. (Table 7) These two methods account for weather as well as basic supply and demand activity that has occurred in the past ten years.

Table 7. Annual Average Price Savings by Counterfactual Method

Counterfactual Method	Average Savings
Constant 2008	6.59
Citygate	***3.69***
Henry Hub	***4.53***
EIA Range by End-user	1.25 – 2.57

[12] AEO 2008 website: Overview: Energy Production and Imports section.

Consumption

Total end-user natural gas consumption has grown approximately 30 percent from 20,937,403,000 mcf in 2009 to 27,265,763,948 mcf in 2018. However, as Figure 8 illustrates, the sectors have not grown uniformly. The graph provides an indexed version of the data in Table 8 to show sector growth.

Table 8. U.S. Consumption

	Consumption, Mcf				
	US Residential	US Commercial	US Industrial	US Electric Power	US Total End-user
2009	4,778,907,000	3,118,592,000	6,167,371,000	6,872,533,000	20,937,403,000
2010	4,782,412,000	3,102,593,000	6,826,192,000	7,387,184,000	22,098,381,000
2011	4,713,777,000	3,155,319,000	6,994,120,000	7,573,863,000	22,437,079,000
2012	4,149,519,000	2,894,926,000	7,226,215,000	9,110,793,000	23,381,453,000
2013	4,897,372,000	3,295,301,000	7,425,452,000	8,190,756,000	23,808,881,000
2014	5,087,471,000	3,466,308,000	7,646,039,000	8,145,982,000	24,345,800,000
2015	4,612,888,000	3,201,734,000	7,521,903,000	9,613,370,000	24,949,895,000
2016	4,346,588,000	3,109,584,000	7,728,688,000	9,985,270,000	25,170,130,000
2017	4,412,282,000	3,164,078,000	7,949,199,000	9,250,066,000	24,775,625,000
2018	4,846,039,514	3,401,210,259	8,254,116,803	10,764,397,372	27,265,763,948

Source: EIA

Estimated Total Cost Savings

To arrive at total cost savings, consumption volumes in Table 8 are multiplied by the estimated price savings as displayed in Tables 4, 5, and 6. Total savings are then shown in Tables 9 through 12.

Henry Hub

The Henry Hub counterfactual price estimation method reveals a $1.08 trillion (2018$) savings to end-users over the ten-year period. (Table 9) Then applying the various yearly savings of between $3.56 and $6.25 (Table 4) to each end-user sector volume reveals savings to the end-user. Electric Power Generation demands large volumes, and as such was assumed to have saved the most, $392 billion over the ten-year period. At the other extreme lies the Commercial end-user sector having saved between $11 billion and $18 billion per year. (Table 9)

Table 9. Savings Based on Henry Hub Counterfactual, 2018$

	US Residential	US Commercial	US Industrial	US Electric Power	US Total End-user
			-- dollars --		
2009	20,031,710,460	13,072,179,891	25,851,725,126	28,807,547,663	87,763,163,140
2010	21,746,195,802	14,107,859,146	31,039,506,387	33,590,403,690	100,483,965,025
2011	23,450,238,902	15,697,175,399	34,794,557,509	37,678,680,337	111,620,652,148
2012	25,924,131,908	18,086,058,525	45,145,799,032	56,919,705,516	146,075,694,981
2013	24,758,595,168	16,659,347,792	37,539,268,001	41,408,251,594	120,365,462,556
2014	22,110,758,374	15,064,989,784	33,230,601,383	35,403,413,548	105,809,763,089
2015	18,779,390,289	13,034,483,471	30,622,194,199	39,136,702,912	101,572,770,871
2016	15,475,002,449	11,070,941,165	27,516,172,623	35,550,201,147	89,612,317,383
2017	16,584,349,842	11,892,752,204	29,878,484,008	34,768,024,936	93,123,610,990
2018	22,061,342,501	15,483,832,564	37,576,436,865	49,004,358,417	124,125,970,347
Total	210,921,715,695	144,169,619,941	333,194,745,133	392,267,289,761	1,080,553,370,530

Citygate

Savings based on the Citygate Counterfactual scenario show a total of $887 billion (2018$) to end-users. (Table 10) Most of the savings accrued in 2018, $121 billion.

