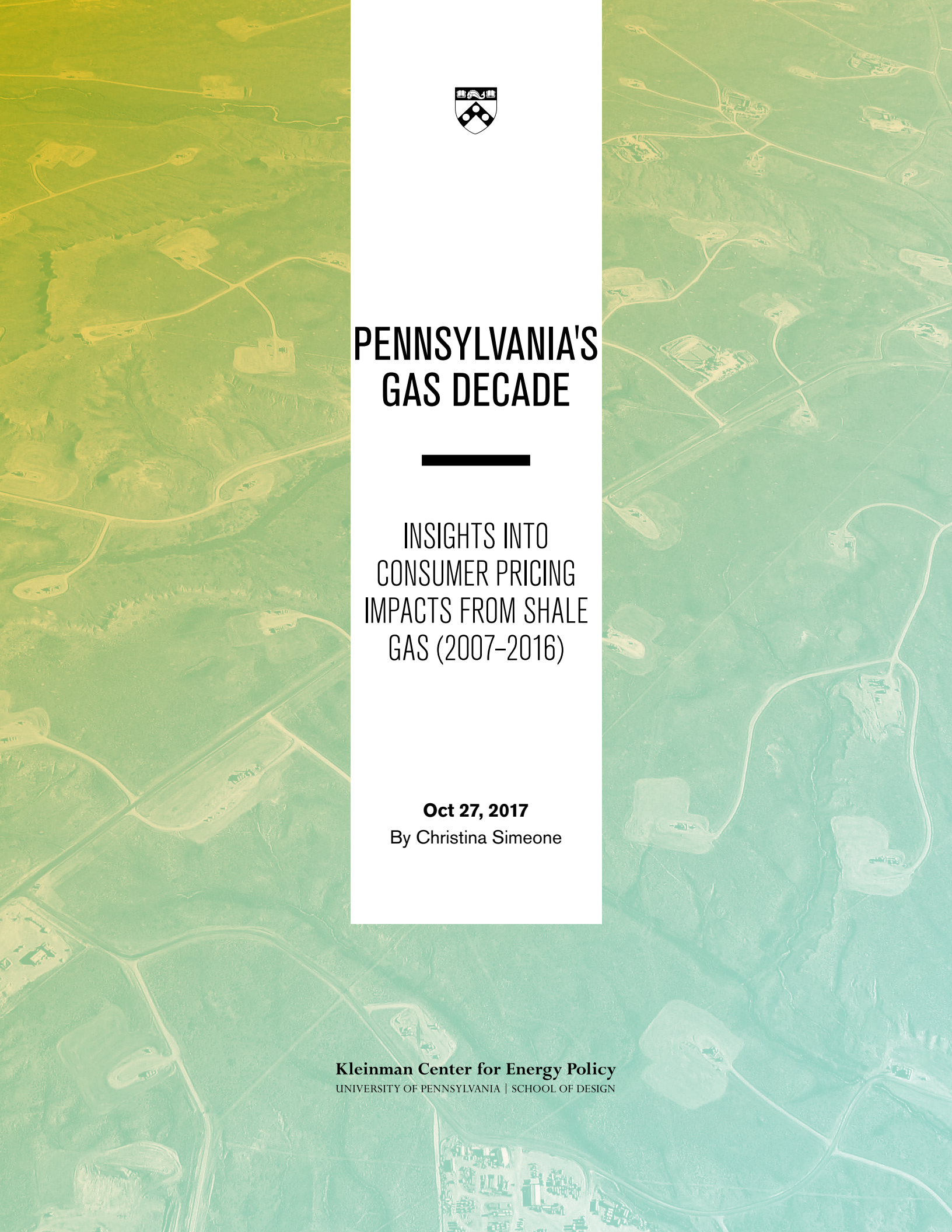

PENNSYLVANIA'S GAS DECADE

INSIGHTS INTO CONSUMER PRICING IMPACTS FROM SHALE GAS (2007–2016)

Oct 27, 2017

By Christina Simeone

Kleinman Center for Energy Policy
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EXECUTIVE SUMMARY

THE FIRST EXPLORATORY MARCELLUS SHALE WELL IN PENNSYLVANIA WAS COMPLETED IN 2004. By 2007, the very early stages of the U.S. and Pennsylvania unconventional shale-based natural gas revolution were slowly starting to take hold. With a decade of data now available (2007–2016), this report explores how the shale revolution has impacted natural gas pricing to Pennsylvania consumers.

Historically, Pennsylvania gas consumers have paid retail prices higher than national averages.

The "Pennsylvania Gas Discount". Between 2007 and 2016, gas commodity costs have decreased significantly for all Pennsylvania consumers. Since 2013, Pennsylvania consumers have generally enjoyed a discount in natural gas commodity costs compared to national commodity prices, benchmarked at the Henry Hub.

Pennsylvania Gas Prices Dropping Faster than National Prices. A comparison of inflation-adjusted annual average retail prices from 2007 to 2016 shows that:

- **Pennsylvania** gas consumers saw significant price decreases with the electric power sector experiencing the most significant reduction of 79%, a value of $7.32/Mcf. Residential retail gas prices fell by 40%, representing a decrease of $6.79/Mcf.
- **National** average prices to all gas consumer sectors also declined. For example, the U.S. electric power sector experienced a 65% reduction, representing a decrease of $5.47/Mcf, and U.S. residential consumers enjoyed a 34% reduction, valued at $5.09/Mcf.

As such, it is clear that Pennsylvania consumers enjoyed more significant cost reductions than national averages.

Pennsylvania's Electric Power Prices Drop Below National Averages. Historically, natural gas prices to Pennsylvania power plants have generally been above U.S. annual average prices. By 2016, annual average delivered electric power prices to Pennsylvania gas generators were $1.04/Mcf lower than the national average.

Citygate and Residential Prices Remain Above National Averages. In 2016, in spite of the Pennsylvania Gas Discount, annual average citygate and residential retail gas prices remain at and above national average prices, respectively. Pennsylvania's residential prices have been higher than national averages since EIA began collecting these data in 1967.

Industrial and Commercial Gas Costs Drop Significantly. The majority of industrial and commercial gas customers buy gas commodity from third parties (e.g. marketers, producers) rather than from their local gas utility. However, only utility gas pricing was publicly available for these sectors. A proxy (called the PA Hubs Average) for Pennsylvania industrial and commercial gas commodity prices was developed based on an average of PA located gas hub bidweek prices. Between 2010 and 2016, in nominal terms, the annual average PA Hubs Average proxy price dropped 65.8%, while Henry Hub prices dropped by 44%.

The Commodity Prices Gas Utilities Charge Customers Have Plummeted. Since 2007, the commodity rates (called purchased gas cost rates) that PA natural gas distribution companies (NGDC's) are permitted to charged their customers has decreased by 72% in real terms, from an inflation adjusted annual average of $11.76/Mcf in 2007, down to just $3.28/Mcf in 2016.

It is important to note that PA NGDC's are required to follow a least-cost natural gas procurement strategy in the competitive wholesale gas markets, then pass along gas costs to retail ratepayers with no profit markup. As a result, gas consumers enjoy the benefits of wholesale gas cost reductions.

The Rates Gas Utilities Charge for Delivery Service Continue to Increase. On a statewide average basis, delivery rates for all customer classes examined (residential, residential heat, and small commercial) have increased. The fastest increase in delivery charges was observed in the residential heating sector, with a compound annual growth rate of 2.67% between 2007–2016.

Fewer Service Terminations, Total Debt, and Customers in Debt. Comparing 2007 levels to 2016 on a statewide annual basis, the total number of customers in debt was reduced by almost 79,000 people, total dollars in debt was reduced by nearly $49 million (nominal terms), and customer service terminations (where gas service is shut off due to debt) were reduced by over 4,000 people. The cost of customer assistance programs also dropped by over $72.5 million (nominal terms).

Pennsylvania Increases Gas Demand Far Beyond National Demand Increase. Comparing 2016 to a 2007 baseline, Pennsylvania overall gas demand grew by 50.5%, while U.S. gas demand grew by 18.5%. Demand from the residential sector decreased in Pennsylvania and nationally by 6.8% and 8%, respectively. U.S. average industrial and commercial gas demand grew by 16% and 3.1%, respectively. This was a greater percentage increase compared to the demand increase in Pennsylvania's industrial sector at 11.4%. Pennsylvania's commercial sector demand actually declined by 2.1% over that time period.

Electric Power Sector Driving Gas Demand Growth, Especially in Pennsylvania. Gas demand from Pennsylvania's electric power sector (including from many new gas-fired power plants) increased by almost 250% between 2007 and 2016. During that time period, the electric power sector grew from the state's smallest to the largest major sector of natural gas demand. U.S. average electric power sector demand grew by 46% during this time, also edging out other U.S. sectors to become the highest volume gas user.

Pennsylvania Production Drives National Supply Increases. Between 2007 and 2016, Pennsylvania's annual natural gas production levels grew by almost 2,800%. The increase was larger than in any other major gas producing state, and made Pennsylvania the biggest driver of America's 32% increase in annual natural gas production. In 2007, Pennsylvania produced less than one percent of the nation's annual gas supply; by 2016 the state contributed over 16% of national annual production.

Pennsylvania Becomes Net Gas Exporter, Consumes Only a Quarter of the Gas it Produces. In 2007, Pennsylvania consumed 4 times more gas than it produced, requiring additional gas to be imported from other states. Since 2011, Pennsylvania has been a net exporter of gas. In 2016, Pennsylvania exported (or stored) 75% of the gas it produced, while still maintaining the PA Gas Discount to the Henry Hub.

Extraordinary Interest in Pipeline Development. Pipeline infrastructure capacity growth has not kept pace with production growth, leading to a local supply glut creating the Pennsylvania Gas Discount to the Henry Hub national price benchmark. Between 2007 and 2016, Pennsylvania saw more project proposals (53 applications) to the Federal Energy Regulatory Commission (FERC) for major interstate gas pipelines than any other state in the nation, almost double the amount of the second highest state (New York, with 27 applications). These 53 projects approved between 2007–2016 represent 12,939 MMcf/day of capacity, and another 7,292 MMcf/d of pipeline capacity impacting Pennsylvania was approved by FERC in the first few months of 2017 (see *Appendix A*). Not all of these pipeline projects will be built, but many that do become operational will enable increasing amounts of gas to be exported outside of Pennsylvania.

Questions for the Future. The consumer cost benefits of Pennsylvania's shale revolution are clear and beyond reproach. Yet, there are at least two major unanswered questions going forward.

1. **How Long Will the Pennsylvania Gas Discount Last?** Growing pipeline capacity will result in greater market access and rising demand for Pennsylvania's natural gas. This increase in demand has the potential to slow or reverse falling gas price trends and erode the PA Gas Discount. This could occur as new or expanded pipeline capacity moves Pennsylvania gas outside the state to new areas of demand, increasing Pennsylvania gas commodity prices and decreasing prices to the destination states.

   In theory, production increases could offset demand increases and maintain the PA Gas Discount. However, it is unclear if there are practical, technical, or other limits (e.g. rent seeking or profit motive by gas producing firms) to increasing production for the direct purpose of moderating price. In addition, it is unclear how production lags could affect price volatility as demand continues to grow. This is an area ripe for future research, along with exploring the net benefits and costs of gas producer versus gas consumer driven strategies for economic development in Pennsylvania.

   Any reduction in the PA Gas Discount will on average result in Pennsylvania's residential (and citygate) customers paying above national average retail gas prices. Given the connection between gas and power prices, it is also important to understand that erosion of the PA Gas Discount has the potential to also increase electric power prices.

2. **Is Additional Gas Industry Evolution Desirable to Meet Power Sector Needs?** Pennsylvania's participation in PJM Interconnection's competitive wholesale electricity markets has enabled cheap gas commodity costs to quickly drive down electricity prices and attract investments into new gas-fired power resources, reducing costs to Pennsylvania power consumers.