Table 10. Savings Based on Citygate Counterfactual, 2018$

	US Residential	US Commercial	US Industrial	US Electric Power	US Total End-user
			-- dollars --		
2009	10,627,647,641	6,935,329,964	13,715,405,188	15,283,590,814	46,561,973,607
2010	16,023,174,733	10,395,045,379	22,870,732,838	24,750,301,734	74,039,254,684
2011	18,328,323,606	12,268,655,838	27,194,857,690	29,449,040,973	87,240,878,108
2012	19,950,392,903	13,918,459,254	34,742,780,658	43,803,607,119	112,415,239,933
2013	22,011,241,123	14,810,732,140	33,373,698,061	36,813,357,306	107,009,028,630
2014	18,500,541,470	12,605,197,140	27,804,750,454	29,622,788,573	88,533,277,637
2015	15,139,304,129	10,507,956,136	24,686,568,836	31,550,675,441	81,884,504,543
2016	14,168,823,184	10,136,490,018	25,193,649,299	32,549,559,581	82,048,522,082
2017	15,323,531,407	10,988,610,566	27,606,984,443	32,124,800,016	86,043,926,432
2018	21,644,571,191	15,191,320,122	36,866,562,531	48,078,593,784	121,781,047,628
Total	171,717,551,386	117,757,796,559	274,055,989,999	324,026,315,340	887,557,653,285

EIA

Based upon the EIA Counterfactual method, total end-user savings amounted to $522 billion over the ten-year period of analysis. (Table 11) The most savings occurred in 2016, when $69.7 billion was saved.

Table 11. Savings Based on EIA Counterfactual, 2018$

	US Residential	US Commercial	US Industrial	US Electric Power	US Total End-user
			-- dollars --		
2009	4,996,034,613	5,211,038,156	18,029,615,781	21,544,155,411	49,780,843,961
2010	6,201,957,746	5,153,192,282	15,236,398,515	16,061,252,999	42,652,801,541
2011	6,260,312,588	6,038,703,665	15,355,060,561	16,484,004,201	44,138,081,015
2012	6,222,901,647	7,419,815,090	23,779,409,281	31,196,962,241	68,619,088,259
2013	7,845,342,154	7,614,434,713	16,077,944,522	17,052,958,443	48,590,679,832
2014	3,627,522,831	4,277,566,569	6,820,218,854	8,960,128,440	23,685,436,694
2015	5,658,595,925	6,973,277,342	19,158,131,773	27,703,896,178	59,493,901,219
2016	6,638,799,138	8,694,883,856	22,430,440,875	31,935,843,733	69,699,967,603
2017	3,203,287,511	7,051,874,699	18,292,433,663	24,434,243,502	52,981,839,375
2018	6,744,020,105	8,277,049,566	19,597,167,767	28,420,243,624	63,038,481,062
Total	57,398,774,258	66,711,835,938	174,776,821,592	223,793,688,773	522,681,120,562

2008 Constant Price

The most savings, $1.6 trillion, were estimated using the 2008 constant price method. (Table 12) In a combination of volume of demand and price savings, the year of greatest savings was 2018, showing a $194 billion savings.

Table 12. Savings Based on 2008 Constant Counterfactual, 2018$

	US Residential	US Commercial	US Industrial	US Electric Power	US Total End-user
			-- dollars --		
2009	27,356,518,251	17,852,161,376	35,304,683,125	39,341,333,581.50	119,854,696,333
2010	25,363,845,544	16,454,811,848	36,203,171,024	39,178,430,044	117,200,258,459
2011	27,668,873,913	18,521,055,105	41,054,004,976	44,456,973,757	131,700,907,751
2012	30,405,983,388	21,212,837,407	52,950,757,243	66,760,176,447	171,329,754,485
2013	30,925,532,254	20,808,902,685	46,889,649,250	51,722,329,621	150,346,413,811
2014	28,996,508,280	19,756,540,848	43,579,301,617	46,428,772,668	138,761,123,413
2015	34,870,318,194	24,202,946,907	56,860,507,134	72,670,585,286	188,604,357,521
2016	33,463,510,965	23,940,064,777	59,501,621,877	76,874,594,999	193,779,792,618
2017	32,088,694,074	23,011,024,900	57,811,222,139	67,271,887,435	180,182,828,547
2018	34,626,056,059	24,302,421,957	58,977,544,515	76,914,070,920	194,820,093,451
Total	305,765,840,921	210,062,767,809	489,132,462,900	581,619,154,757	1,586,580,226,388

Summary of Total Cost Savings

The sum of end-user savings is displayed in Table 13. The 2008 constant price scenario shows the largest savings. The savings are based upon the difference in the 2008 price of natural gas and the actual price of natural gas in subsequent years. At the other extreme is the EIA counterfactual calculations showing the smallest savings and likely due to its forecasted prices that incorporate reduced prices due to foreseen increases in shale production.

Table 13. Savings: Sum of End-user Annual Results by Counterfactual Method, 2018$

	Counterfactual Prices			
	2008 Constant	Henry Hub	Citygate	EIA
2009	119,854,696,333	87,763,163,140	46,561,973,607	49,780,843,961
2010	117,200,258,459	100,483,965,025	74,039,254,684	42,652,801,541
2011	131,700,907,751	111,620,652,148	87,240,878,108	44,138,081,015
2012	171,329,754,485	146,075,694,981	112,415,239,933	68,619,088,259
2013	150,346,413,811	120,365,462,556	107,009,028,630	48,590,679,832
2014	138,761,123,413	105,809,763,089	88,533,277,637	23,685,436,694
2015	188,604,357,521	101,572,770,871	81,884,504,543	59,493,901,219
2016	193,779,792,618	89,612,317,383	82,048,522,082	69,699,967,603
2017	180,182,828,547	93,123,610,990	86,043,926,432	52,981,839,375
2018	194,820,093,451	124,125,970,347	121,781,047,628	63,038,481,062
Sum	1,586,580,226,388	1,080,553,370,530	887,557,653,285	522,681,120,562

Figure 11, Table 14, and Table 15 illustrate total savings across methods. The Henry Hub and Citygate savings are shown to be in the middle range and moving relatively in unison due to their forecast prices being a function of the price of WTI oil.