   On the other hand, low power prices threaten the viability of higher-cost, traditional power generators. PJM maintains reliability is not threatened as gas penetration increases on the grid. However, some point to grid resiliency concerns associated with greater reliance on just-in-time gas pipeline fuel delivery. Federal subsidies have been proposed to assist economically struggling generators with on-site fuel stockpiles, at least in part due to real or perceived resiliency concerns.

   A decade ago, the power sector demand for gas in Pennsylvania was less than demand from traditional sectors (e.g. industrial, commercial, residential). However, the shale gas revolution has catapulted the electric power sector into the nation and the state's top consumer of natural gas.

   Changes have already been made to better coordinate gas and electricity markets. More research is needed to determine what additional gas industry changes may be beneficial to serve its new top customer, perhaps especially in light of contemporary perceptions about resiliency. Some initial ideas to explore include but are not limited to: greater flexibility in gas contracting, more frequent intra-day gas nominations, innovations in pipeline services, increased gas market and index price transparency, and other potential improvements.

READ THE FULL REPORT:
kleinmanenergy.upenn.edu/paper/pennsylvanias-gas-decade

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PENNSYLVANIA'S GAS DECADE
INSIGHTS INTO CONSUMER PRICING IMPACTS FROM SHALE GAS (2007–2016)

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INTRODUCTION

THE FIRST WELL EXPLORING THE MARCELLUS SHALE FORMATION IN PENNSYLVANIA WAS COMPLETED IN WESTERN PENNSYLVANIA'S WASHINGTON COUNTY, BY RANGE RESOURCES IN 2004 (CARTER, ET AL. 2011). Experiments with hydraulic fracturing techniques, which were first used in Texas' Barnett Shale play, began at this well in Pennsylvania. The first permit for Marcellus exploration in northeast Pennsylvania was issued in 2006 in Lycoming County (Carter, et al. 2011). By 2007, the very early stages of Pennsylvania unconventional shale-based natural gas revolution were slowly starting to take hold.

Over a decade later, the impact of shale gas on local, regional, national, and even international energy markets has been significant and disruptive. Natural gas has eroded coal's dominance in regional power markets; electric power prices have plummeted as a result of cheap natural gas; the United States became a net natural gas exporter in 2017; and a wave of interest in new natural gas pipeline infrastructure projects has developed.

Pennsylvania's shale gas revolution has elated those focused on economic development and job opportunities, and has dismayed those concerned with potential negative environmental, public health, and land use impacts. These opportunities and controversies are not explored in this report. Rather, with a decade of data now available, this report reviews how the shale revolution has impacted natural gas consumer prices.

The first section of this paper provides a brief overview of the significance of Pennsylvania shale gas to national gas production, and the increased interest in building pipeline infrastructure to move shale gas out of Pennsylvania that has ensued. Section 2 presents an overview of Pennsylvania natural gas distribution companies (NGDCs), which are critical to delivering gas to consumers and meaningful to end use consumer pricing. Section 3 details Pennsylvania's long history of promoting competition in the natural gas industry, beginning with policies to allow gas-on-gas competition in western Pennsylvania, to facilitating transportation and bypass policy, and finally through promoting retail competition for natural gas supply.

Section 4 compares national and state natural gas usage trends, which have been significantly impacted by cheap and abundant natural gas supply. Section 5 compares national and state price trends broadly and by customer class, including developing a proxy approach to understanding private natural gas contract pricing. Section 6 reviews historic data on NGDC purchased gas cost rates, the Pennsylvania Public Utility Commission (PA PUC) approved rates utilities charge customers for gas commodity costs. Section 7 reviews historic data about NGDC delivery rates for various customer classes, to better understand how these charges are affecting retail prices to consumers. Section 8 reviews Universal Service program impacts resulting from lower commodity prices. Section 9 presents report conclusions and key questions about consumer pricing for the future.

SECTION I:
PRODUCTION AND PIPELINES

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THE STORY OF THE AMERICAN SHALE GAS REVOLUTION THAT PENNSYLVANIA IS HELPING TO LEAD HAS BEEN WIDELY AND WELL EXPLORED BY COUNTLESS SOURCES.

This section provides a very brief overview of the shale gas revolution, both in terms of natural gas production and demand for pipeline infrastructure, as expedient background for the reader.

NATURAL GAS PRODUCTION

Advances in hydraulic fracturing technology enabled the economic production of unconventional shale-based gas, unleashing significant new supplies of gas resources. *Figure 1* shows the dramatic increase in importance that shale gas has taken in contributing to overall U.S. natural gas production. Development of shale gas resources began in earnest in 2007, prompting the U.S. Energy Information Administration (U.S. EIA) to separately breakout and track withdrawals from shale plays.

According to the U.S. EIA, Pennsylvania's 2015 estimated dry natural gas contained in total natural gas "Proved Reserves"[1] totaled 55,894 billion cubic feet, more than any other state's reported reserves except for Texas, and over 18% of total U.S. reserves (U.S. Energy Information Administration 2016). Pennsylvania's rich underground Marcellus and Utica shale gas plays have proved to be especially productive.

Figure 2 shows annual natural gas gross withdrawals from the top 16 major U.S. gas producing states

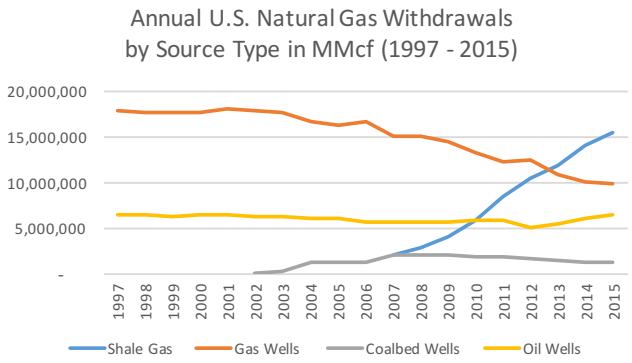

Figure 1: *Data for this figure was taken from the U.S. Energy Information Administration's (U.S. EIA) database for natural gas gross withdrawals and production (U.S. Energy Information Administration 2017).*

(including off and onshore production) as well as federal offshore production, between 1997 and 2016. Production from these 16 states along with the federal offshore accounted for approximately 95%–98% of total U.S. natural gas withdrawals during the time period examined.

Pennsylvania's growing and significant contribution to total U.S. gas production is easily seen in the red portion of the graph. In fact, in 2016, Pennsylvania was second only to Texas in total gas production.

[1] U.S. EIA defines "Proved Reserves" as the estimated quantities of natural gas which analysis of geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Reservoirs are considered proved if economic producibility is supported by actual production or conclusive formation test (drill stem or wire line), or if economic producibility is supported by core analyses and/or electric or other log interpretations.

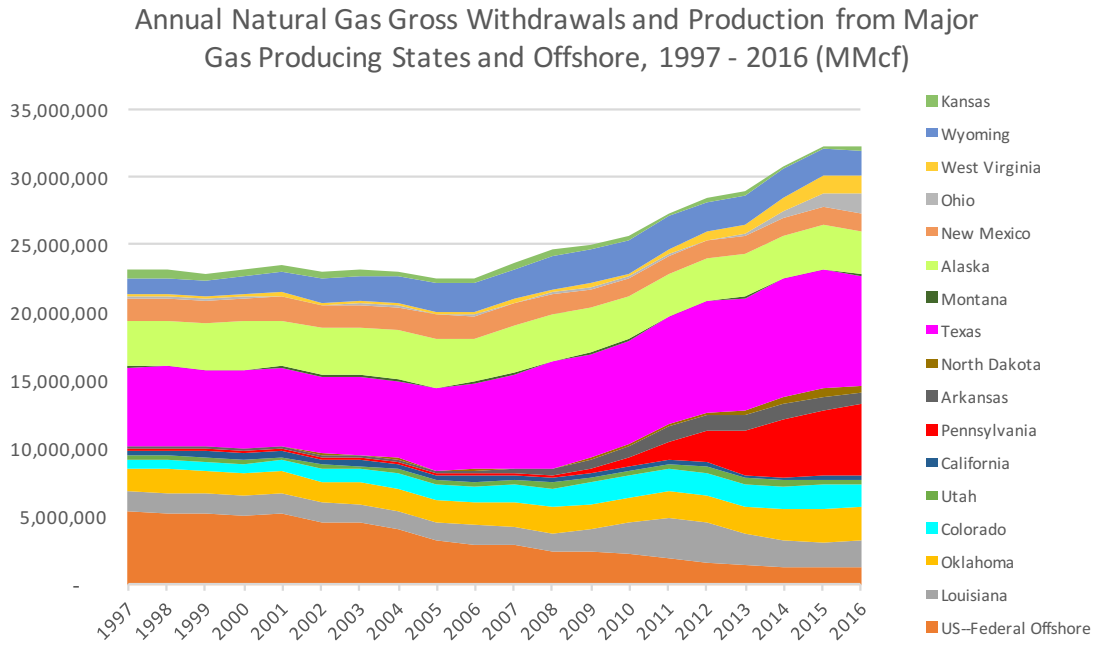

Figure 2: *2016 data for "U.S. Federal Offshore" production was not available at the time of this analysis; therefore 2015 production levels were inserted as a proxy for 2016 production. The 2015 production figure is a conservative proxy given the 5-year average of federal offshore production. Data for this figure was taken from U.S. Energy Information Administration (U.S. EIA) natural gas databases for gross withdrawals and production (U.S. Energy Information Administration 2017).*

As shown in *Table 1*, between 2007 and 2016, total U.S. gas withdrawals and production increased by 32%, while Pennsylvania's withdrawals and production increased by an astounding 2,788%. Pennsylvania's gas resources have largely driven the trend of total U.S. gas withdrawals growth. This increase in Pennsylvania production catapulted Pennsylvania from supplying less than one percent of total U.S. production in 2007, to over 16% in 2016.

Pennsylvania's increase in gas production was greater than that of any major gas producing state between 2007 and 2016, in both percentage growth rate and volume terms. *Table 2* shows that Pennsylvania's compound annual growth rate (CAGR)[2] in gas production was over 45%, far higher than any other major gas producing state. In terms of actual annual production volume levels, PA output rose by 5,081,696 MMcf (5,263,973 MMcf in 2016 minus 182,277 MMcf in 2007), compared to the overall U.S. increase of 7,983,729 MMcf (32,647,385 MMcf in 2016 minus 24,663,656 MMcf in 2007). Almost 64% of the total increase in U.S. annual production levels came from Pennsylvania.

The impacts of this new natural gas production have been significant and widespread. Reduced natural gas commodity costs have driven down electric power prices, reducing electricity costs to households and businesses. For example, PJM Interconnection's annual average wholesale energy price of $36.36 per megawatt hour (MWh) in 2015 was lower than the inflation adjusted 2000 price of $42.28/MWh ($30.72 in nominal terms) (Simeone and Hanger 2016).[3]

Just a decade ago, the U.S. was contemplating new pipeline capacity to bring natural gas to the lower 48 states from Alaska, and was building liquefied natural gas (LNG) import terminals. In 2017, after decades of being a net natural gas importer, the United States became a net exporter of gas and is expected to continue to increase net export volumes (Zarestskaya and Dyl 2017). After being a net gas importer for over 60 years, the increase in U.S. gas production has led to reduced Canadian imports, increased exports to Mexico, and growing LNG exports and export capacity (Dyl and Zaretskaya 2017).

[2] Compound annual growth rate (CAGR) measures the rate of growth over a period of years taking into account the effect of annual compounding. Applied to natural gas production, compounding reflects the ability of production levels in one period to contribute to production levels in the next period. For example, assets and investments (e.g. drilling equipment and wells drilled) in one year may continue to contribute to production in the next year. An alternative metric would be the use of a simple annual growth rate.