Figure 11. Savings to End-users: Annual Results by Counterfactual Method, 2018$

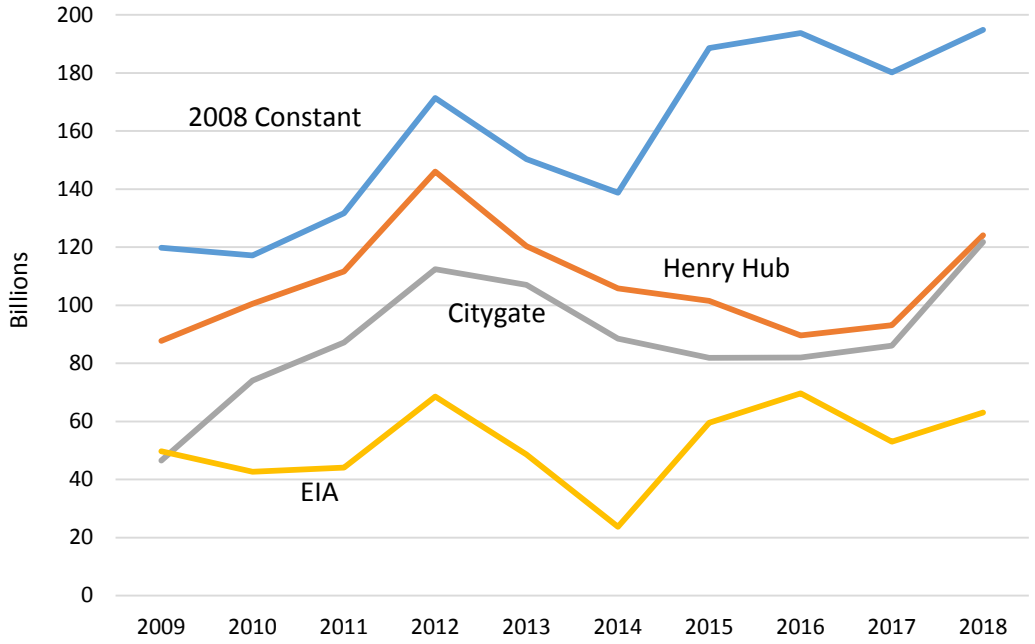
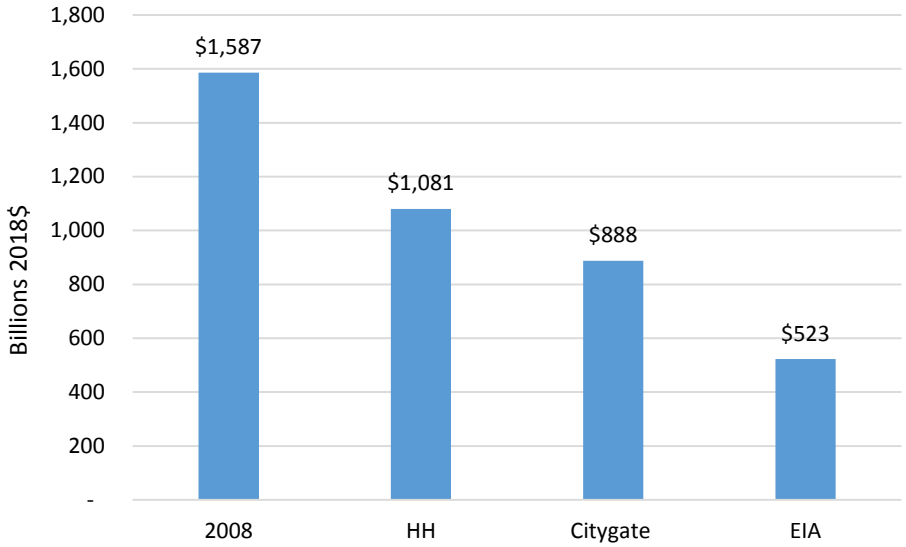


Table 14. Savings: Sum of End-user Ten-year Savings by Counterfactual Method

Counterfactual Method	Sum of End-user Savings
	-- billions of 2018$ dollars --
2008 Constant	1,587
HH	1,081
Citygate	888
EIA	523

Figure 12. Ten-year Sum of End-user Savings: Four Counterfactuals, 2018$



Savings to Consumers Based on Consumer Expenditures Survey

The Consumer Expenditure Survey (CE) is published by the Bureau of Labor Statistics and provides data on expenditures, income, and demographic characteristics of consumers in the United States. Since state level CE data is not available our analysis focuses on Census regions. Depending upon the region, the household natural gas bill declined from 2008 to 2017 by between 27 percent and 35 percent. (Table 15) Consumers living in the Northeast benefited the most from reduced natural gas prices. Compared to 2008, the natural gas bill for 2017 in that region decreased by $646 per household. This amounted to an equivalent increase in income of 0.8% for a Northeastern household.

Figure 13. 2017 Natural Gas Savings By Census Region

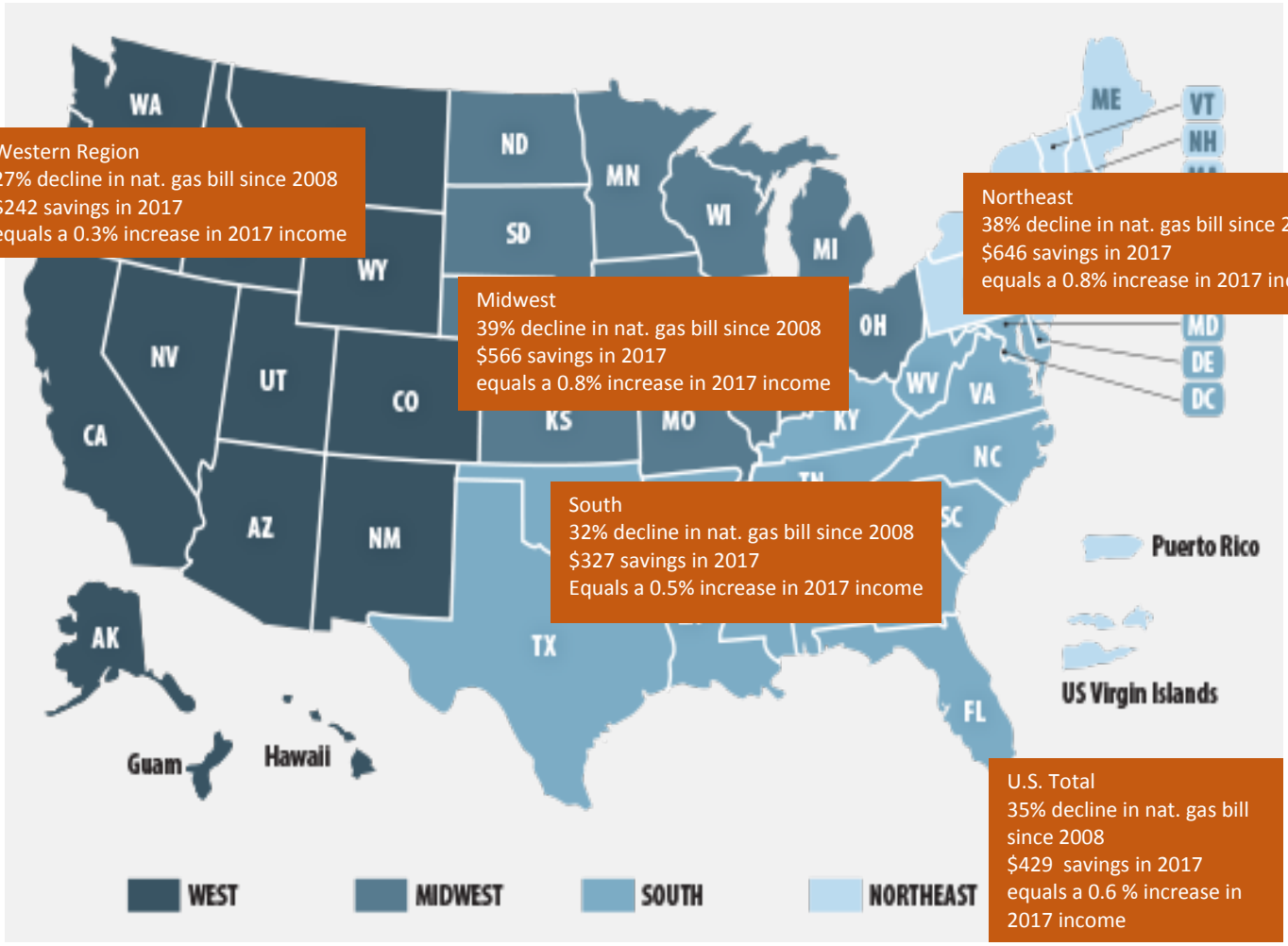


Table 15. Natural Gas Savings by Region

	U.S.	Northeast	Midwest	South	West
Ave. Nat. Gas Bill 2017	$813	$1,041	$900	$708	$639
dif 2008-2017	$429	$646	$566	$327	$242
% Decrease in Annual Bill	35%	38%	39%	32%	27%
What today's nat. gas bill would be w/o shale	$1,242	$1,687	$1,466	$1,035	$882
Nat. Gas as % income in 2008	1.7%	2.1%	2.1%	1.5%	1.1%
Nat. Gas as % income in 2017	1.1%	1.2%	1.3%	1.0%	0.8%
Natural Gas Savings as % of income in 2017	0.6%	0.8%	0.8%	0.5%	0.3%

In addition to estimates of regional savings we also estimated savings by income quintile. Overall, households saved an average of $429 in 2017 due to increases in natural gas production. This represents a 35% drop in their natural gas bill since 2008. Since the $429 saved in 2017 amounts to 0.6% of the household's 2017 income, then the savings is equivalent to receiving just over half a percent raise in income.

For low income families the savings are more meaningful. Families earning the least, those in the lowest 20 percent saw their natural gas bills decline by 30% since 2008, and realized a savings of $315 in 2017. Such savings are significant to a low income family and amount to a 2.7% boost in earnings. To put the benefit of lower cost natural gas in perspective, the average household heating assistance benefit reported paid by the Health and Human Services' LIHEAP program for FY2014 was $301.[13]

Table 16. Natural Gas Savings by Income

		Income Level				
	U.S.	Lowest 20 percent	Second 20 percent	Third 20 percent	Fourth 20 percent	Highest 20 percent
Ave. Nat. Gas Bill 2017	$813	$722	$754	$772	$798	$944
dif 2008-2017	$429	$315	$368	$414	$470	$510
% change	35%	30%	33%	35%	37%	35%