[3] PJM Interconnection is the operator of the electricity grid operating over 13 Mid-Atlantic states and D.C. More information about PJM can be found on its website at www.pjm.com

Growth Metrics for U.S. and Pennsylvania Annual Natural Gas Production and Withdrawals					
	1997	2007	2016	% Change (1997 - 2007)	% Change (2007 - 2016)
U.S. Total Production (MMcf)	24,212,677	24,663,656	32,647,385	1.9%	32%
PA Total Production (MMcf)	80,000	182,277	5,263,973	128%	2788%
PA as % of U.S. Production	0.33%	0.74%	16.12%		

Table 1: *Data for Table 1 was taken from U.S. Energy Information Administration (U.S. EIA) natural gas databases for gross withdrawals and production (U.S. Energy Information Administration 2017).*

NEW NATURAL GAS PIPELINES

As low cost natural gas supply has grown, so has demand. This new demand has created the need to build new or expand existing pipeline infrastructure to bring growing gas volumes to interested customers. Given Pennsylvania's gas resources, it is not surprising that the state has seen a great deal of interest in building pipelines to move gas from Pennsylvania to other states. However, many pipeline projects approved by FERC are never completed.

- Between 2007 and 2016, FERC approved 234 major interstate natural gas pipeline projects representing 121,317 MMcf per day of new capacity and 10,250 miles of new pipe (O'Reilly 2017).[4]
- In 2016 alone, FERC approved 38 major gas pipelines located in 23 different states, mostly concentrated in the Marcellus and Utica shale regions of the Mid-Atlantic. In fact, nine of these pipeline projects traversed Pennsylvania, far more than the one to four projects on average that crossed the other 22 states impacted by these projects (O'Reilly 2017).
- In early 2017, FERC approved additional pipeline projects to move natural gas from the Marcellus region of the Mid-Atlantic, including five projects spanning parts of Pennsylvania. The projects involving Pennsylvania include: the Rover Project Pipeline, a $4.2 billion project that aims to reach almost 3.3 billion cubic feet (Bcf) per day of capacity, the $2.6 billion Atlantic Sunrise Pipeline project adding 1.7 Bcf/day of capacity, the Leach Xpress Project representing 1.53 Bcf/day of capacity, the Northern Access project with 497 MMcf/day of capacity, the Orion Project with 135 MMcf/day of capacity (Tsai 2017).

Comparing Gas Production and Withdrawals by Compund Annual Growth Rate and Annual Production Levels (2007 - 2016)		
	Compound Annual Growth Rate	Change in Annual Production Levels (MMcf)
Pennsylvania	45.31%	5,081,696
Ohio	36.68%	1,378,759
North Dakota	26.92%	534,325
West Virginia	21.91%	1,143,924
Arkansas	13.22%	556,503
Oklahoma	3.68%	684,630
Colorado	3.46%	448,748
Louisiana	3.41%	486,773
U.S. Total	3.16%	7,983,729
Texas	1.70%	1,138,360
Utah	-0.53%	(18,110)
Alaska	-0.82%	(249,344)
New Mexico	-2.08%	(268,458)
Wyoming	-2.69%	(491,044)
Kansas	-4.19%	(117,335)
California	-5.12%	(127,938)
US Federal Offshore	-8.24%	(1,540,936)
Montana	-9.07%	(69,356)

Table 2: *Data to support the calculations in Table 2 were taken from U.S. Energy Information Administration (U.S. EIA) natural gas databases for gross withdrawals and production (U.S. Energy Information Administration 2017).*

[4] FERC defines "major" as a natural gas company whose combined gas transported or stored for a fee exceed 50 million dekatherms in each of the three previous three years, and "non-major" as not meeting the threshold for major but having total gas sales or volume transaction exceeding 200,000 dekatherms in each of the previous three calendar years.

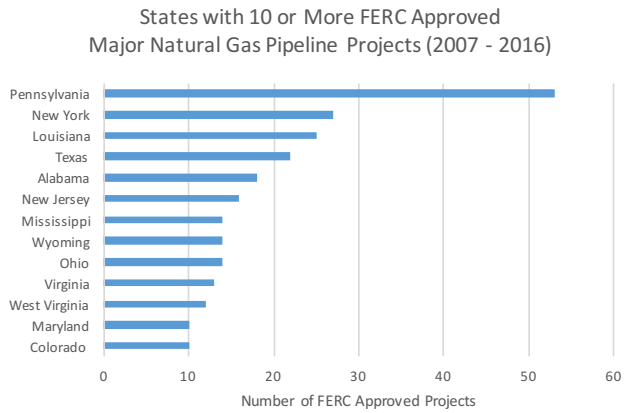

Figure 3: *This figure was reproduced from an S&P Global research report performed by Jim O'Reilly (O'Reilly 2017).*

As shown in *Figure 3*, between 2007 and 2016, FERC approved more major natural gas pipelines impacting Pennsylvania that in any other state. At 53 total projects approved, this is almost double the amount of the second most impacted state, New York, at 27 projects. As shown in *Appendix A*, these 53 projects represent 12,939 MMcf/day of capacity.

In addition to interstate pipeline projects reviewed by FERC that seek to move Pennsylvania gas to other states, there may also be development of new or expanded intrastate pipeline capacity to serve increased gas demand within the state.

THE PENNSYLVANIA GAS DISCOUNT

Development of Pennsylvania's significant natural gas supply has outpaced development of new take away pipeline capacity. As local supply outstrips demand from existing pipeline-accessible markets, natural gas prices in the region have plummeted, creating a regional price discount. *Figure 4* shows this regional price discount by comparing a straight line (i.e. unweighted) average of Pennsylvania area natural gas hub spot prices to the Henry Hub spot price.[5] Pricing at the Henry Hub has historically been considered the national benchmark for natural gas pricing. Where the brown columns fall below zero on the x-axis, the average PA Hub's price fell below the Henry Hub price. The "Pennsylvania Gas Discount" to the Henry Hub appears mid-way through 2013.

As new and/or expanded pipelines are built, take away capacity will increase, enabling greater volumes of Pennsylvania-produced gas to reach new sources of demand. Some new demand will be within Pennsylvania and some will be outside the state (i.e. via new or expanded interstate pipelines). It is unclear how increased pipeline takeaway capacity, especially with respect to interstate pipelines, will affect the price Pennsylvanians pay for gas.

Figure 5 shows historic natural gas consumption and production withdrawals in Pennsylvania. These data show that in 2007, Pennsylvania was a net importer of natural gas and consumed 4 times more gas than it produced. Since 2011, Pennsylvania has been producing more gas than it consumes, becoming a net gas producer/exporter (though it is unclear how much of this additional gas is exported versus injected into storage). In 2013, the first year the Henry Hub discount appears, Pennsylvania consumed only about 34 percent of the gas it produced. On balance, the remaining volumes were available for export and consumption outside of Pennsylvania. In 2016, Pennsylvania consumed only about 25% of the gas it produced, and the Henry Hub discount persisted. This gives credence to the notion that Pennsylvania can export a considerable amount of gas, while maintaining discounts to national average pricing.

However, some argue that a significant increase in interstate pipeline take away capacity will increase natural gas prices—through demand growth—eroding the regional price discount. Others maintain that Pennsylvania has such significant gas supply resources and storage capacity that any increase in demand can easily be met by production increases, including demand from international LNG markets. Between these perspectives, some argue that prices may stay low on average, but become more volatile, as increased demand will make pricing more sensitive to any lags or bottlenecks in the production process.

The longevity of the PA Gas Discount is an open and unanswered research question that requires further exploration and analysis.

[5] The Pennsylvania area hubs included in the price average are Dominion N, Dominion S, Leidy, TCO Pool, and TETCO M3

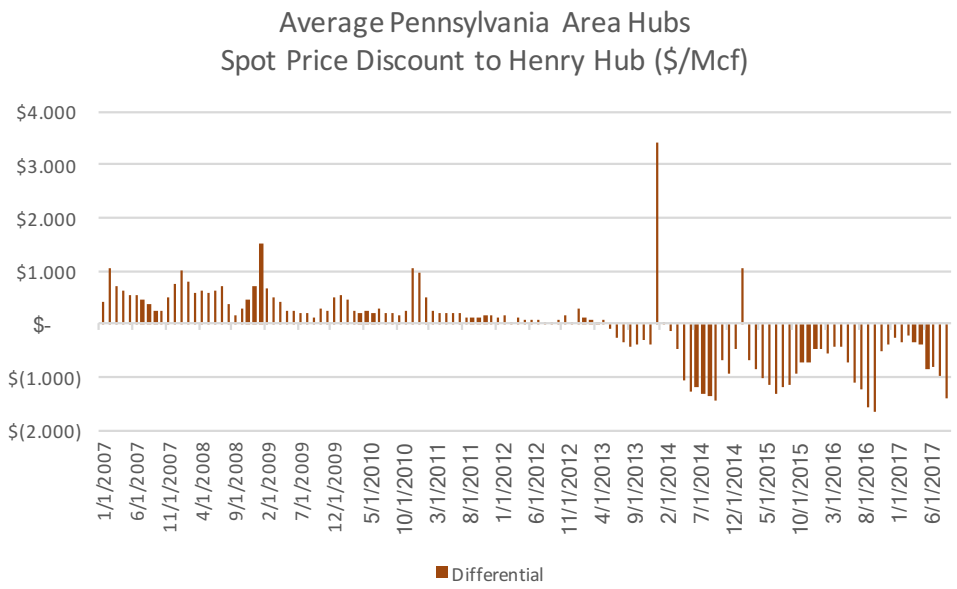

Figure 4: *The positive differential (i.e. local price spike) in early 2014 is attributed to the January 2014 polar vortex. Pennsylvania area hubs included in spot price calculation are Dominion S, Dominion N, Leidy, TCO Pool and TETCO M3. Data for this figure was taken from SNL Energy's commodity charting database (SNL Energy 2017).*

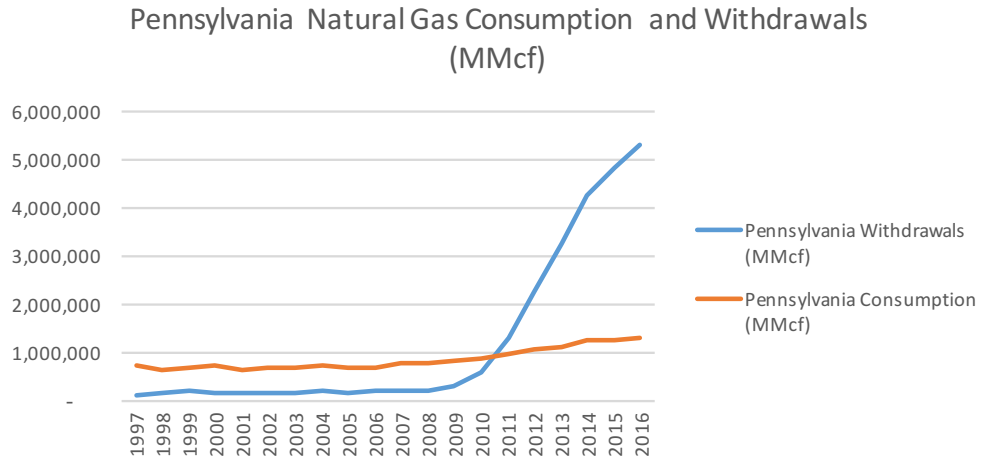

Figure 5: *Data for this figure was taken from the U.S. EIA's natural gas annual database for consumption and gross gas withdrawals (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017)*

SECTION II:
PENNSYLVANIA'S NATURAL GAS DISTRIBUTION COMPANIES

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ACCORDING TO THE PENNSYLVANIA PUBLIC UTILITY COMMISSION (PA PUC) THERE ARE NEARLY 3 MILLION NATURAL GAS CUSTOMERS IN PENNSYLVANIA, with the large majority (2.7 million) being residential customers (Pennsylvania Public Utility Commission 2016). As of January 2017, there were ten large—classified as having annual revenues over $40 million—natural gas distribution company (NGDCs) territories operating in Pennsylvania, shown in *Figure 6*. In addition, there are fifteen small gas utility territories—classified as having annual revenues under $40 million—operating in the state. This section focuses on data pertaining to Pennsylvania's large NGDCs, which include:

- Columbia Gas of Pennsylvania, herein referred to as "Columbia"
- National Fuel Gas Distribution Co., herein referred to as "NFG"
- PECO Energy Company, herein referred to as "PECO"
- Peoples Natural Gas Company, a territory formerly owned by Dominion and herein referred to as "Peoples-Dominion" or "Peoples"
- Peoples Natural Gas Company, a territory formerly owned by Equitable and herein referred to as "Peoples-Equitable" or "Equitable"
- Peoples TWP LLC, a territory formerly owned by TW Phillips and herein referred to as "Peoples – TWP"
- Philadelphia Gas Works, herein referred to as "PGW"
- UGI Utilities Inc., herein referred to as "UGI"
- UGI Penn Natural Gas Inc., a territory formerly owned by PG Energy and herein referred to as "UGI Penn"
- UGI Central Penn Gas Inc., a territory formerly owned by PPL Gas and herein referred to as "UGI Central Penn"

Table 3 provides an overview of customer and gas usage statistics for each PA NGDC. Transportation customers are customers that purchase gas supply from third party suppliers instead of the NGDC, but still take delivery service from the NGDC. This concept will be explored in more detail in the next sub-section of this report. Note that data for Peoples and Peoples-Equitable territories are combined, making these data less useful for analysis purposes and therefore are excluded from the observations below. A few summary observations from these data include:

- PECO and PGW have the greatest number of customers, and these customers are primarily residential.
- PECO has the greatest number of commercial customers taking NGDC service, UGI has the most industrial customers taking NGDC service, and Columbia has the largest number of transportation customers.
- UGI has the highest total gas requirement,[6] and Peoples TWP has the lowest
- Peoples TWP has fewest transportation customers, but these transportation customers have the highest average transportation customer usage in the state.

[6] A gas utility's total gas requirement reflects total gas sales, in addition to unaccounted for gas (e.g. gas that leaks during distribution)

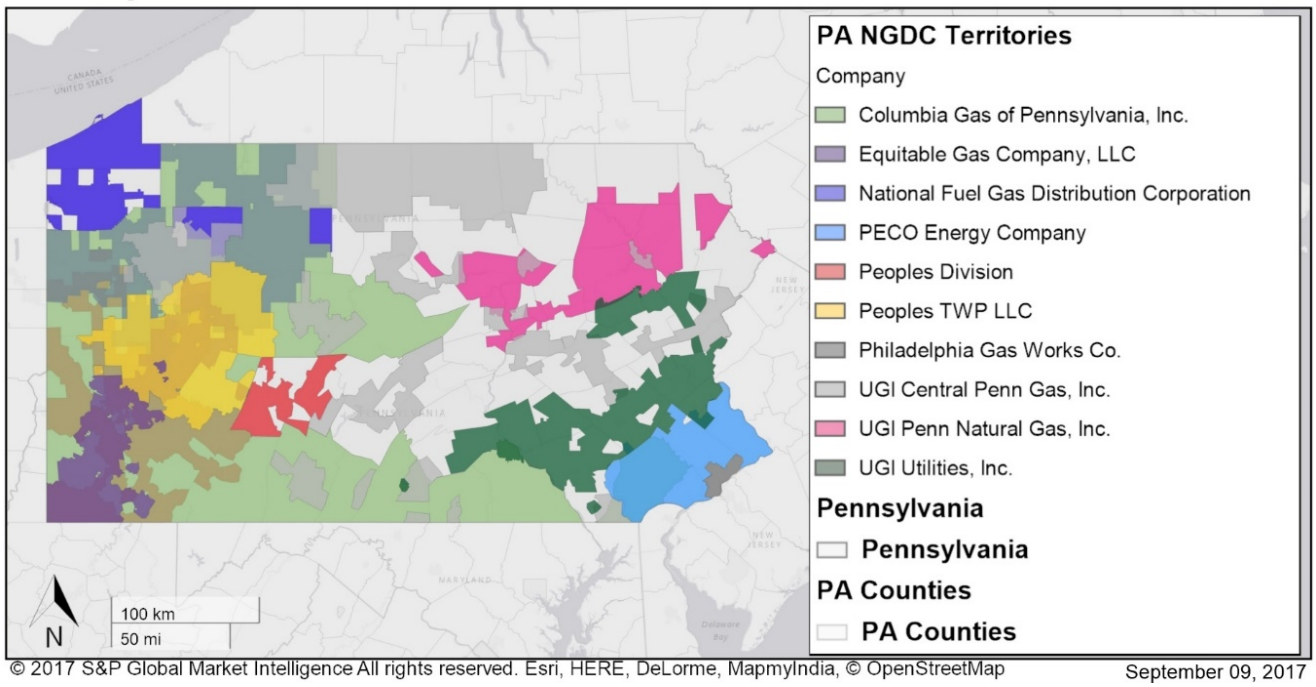

Figure 6: *This map of Pennsylvania's 10 large natural gas distribution companies (NGDCs) was produced through S&P Market Intelligence mapping tools via SNL Energy (S&P Market Intelligence via SNL Energy 2017)*

PA NGDC Customer and Gas Usage Statistics for 2015										
PA NGDC Territory	Total Customers	# Residential Customers	Avg Residential Customer Usage (Mcf)	# Commercial Customers	Avg Commercial Customer Usage (Mcf)	# Industrial Customers	Avg Industrial Customer Usage (Mcf)	# Transportation Customers	Avg Transport Customer Usage (Mcf)	Total Gas Requirement (MMcf)
Columbia	423,348	276,091	79	28,933	322	285	793	118,039	373	73,279
Peoples & Peoples Equitable	609,575	474,534	90	21,390	459	80	3,913	113,571	557	122,886
Peoples TWP	60,296	55,869	91	4,230	457	2	-	195	80,005	27,523
NFG	213,471	169,438	89	10,706	206	173	566	33,154	823	47,147
PECO	506,967	463,586	85	42,508	459	18	-	855	31,936	89,173
PGW	497,880	471,043	78	22,715	372	555	793	3,567	8,405	96,685
UGI	328,886	296,028	71	26,538	312	559	780	5,761	1,656	147,562
UGI Central Penn	87,663	71,751	88	9,123	332	130	2,185	6,659	7,904	30,075
UGI Penn	170,417	151,182	107	12,519	395	57	2,281	6,659	7,904	69,913
Total	2,898,503	2,429,522		178,662		1,859		288,460		704,243

Table 3: *Data for Peoples and Peoples Equitable territories are combined. Reported average industrial customer usage of zero in PECO territory may be related to separate tracking system for each customer class. For example, customers may initially be classed in one category, but subsequently assigned to a different rate class depending on actual usage. This may give the appearance of zero Mcf usage, when instead, the customer may have moved to a different rate class. These 2015 data were taken from the PA PUC's Pennsylvania Gas Outlook report for 2016 (Stewart 2016).*

SECTION III
NATURAL GAS COMPETITION IN PENNSYLVANIA

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THE FEDERAL GOVERNMENT OPENED THE DOORS TO COMPETITION IN THE NATURAL GAS INDUSTRY, for example by lifting price controls on gas production (Natural Gas Policy Act of 1978 and Wellhead Decontrol Act of 1989), and restructuring the interstate pipeline industry (FERC Orders 436 of 1985, 636 of 1992, and 637 of 2000). Pennsylvania has also taken significant actions to promote competition in the natural gas industry. Although the Pennsylvania Natural Gas Choice and Competition Act passed in 1999 (the Gas Competition Act), gas industry competition was taking place well before its passage. Competition began by allowing NGDCs serving overlapping territories (called gas-on-gas competition) to compete to serve large volume use customers. Pennsylvania also allowed gas transportation and bypass service, both of these actions benefitted large end-use customers. Retail competition, established by the Gas Competition Act, extended supplier choice to lower usage customers, such as those in the residential sector.

GAS-ON-GAS "COMPETITION"

As can be seen back in *Figure 6*, many areas of the state (mostly in western Pennsylvania) are served by more than one NGDC. These overlapping service territories have given rise to what has been termed "gas-on-gas" competition, a form of gas industry competition the PA PUC has tolerated since the 1980's (Pennsylvania Public Utility Commission 2005). Overlapping NGDC territories in western Pennsylvania were brought about by a combination of the Natural Gas Company Act (NGCA) of 1885 and the resource richness of the area. Provisions in the NGCA governed how gas companies could claim service territories, which included filing a charter indicating,

> *"[t]he place or places where natural gas is intended to be mined for and produced or received, the place or places where it is to be supplied to consumers, [and] the general route of its pipe line or lines and branches…" (Pennsylvania Public Utility Commission 2005)*

Given the location of gas resources and complex terrain in western Pennsylvania, many competing gas companies built gas production, transportation, and delivery infrastructure in close proximity to one another and claimed overlapping territories under the NGCA (Pennsylvania Public Utility Commission 2005).

The PA PUC historically permitted competition between NGDCs, for example, by allowing customers to choose their preferred NGDC, permitting one NGDC to serve the existing customer of another NGDC, revoking the requirement to get commission approval before one NGDC could serve the customer of another NGDC.[7] Intense competition among NGDCs in these areas arose from gas-on-gas competition, for example, the development of flexible rate tariffs or flex rates. The PA PUC approves maximum rates NGDCs can charge to customers. However, with flex rates, NGDCs with overlapping territories are permitted to offer discounted distribution rates (and/or other incentives) on a case-by-case basis to nonresidential customers in order to attract or retain these customers. The notion is securing a discounted rate is better than losing the customer altogether. This practice is not without controversy, as consumer advocates argue reduced revenues from flex rate customers are recovered from the NGDC's captive (i.e. residential)

[7] A more detailed discussion of Pennsylvania's gas-on-gas competition history is included in (Pennsylvania Public Utility Commission 2005).

customers.[8] In fact, it may be a misnomer to call gas-on-gas competition a true form of market competition, since discounts to secure large volume use customers are treated as shifted costs recovered from captive ratepayers.

Gas-on-gas "competition" continues to occur in four NGDCs: Columbia, Peoples-Equitable, Peoples, and Peoples TWP. Somewhat dated information suggests gas-on-gas rate discounting may apply to only about 400 commercial and industrial customers in Pennsylvania (Triscari 2014).

COMPETITION EXPANDS FOR LARGE VOLUME USE CUSTOMERS

Beyond the distribution companies, competition from third party entities (e.g. producers and marketers) began to accelerate to secure large volume gas users in the commercial and industrial sectors. In addition to using more gas, these customers were also attractive targets for competition because they were generally more cost effective to serve compared to residential customers, creating the potential for competitive pricing. These larger customers tend to have relatively consistent demand throughout the year, high load factors, little need for storage services, and may have lower pipeline unit costs compared to NGDCs that need to pay to reserve pipeline space to meet seasonal peak demand (Pennsylvania Public Utility Commission 2005). In addition, prior to the passage of Act 4 of 1999 (a tax reform act), the sale of natural gas by NGDCs was subject to gross receipts tax. However, sale of gas by gas producers and marketers was not subject to gross receipts tax, creating a competitive cost advantage for these entities. Pennsylvania encouraged competition among these various third-party entities to serve large use customers through bypass and transportation policies.

Bypass of the local NGDC occurs when a third-party entity seeks to supply and/or serve the commercial or industrial end use customer directly, thus "bypassing" the NGDC's infrastructure. Bypass only applies to customers that can directly connect to a transportation pipeline instead of the NGDC's distribution line. When bypass competition first started to occur in the 1980's NGDC's maintained this practice was a threat to their business and petitioned the commission to regulate bypass entities.[9] The PA PUC declined to regulate bypass entities, but did subsequently investigate the issue and found bypass should continue to be addressed on a case-by-case basis.