What today's nat. gas bill would be w/o shale	$1,242	$1,038	$1,122	$1,186	$1,268	$1,454
Nat. Gas as % income in 2008	1.7%	8.7%	3.5%	2.2%	1.5%	0.8%
Nat. Gas as % income in 2017	1.1%	6.2%	2.5%	1.4%	0.9%	0.5%
Natural Gas Savings as % of income in 2017	0.6%	2.7%	1.2%	0.8%	0.5%	0.3%

[13] Low Income Home Energy Assistance Program Report to Congress for Fiscal Year 2014 U.S. Dept. of Health and Human Services Administration for Children and Families Office of Community Services Division of Energy Assistance, p.6.

Shale Crescent USA Savings

Savings within the Shale Crescent are estimated to be $92 billion over the ten-year period (Table 15) Since Citygate prices were available for the individual states, we used the Citygate counterfactual method to calculate individual state savings. Ohio end-users saved $45 billion over the ten years of interest with Industrial users saving an estimated $13.9 billion. (Table 17) Pennsylvania end-users saved $43.9 billion and its Industrial users an estimated $9.5 billion. (Table 20) West Virginia end-users saved a total of $3.7 billion while the Industrial users portion was $1.3 billion in savings over the ten-year period. (Table 23) In total, Industrial end-users in the Shale Crescent USA saved $24.7 billion in the past ten years due to increased natural gas supplies driving down the cost of natural gas.

Table 17. Shale Crescent USA Savings, 2018$

State	Ten-year Savings
	-- 2018 dollars --
Ohio	45,325,567,530
Pennsylvania	43,933,440,019
West Virginia	3,689,476,685
Sum	92,948,484,234

Savings: Ohio

Table 18. Ohio Price Savings, 2018$

	OH Citygate Counterfactual	OH Actual Citygate	OH Savings
2009	11.08	7.72	3.36
2010	11.70	7.91	3.79
2011	11.45	6.15	5.30
2012	11.23	4.89	6.34
2013	11.02	4.86	6.16
2014	10.90	5.21	5.69
2015	9.03	4.76	4.27
2016	8.41	3.42	4.99
2017	8.91	4.06	4.85
2018	9.66	3.41	6.25

Table 19. Ohio Consumption, Mcf

	Residential	Commercial	Industrial	Electric Power	Sum
2009	292,429,000	160,612,000	232,632,000	37,668,000	723,341,000
2010	283,703,000	156,407,000	269,287,000	58,161,000	767,558,000
2011	286,132,000	161,408,000	268,034,000	92,845,000	808,419,000
2012	250,871,000	145,482,000	264,405,000	171,590,000	832,348,000
2013	297,361,000	168,233,000	274,020,000	161,174,000	900,788,000
2014	320,568,000	183,105,000	303,366,000	175,221,000	982,260,000
2015	285,306,000	166,602,000	276,004,000	208,222,000	936,134,000
2016	255,826,000	152,478,000	275,358,000	212,528,000	896,190,000
2017	258,699,000	156,979,000	277,767,000	205,619,000	899,064,000
2018	282,667,915	166,472,422	283,781,805	299,739,255	1,032,661,396

Table 20. Ohio Savings, 2018$

	Ohio Residential Savings	Ohio Commercial Savings	Ohio Industrial Savings	Ohio Electric Power Savings	Ohio Total
			-- dollars --		
2009	981,574,586	539,114,306	780,858,461	126,437,363	2,427,984,715
2010	1,076,251,385	593,343,216	1,021,563,067	220,638,685	2,911,796,352
2011	1,517,180,220	855,846,340	1,421,217,770	492,299,350	4,286,543,680
2012	1,590,521,507	922,355,513	1,676,327,033	1,087,880,167	5,277,084,220
2013	1,830,292,574	1,035,494,267	1,686,625,923	992,045,276	5,544,458,040
2014	1,823,716,076	1,041,687,043	1,725,853,644	996,834,851	5,588,091,614
2015	1,219,061,181	711,860,357	1,179,315,410	889,695,125	3,999,932,072
2016	1,276,321,589	760,716,125	1,373,767,171	1,060,306,907	4,471,111,792
2017	1,255,866,774	762,062,127	1,348,433,299	998,187,353	4,364,549,554
2018	1,766,642,102	1,040,433,577	1,773,603,788	1,873,336,024	6,454,015,490
Total	14,337,427,994	8,262,912,870	13,987,565,566	8,737,661,100	45,325,567,530

Savings: Pennsylvania

Table 21. Pennsylvania Price Savings, 2018$

	PA Citygate Counterfactual	PA Actual Citygate	PA Savings
2009	11.26	9.14	2.12
2010	11.99	8.11	3.88
2011	11.65	7.01	4.64
2012	11.43	6.04	5.39
2013	11.18	5.67	5.51
2014	11.10	5.93	5.17
2015	8.98	4.64	4.34
2016	8.25	3.89	4.36
2017	8.90	4.36	4.54
2018	9.85	5.07	4.78

Table 22. Pennsylvania Consumption, Mcf

	Residential	Commercial	Industrial	Electric Power	Sum
2009	227,714,000	144,092,000	173,323,000	210,542,000	755,671,000
2010	223,642,000	141,699,000	200,016,000	245,559,000	810,916,000
2011	219,446,000	141,173,000	199,594,000	306,266,000	866,479,000
2012	197,313,000	126,936,000	200,169,000	393,775,000	918,193,000
2013	231,861,000	149,114,000	215,406,000	362,349,000	958,730,000
2014	254,816,000	159,636,000	237,013,000	388,056,000	1,039,521,000
2015	235,669,000	152,091,000	212,050,000	437,976,000	1,037,786,000
2016	215,512,000	142,724,000	212,253,000	501,116,000	1,071,605,000
2017	218,719,000	145,910,000	219,028,000	440,807,000	1,024,464,000
2018	247,383,274	156,271,761	228,737,561	565,806,778	1,198,199,375