Gas transportation service occurs when a third-party entity seeks to supply gas to a large end use customer, but still uses the NGDC's distribution system. As will be explored in Section 5, third party entities can often offer large use customers much more attractive commodity pricing compared to the NGDC-offered price, causing many of these customers to contract with these alternative suppliers. In 1986, the PA PUC established regulations governing transportation service for certain large volume gas transactions. Precedent in case law enabled smaller annual volumes (<50,000 Mcf per year) to be eligible for transportation service and regulations eventually codified the practice. In 1991, PA PUC further promoted transportation service by amending the transportation regulations to reduce minimum annual volumes to 5,000 Mcf, increased the number of customers that could participate in a buying group from three to ten, and required firm service customers to purchase standby sales service unless they meet certain criteria.[10]

RETAIL COMPETITION

The Natural Gas Choice and Competition Act of 1999 (the Gas Competition Act) was most significant to the residential sector because on a statewide basis it enabled this customer class to choose commodity supply from either the NGDC (i.e. default service) or from a third party natural gas supplier (NGS), while continuing to receive delivery service from the NGDC. The Gas Competition Act enabled retail choice starting on November 1, 1999. The remainder of this section reviews residential, commercial and industrial shopping statistics for Pennsylvania, to identify how the different customer classes have responded to competitive supply opportunities.

Broadly speaking, these data show that shopping penetration is lower in the residential sector compared to the industrial and commercial classes, and that the industrial class has almost fully switched to competitive suppliers.

[8] A more detailed discussion of the flex rate component of gas-on-gas competition can be found at PA PUC dockets P-2011-2277868 *"Joint Petition for Generic Investigation or Rulemaking Regarding "Gas-On-Gas" Competition Between Jurisdictional Natural Gas Distribution Companies"*, and I-2012-2320323 *"Generic Investigation Regarding Gas-On-Gas Competition Between Jurisdictional Natural Gas Distribution Companies"* of May 4, 2017, opinion and order located at http://www.puc.state.pa.us//pcdocs/1519501.docx

[9] See *Petition of the Pennsylvania Gas Association for the Issuance of a Regulation Setting Forth the Conditions Precedent to the Provision of Natural Gas Sales or Transportation Services within the Commonwealth of Pennsylvania*, 66 Pa. PUC 383, order entered February 2, 1988 at Docket No. P-870236

[10] See *Minimum Threshold for Natural Gas Transportation Service*, Order, June 1991, Docket L-890050

Residential Customer Shopping Statistics

Figure 7 shows the percent of total NGDC residential customers that are receiving natural gas supply from third party NGSs. Residential shopping penetration has historically been and generally continues to be highest in western PA NGDC territories. This may or may not be attributed to the substantial retail choice pilot programs that were implemented prior to the passage of the 1999 Gas Competition Act in Columbia, Peoples-Equitable, and Peoples territories. As discussed earlier in this section, in addition to potential commodity costs differences, early shopping customers had an incentive to shop prior to the passage of Act 4 in 1999, as they could avoid paying gross receipts tax by selecting an alternative supplier. In several territories - PGW, Peoples TWP, UGI Central Penn, UGI Penn – shopping percentages in 2017 were very low, ranging from 0% to 2.5%. OCA did not track residential percent of load served by competitive suppliers over this time period. However, the U.S. EIA did track this information, which is explored in Section 5's discussion of residential retail prices.

Commercial Customer Shopping Statistics

Figures 8 and 9 show commercial class shopping penetration by percent of total commercial customers shopping by NGDC territory and percent of total commercial load served by a competitive supplier by NGDC service territory, respectively. As measured by percent of total commercial customers, the commercial class has more consistent shopping penetration numbers across service territories, compared to the residential sector. More meaningfully, the percent of total load being served by competitive suppliers is very high, ranging from a low of 49% (PECO) to over 78% (UGI) in May 2017.

Industrial Customer Shopping Statistics

Figures 10 and 11 show industrial class shopping penetration by percent of total industrial customers shopping per NGDC territory and percent of total industrial load served by a competitive supplier by NGDC territory, respectively. Although the percentage of customers shopping varies widely between territories, the percent load data consistently remained within a very tight band between 95% - 100%. This load data emphasizes that most industrial gas sales are procured competitively.

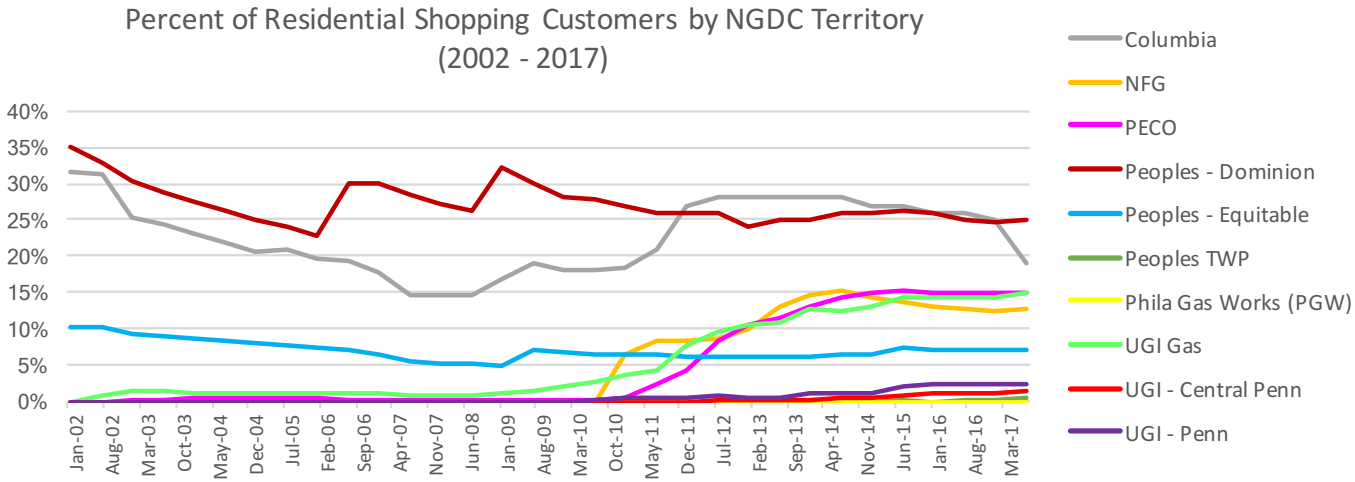


Figure 7: *Residential data from 2002 through 2017 was taken from the PA Office of the Consumer Advocate's quarterly natural gas shopping statistic reports for January and July of each year (Pennsylvania Office of Consumer Advocate 2001 - 2017).*

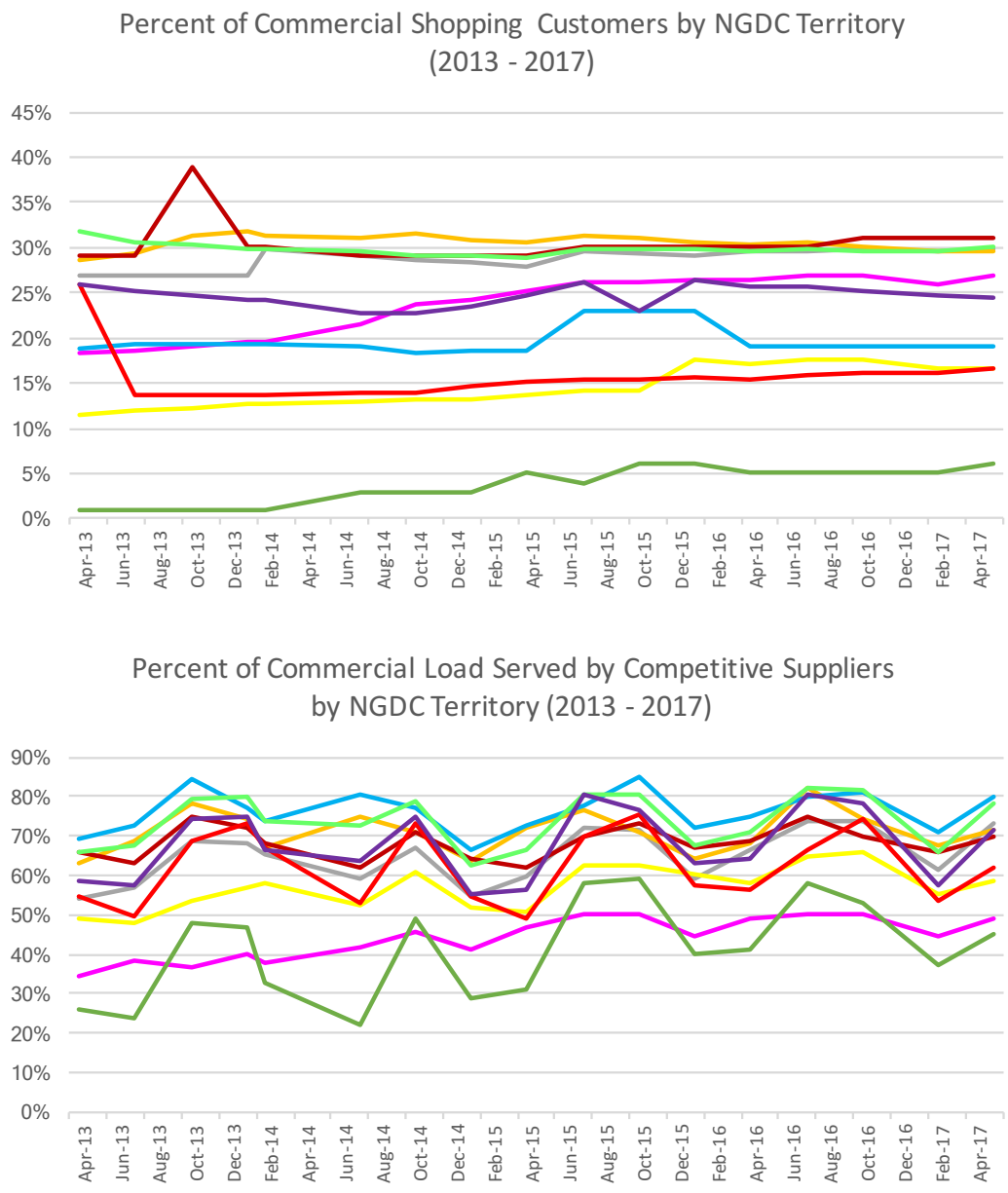
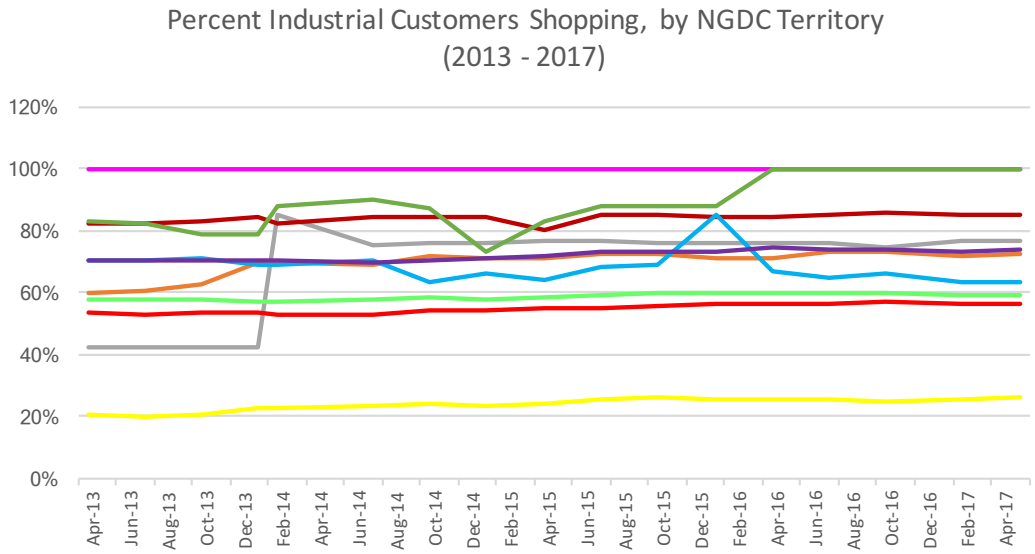