Table 23. Pennsylvania Savings, 2018$

	PA Residential Savings	PA Commercial Savings	PA Industrial Savings	PA Electric Power Savings	Sum
			—Dollars --		
2009	481,983,401	304,987,626	366,858,468	445,636,848	1,599,466,343
2010	868,114,250	550,034,972	776,404,879	953,189,773	3,147,743,874
2011	1,018,651,856	655,314,467	926,500,362	1,421,663,777	4,022,130,462
2012	1,064,449,141	684,784,663	1,079,856,472	2,124,307,372	4,953,397,649
2013	1,276,532,747	820,961,283	1,185,938,182	1,994,946,818	5,278,379,030
2014	1,318,013,084	825,703,004	1,225,928,651	2,007,185,127	5,376,829,866
2015	1,023,009,872	660,208,150	920,482,725	1,901,199,444	4,504,900,192
2016	938,743,982	621,688,333	924,548,175	2,182,800,165	4,667,780,656
2017	993,004,051	662,444,603	994,406,939	2,001,303,666	4,651,159,258
2018	1,183,371,515	747,534,576	1,094,178,720	2,706,567,878	5,731,652,688
Sum	10,165,873,899	6,533,661,676	9,495,103,574	17,738,800,870	43,933,440,019

Savings: West Virginia

Table 24. West Virginia Price Savings, 2018$

	WV Citygate Counterfactual	WV Actual Citygate	WV Savings
2009	10.29	8.26	2.03
2010	11.32	7.27	4.06
2011	11.37	6.60	4.77
2012	11.13	5.46	5.67
2013	10.98	5.01	5.97
2014	10.79	5.38	5.41
2015	8.00	4.24	3.76
2016	7.25	3.62	3.63
2017	7.96	3.95	4.01
2018	9.07	4.45	4.62

Table 25. West Virginia Consumption, Mcf

	Residential	Commercial	Industrial	Electric Power	Sum
2009	26,172,000	23,761,000	24,432,000	1,109,000	75,474,000
2010	27,021,000	24,907,000	26,023,000	1,480,000	79,431,000
2011	25,073,000	24,094,000	25,443,000	2,579,000	77,189,000
2012	22,538,000	22,634,000	26,926,000	2,361,000	74,459,000
2013	26,514,000	24,252,000	26,780,000	2,840,000	80,386,000
2014	28,257,000	24,101,000	27,796,000	6,711,000	86,865,000
2015	24,807,000	23,026,000	25,474,000	13,221,000	86,528,000
2016	23,210,000	22,698,000	32,281,000	10,167,000	88,356,000
2017	22,385,000	22,421,000	38,358,000	11,295,000	94,459,000
2018	25,898,715	24,913,773	34,626,543	11,713,946	97,152,977

Table 26. West Virginia Savings, 2018$

	WV Residential Savings	WV Commercial Savings	WV Industrial Savings	WV Electric Power Savings	Sum
2009	53,142,612	48,247,042	49,609,517	2,251,840	153,251,011
2010	109,682,207	101,101,171	105,631,178	6,007,537	322,422,093
2011	119,566,519	114,897,926	121,330,951	12,298,570	368,093,966
2012	127,845,870	128,390,426	152,736,618	13,392,675	422,365,588
2013	158,248,083	144,747,398	159,835,697	16,950,462	479,781,640
2014	152,853,538	130,372,054	150,359,803	36,302,512	469,887,907
2015	93,253,702	86,558,622	95,761,068	49,699,972	325,273,364
2016	84,308,393	82,448,596	117,258,045	36,930,781	320,945,815
2017	89,779,146	89,923,530	153,841,790	45,300,668	378,845,135
2018	119,588,993	115,040,960	159,890,308	54,089,907	448,610,168
Sum	1,108,269,062	1,041,727,724	1,266,254,975	273,224,924	3,689,476,685