Figure 8 (top) and 9 (bottom): *Commercial data for 2013 through 2017 was taken from the PA PUC's shopping statistics that are published on the "questions to ask natural gas suppliers" page of pagasswitch.com and through outreach to the commission for access to archived data (Pennsylvania Public Utility Commission 2017). These data where generally available on a quarterly basis from 2013 through May 2017.*



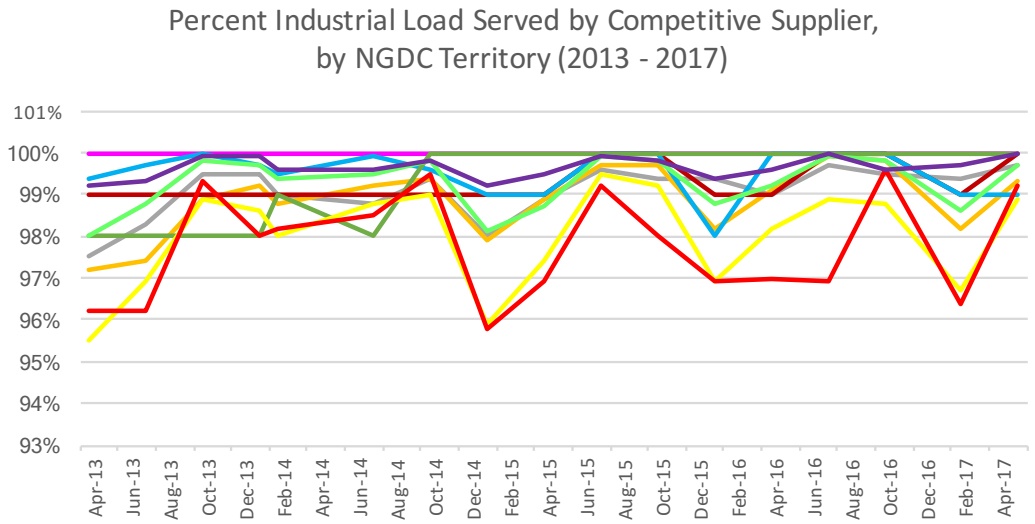


Figure 10 (top) and 11 (bottom): *Industrial data for 2013 through 2017 was taken from the PA PUC's shopping statistics that are published on the "questions to ask natural gas suppliers" page of pagasswitch.com and through outreach to the commission for access to archived data (Pennsylvania Public Utility Commission 2017). These data where generally available on a quarterly basis from 2013 through May 2017.*

SECTION IV
OVERVIEW OF U.S. AND STATE NATURAL GAS USAGE TRENDS

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COST-EFFECTIVE DEVELOPMENT OF UNCONVENTIONAL SHALE GAS PLAYS IN THE UNITED STATES HAS INCREASED GAS SUPPLY AND DECREASED COSTS. Pennsylvania's shale resources have contributed significantly to regional supply increases and commodity cost decreases. This section explores the extent to which national- and state-level consumer natural gas usage patterns have changed as a result of this low-cost supply.

REVIEW OF DATA

Figures 12 and 13 show natural gas deliveries to industrial, commercial, residential, and electric power end use consumers in the U.S. and in Pennsylvania, respectively. The most obvious observation in both figures is the relative flatness of demand in the residential, commercial and industrial sectors, and the growth of natural gas deliveries to the electric power sector. The growth in Pennsylvania's electric power sector demand is especially pronounced.

Figures 14 and 15 compare 2016 natural gas deliveries in the U.S. and Pennsylvania, to 1997 and 2007 baselines. Data for these graphs were taken from the same sources as *Figures 12 and 13*. These figures more dramatically show the increase in electric power sector demand. In addition, the different comparative industrial demand for the U.S. and PA is more apparent in these figures. U.S. industrial demand has historically exceeded U.S. residential and commercial demand, whereas residential demand in Pennsylvania has historically exceeded industrial and commercial demand. In both graphs, the increase in industrial demand since 2007 is apparent.

Table 4 uses the data from *Figures 12 and 13* to calculate the percent usage change between 2007 and 2016, for the four end use customer sectors.

Table 5 calculates the percentage change in the total number of U.S. and PA natural gas end use customers per customer sector, between 2007 and 2016.

Comparing 2016 U.S. and PA Gas Deliveries (MMcf) to 2007 Baseline		
	U.S.	PA
Total	18.5%	50.5%
Industrial	16.0%	11.4%
Commercial	3.1%	-2.1%
Residential	-8.0%	-6.8%
Electric Power	45.9%	247.8%

Table 4: *This table uses the data from Figures 12 and 13 to calculate the percent change in gas deliveries (MMcf) between 2007 and 2016, for total and various sectors.*

Comparing 2016 Number of U.S. and PA Gas Customers by Sector to 2007 Baseline		
	U.S.	PA
# of Industrial Customers	-4.93%	-4.21%
# of Commercial Customers	3.08%	1.65%
# of Residential Customers	5.31%	5.24%
# of Electric Power Customers	3.59%	15.22%

Table 5: *Data for the number of U.S. and PA natural gas residential, commercial, and industrial customers was taken from U.S. EIA databases. (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017). Data for the total number of electric power customers for the U.S. and PA were taken from the U.S. EIA's electricity data browser (U.S. Energy Information Administration 2016).*

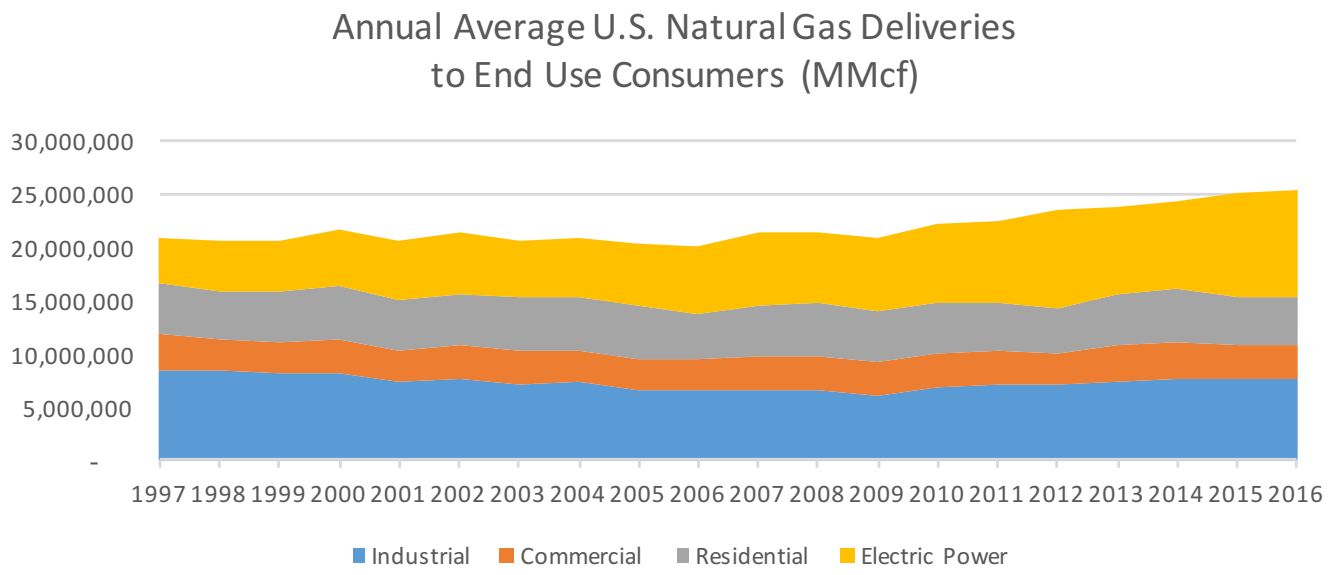

Figure 12: *Data was taken from the U.S. EIA's database of natural gas consumption by end use for the U.S. (U.S. Energy Information Administration 2017).*

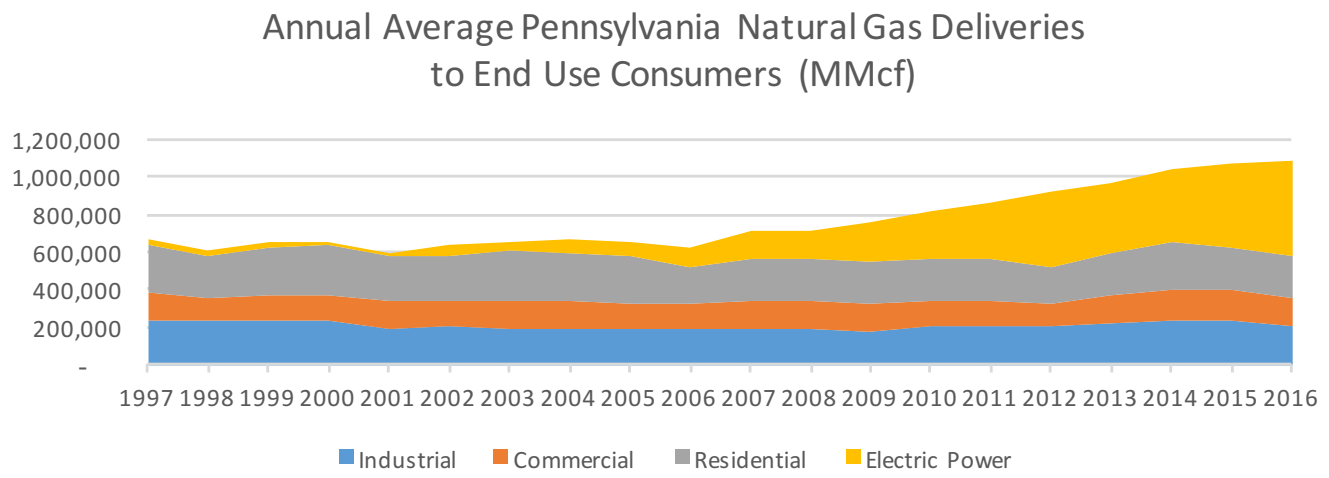

Figure 13: *Data was taken from the U.S. EIA's Natural Gas Annual with data for Pennsylvania (U.S. Energy Information Administration 2017).*

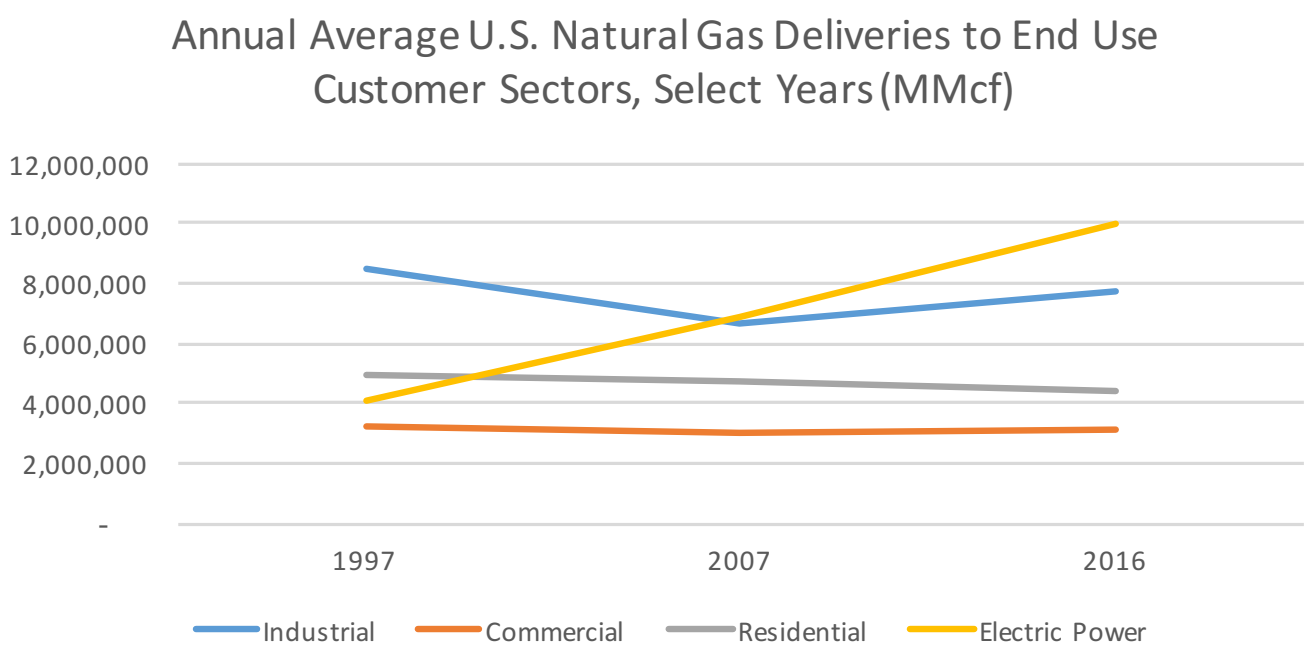

Figure 14: *Data was taken from the U.S. EIA's database of natural gas consumption by end use for the U.S. (U.S. Energy Information Administration 2017).*

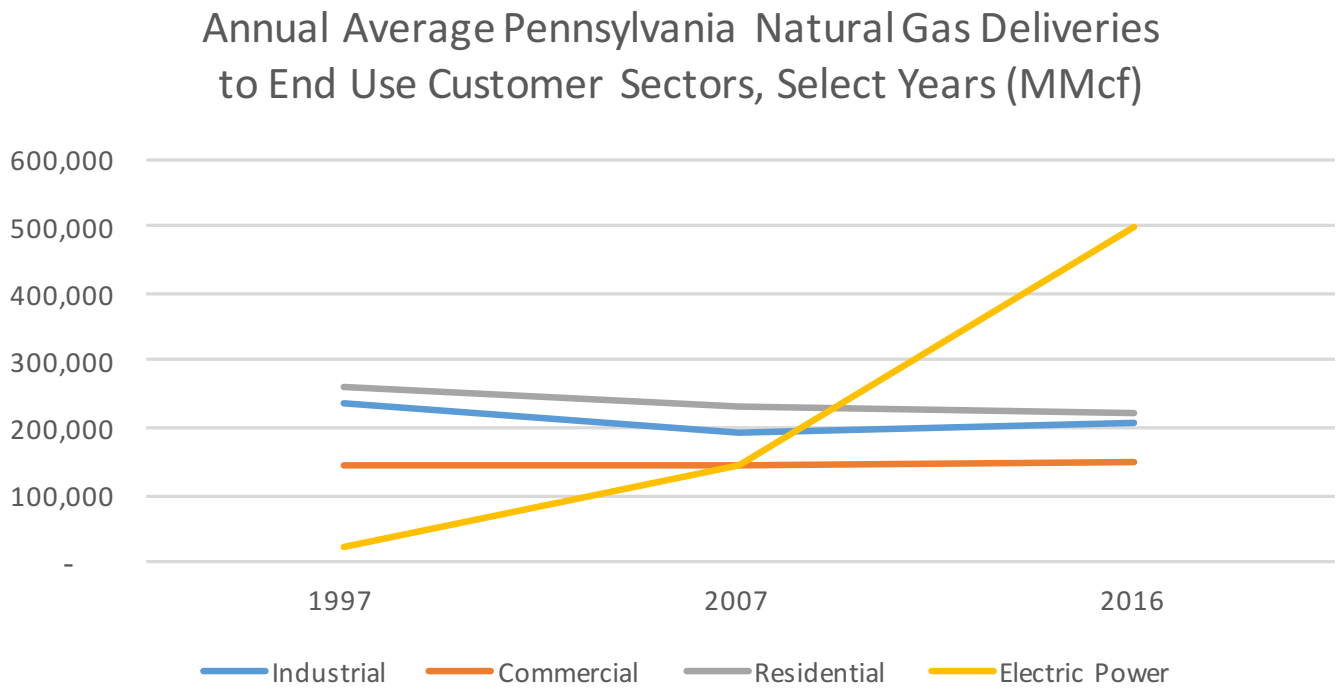

Figure 15: *Data was taken from the U.S. EIA's Natural Gas Annual with data for Pennsylvania (U.S. Energy Information Administration 2017).*

OBSERVATIONS AND EXPLORATION

Overall Gas Demand Increase was Larger in PA than U.S. Natural gas deliveries in the U.S. increased by 18.5% since 2007. Over the same period, Pennsylvania deliveries increased by 50.5%, a 2.7 times increase compared to the national trend.

Enormous Increase in PA Electric Power Sector Demand. U.S. power sector natural gas deliveries increased by about 46% in that time period. The rapid increase in Pennsylvania's natural gas use has been driven by the electric power sector, deliveries to which have increased by almost 250% since 2007. Pennsylvania's electric power sector gas demand use grew more than 5.3 times that of the U.S. power sector's gas demand.

Large Increase in U.S. and PA Industrial Sector Demand. Between 2007 and 2016, gas deliveries to the U.S. industrial sector grew by 16%, compared to an 11.4% increase in PA. During the same time period, the number of industrial customers decreased by 4.93% for the U.S., while decreasing by 4.21% in PA (U.S. Energy Information Administration 2017). In 2007, average consumption of natural gas per U.S. industrial customer was 33,561 Mcf, and 39,138 Mcf for PA industrial customers. By 2016, average consumption of natural gas per U.S. industrial customer was 40,964 Mcf (a 22% increase from 2007), and 45,519 Mcf for PA industrial customers (a 16.3% increase from 2007) (U.S. Energy Information Administration 2017).

U.S. Commercial Sector Demand Growing, While PA Commercial Demand Falls. When comparing 2007 to 2016, a slight increase of 3.1% in deliveries to the U.S. commercial sector was experienced and a slight decrease of 2.1% for PA's commercial class was observed. During the same time period, U.S. commercial customers increased by 3.08%, while PA commercial customers increased by only 1.65%.

Decreasing U.S. and PA Residential Sector Demand. A significant decrease in natural gas deliveries to the residential sector was observed between 2007 to 2016, 8% for the U.S. and 6.8% for PA. However, the number of residential natural gas customers has increased during the same time period by 5.31% for the U.S., and 5.24% for Pennsylvania.

Increased residential energy efficiency (e.g. through replacement of old appliances with new higher efficiency gas using appliances) is one potential explanation connecting these data. Temperature has a profound impact on the demand for residential heating and cooling. Therefore, another potential explanation for reduced residential natural gas demand could be a reduction in the number of heating degree days (i.e. a measure in the difference between outdoor temperatures and the indoor temperature people consider comfortable, benchmarked at 65°F), reducing gas demand for heating. Data in *Figure 16* from the National Oceanic and Atmospheric Administration (NOAA) for Pennsylvania indicates a negative trend in the number of heating degree days experienced between 2007 through 2016 (NOAA National Centers for Environmental Information 2017). In other words, the number of heating degree days fluctuated over the period, but the overall trend is the number of heating degree days decreased in PA. Therefore, warmer winter temperatures may also contribute to reduced residential heating demand.

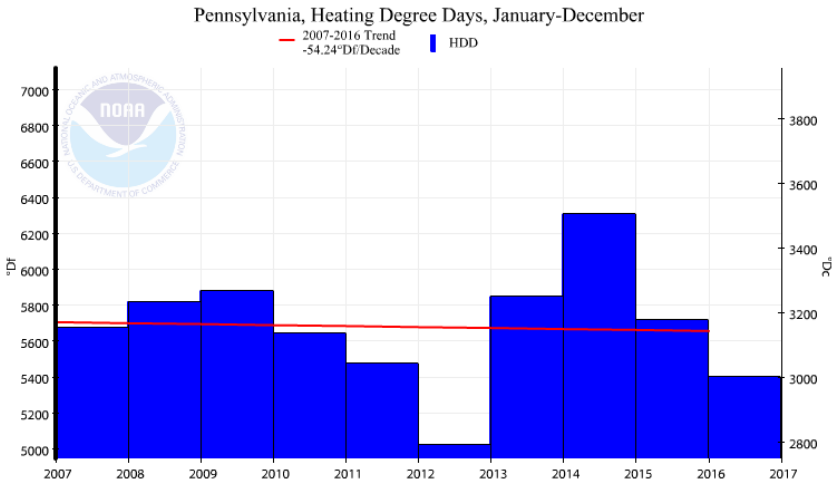

Figure 16: *Graphic reproduced from NOAA's National Centers for Environmental Information "Climate at a Glance" tool (NOAA National Centers for Environmental Information 2017)*

SECTION V
OVERVIEW OF U.S. AND PA PRICE TRENDS

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CHEAP, PLENTIFUL SHALE GAS HAS HELPED REDUCE GAS COMMODITY RELATED COSTS TO ALL CONSUMER SECTORS IN PENNSYLVANIA, AND NATIONALLY. However, consumer sectors are impacted differently based on a variety of factors that will be explored in this section.

Data Sources and Limitations

A detailed discussion of data sources and limitations is included in *Appendix B* of this report.

Primary Data Sources. National and state natural gas pricing and usage data for various customer sectors were taken U.S. EIA's natural gas annual database, which pulls data from a variety of monthly and annual survey input sources, depending on the sector.

Delivered Electric Power Prices. These prices include the delivered cost of natural gas to power plants over 50 megawatts. These costs include, for example, commodity costs, pipeline charges, distribution system charges (if applicable), financial hedging, losses, and other costs.

Citygate Prices. These prices represent the total cost paid by local distribution companies for gas received at the physical point where the gas is transferred from the pipeline company or transmission system to the distribution system.

Residential, Commercial and Industrial Sector Data Limitations. EIA is able to obtain pricing information for gas sold by NGDCs (i.e. default supply), but has less pricing information on gas sold by competitive third-party entities. However, EIA does track total gas volumes moving through the NGDC's system, which includes default and competitively supplied gas. Given these data limitations, it is important to pay attention to the percent of total gas volume that is represented by the reported price.

However, residential and commercial pricing data for 2002–2010 is complete, as EIA required both Pennsylvania competitive suppliers and NGDCs to report pricing data for these customer classes during these years.

NGDC offered prices (i.e. default pricing) is available for all years and customer sectors. EIA's default pricing data for the residential sector will cover most volumes of gas delivered. EIA default pricing data for the commercial and industrial sectors is associated with only a small volume of total gas delivered to these sectors and does not accurately reflect actual prices paid by the majority of these customers. EIA default NGDCs pricing for large gas use customers does not reflect the bulk discounts these customers can secure through third-party suppliers.

Commercial and Industrial Proxy Price for Pennsylvania. As a result of the EIA data limitations, this section of the report develops a proxy price approach, called the PA Hubs Average, to provide a more accurate approximation of commercial and industrial natural gas pricing for Pennsylvania. The PA Hubs Average is an unweighted average of prices from five major Pennsylvania area natural gas hubs, including TCO pool, TETCO M3, Dominion N, Dominion S, and Leidy. The primary limitation of the PA Hubs Average is it excludes costs to move the gas from hub to meter, which may include pipeline and NGDC delivery charges, for example. As such, the PA Hubs Average understates the cost to commercial and industrial customers, whereas the EIA data overstates costs to these customer classes (aside from commercial customer data from 2002–2010).

Comparing Inflation Adjusted Annual Average Prices ($/Mcf) for U.S. Customer Sectors							
	1997		2007		2016	Comparing Real Terms	
	Nominal	Real	Nominal	Real		1997 to 2016	2007 to 2016
Citygate	$ 3.66	$ 5.47	$ 8.16	$ 9.45	$ 3.71	$ (1.76)	$ (5.74)
Residential (NGDC-only)	$ 6.94	$ 10.38	$ 13.08	$ 15.14	$ 10.05	$ (0.33)	$ (5.09)
Industrial (NGDC-only)	$ 3.59	$ 5.37	$ 7.68	$ 8.89	$ 3.52	$ (1.85)	$ (5.37)
Commercial (NGDC-only)	$ 5.80	$ 8.67	$ 11.34	$ 13.13	$ 7.28	$ (1.39)	$ (5.85)
Electric Power	$ 2.78	$ 4.16	$ 7.31	$ 8.46	$ 2.99	$ (1.17)	$ (5.47)

***Table 6**: This table uses pricing data from Figure 17. Inflation adjustments were performed using the U.S. Bureau of Labor and Statistics annual CPI-U data through 2016*

U.S. AND PA RETAIL PRICE TRENDS, IN REAL AND NOMINAL TERMS

National and state pricing information were compared and examined to understand similarities and differences between respective trends. National and state pricing trends are first examined, followed by a more detailed comparison between U.S. and state sectoral prices.

Figure 17 shows U.S. annual average natural gas retail prices to the residential, commercial, industrial, and electric power sectors, as well as the citygate price, in nominal terms. It is important to reiterate that residential, industrial, and commercial prices shown in these graphs represent gas purchased and delivered by NGDCs. For the commercial and industrial classes, with high volumes of gas being supplied by competitive third parties, these prices are likely to be much higher than what these customer classes are actually paying on average. Overall, a somewhat consistent upward trend in price is observed from 1997 through 2008, with a clear downward overall price trend thereafter. This figure also shows that U.S. average annual residential retail prices are the highest, followed by the prices to the commercial sector, citygate, industrial sector, and electric power sector.

Percent Change in Prices ($/Mcf) to U.S. Sectors, Comparing 1997, 2007 to 2016 in Real Terms		
	2016 % Change in Real Terms	
	From 1997	From 2007
Citygate	-32%	-61%
Residential (NGDC-only)	-3%	-34%
Industrial (NGDC-only)	-34%	-60%
Commercial (NGDC-only)	-16%	-45%
Electric Power	-28%	-65%

***Table 7:** This table uses data from Table 6 to calculate percent change in price in real terms.*

This general pricing hierarchy is somewhat expected as a result of the cost structure of different customer classes:

- Residential sector prices are expected to be the highest given charges for both transmission and delivery infrastructure, use of comparatively higher cost firm pipeline service, as well as lower per customer volume usage (reducing bulk purchase discounts).
- Electric power sector prices are often low because electric power generation units use large volumes of natural gas (i.e. bulk purchase discounts) and typically bypass the distribution system and connect directly to the pipeline transmission trunk line, therefore reducing distribution-related charges. In addition, pipeline delivery contracts to power providers to can be “interruptible”, which reduces costs but also introduces the risk of not receiving gas supply when needed.
- Citygate prices apply to the NGDC procurement of natural gas supply for their customers. Although citygate prices represent a larger volume of gas compared to a large gas fired generation plant or industrial gas user, the premium for firm delivery of gas that NGDCs typically requires makes the citygate price more expensive.

Table 6 provides the nominal and adjusted real price data for 1997 and 2007 and calculates the differences in real terms to 2016 prices. *Table* 7 converts these dollar values in real terms into percentages. Inflation adjustments were performed using the U.S. Bureau of Labor and Statistics annual CPI-U data through 2016 (U.S. Bureau of Labor and Statistics 2016).

Observations from these data indicate a significant decrease in natural gas prices was observed comparing 2016 prices to inflation adjusted prices from 1997 and 2007.

- U.S. annual average retail prices to all sectors have actually decreased in real terms over the twenty-year period examined, with the most significant price decreases observed between 2007 and 2016.
- Since 2007, electric power sector U.S. annual average prices have decreased the greatest amount on a percentage basis at 65%.
- Since 2007, commercial NGDC-only prices decreased the most, as measured by per unit dollar value at $5.85/Mcf.
- Since 2007, the price decrease to the residential sector has been the least significant on both a dollar per unit and percentage basis.

Figure 18 compares Pennsylvania annual average natural gas prices in nominal terms for the residential, commercial, industrial, and electric power sectors, and the citygate. Again, note the residential, commercial, and industrial sector prices pertain only to NGDC sold gas. As reviewed in Section 3, less than 5% of industrial volumes and between 20% to 60% of commercial volumes are supplied by PA NGDCs.

Similar to the U.S. annual average data in *Figure 17*, Pennsylvania's residential and commercial sector prices consistently are the highest and the electric power sector is relatively consistently the lowest. Departing from national trends, PA's average annual industrial NGDC-only prices tends to be higher than PA's citygate prices. This may be related to Pennsylvania's higher than the national average penetration of industrial natural gas customers that procure gas outside of the NGDC, through third party entities. If NGDC's only sell small volumes of gas to the industrial sector, they will be less likely to contract for the volumes needed to secure bulk discount pricing and may rely more heavily on spot market procurement.

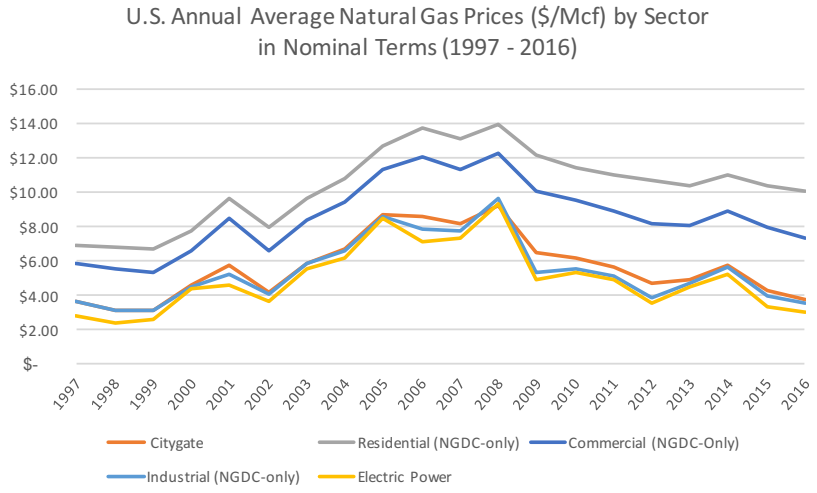

***Figure 17**: Data for this figure was taken from the U.S. EIA database for annual average U.S. natural gas prices by sector (U.S. Energy Information Administration 2017)*

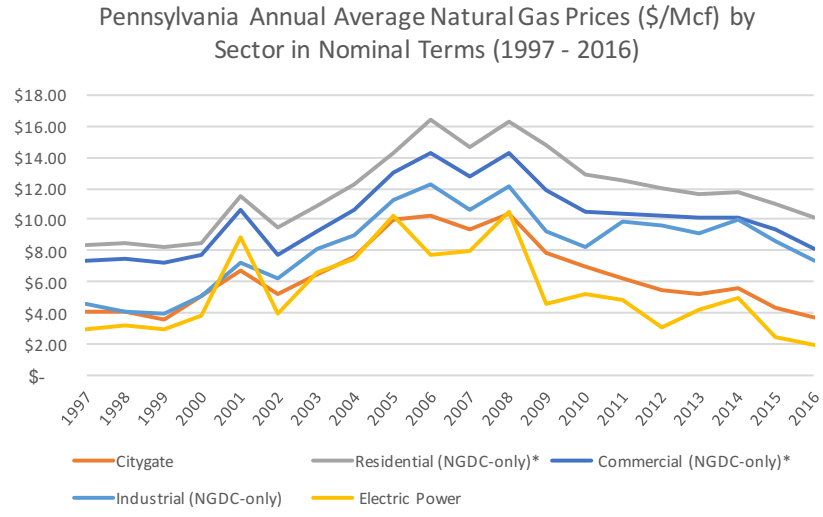

***Figure 18**: *From 2002–2010, U.S. EIA collected residential and commercial natural gas price information from Pennsylvania NGDC's and third-party marketers. So, during that time period the pricing is associated with 100% of gas volumes sold to those respective customer classes and represents both NGDC and competitive supplier pricing. Data for this figure was taken from the U.S. EIA's database for annual natural gas summary data for Pennsylvania (U.S. Energy Information Administration 2017).*

Comparing Inflation Adjusted Annual Average Prices ($/Mcf) for PA Customer Sectors							
	1997		2007		2016	Comparing Real Terms	
	Nominal	Real	Nominal	Real		1997 to 2016	2007 to 2016
Citygate	$ 4.09	$ 6.12	$ 9.35	$ 10.82	$ 3.72	$ (2.40)	$ (7.10)
Residential (NGDC-only)*	$ 8.33	$ 12.46	$ 14.66	$ 16.97	$ 10.18	$ (2.28)	$ (6.79)
Industrial (NGDC-only)	$ 4.61	$ 6.81	$ 10.64	$ 12.16	$ 7.40	$ 0.59	$ (4.76)
Commercial (NGDC-only)*	$ 7.35	$ 10.99	$ 12.77	$ 14.78	$ 8.15	$ (2.84)	$ (6.63)
Electric Power	$ 3.02	$ 4.52	$ 8.01	$ 9.27	$ 1.95	$ (2.57)	$ (7.32)

***Table 8**: *Residential and commercial data between 2002-2010 reflects both NGDC and competitive supplier prices. This table uses data from Figure 18 and adjusts for inflation using the U.S. Bureau of Labor and Statistics annual CPI-U data through 2016 (U.S. Bureau of Labor and Statistics 2016).*

Table 8 provides the nominal and adjusted real price data for 1997 and 2007 and calculates the differences in real terms to 2016 prices. *Table 9* converts these dollar values in real terms into percentages. Inflation adjustments were performed using the U.S. Bureau of Labor and Statistics annual CPI-U data through 2016 (U.S. Bureau of Labor and Statistics 2016).

Observations from these data indicate a significant decrease in natural gas prices was observed comparing 2016 prices to inflation adjusted prices from 1997 and 2007.

- Since 2007, prices to all customer classes went down significantly (39% to 79%).
- Since 1997, prices went down for all customer classes, except for the NGDC-only industrial sector, which increased by 9%.
- Since 2007, with the exception of the industrial NGDC-only prices, PA prices tended to decrease more than U.S. prices both in real dollars per unit terms and on a percentage basis.
  - The relatively higher NGDC-only industrial prices may be the result of utility dependence on higher cost procurement options given the small volume of industrial load served.
- Since 2007, electric power sector PA annual average prices have decreased the greatest amount on a percentage and unit cost basis, at 79% valued at $7.32/Mcf.

Percent Change in Prices ($/Mcf) to PA Sectors, Comparing 1997, 2007 to 2016 in Real Terms		
	2016 % Change in Real Terms	
	From 1997	From 2007
Citygate	-39%	-66%
Residential (NGDC-only)*	-18%	-40%
Industrial (NGDC-only)	9%	-39%
Commercial (NGDC-only)*	-26%	-45%
Electric Power	-57%	-79%

***Table 9:** This table uses data from Table 8 to calculate percentage change in price in real terms.*

U.S. AND PA CITYGATE PRICES

Figure 19 shows U.S. and Pennsylvania annual average citygate prices, representing all the volumes of gas purchased by NGDCs for sale and delivery to consumers in their applicable service territories. These prices represent the total cost (e.g. acquisition, storage, transport, etc.) paid by NGDCs for gas received at the physical point where the gas is transferred from the pipeline company or transmission system to the distribution system.

The following observations from *Figure 19* and *Table 10* can be made:

- **Pennsylvania Has Higher Citygate Prices.** PA prices have historically been higher than national prices, with the largest annual differential of $1.69 observed in 2006.
- **Prices Converging.** PA prices are converging to national price averages. The differential has generally narrowed since 2009 and was almost zero in 2016.

U.S. and PA Annual Averge Citygate Prices ($/Mcf) and Differentials in Nominal Terms						
	US		PA		Differential	
1997	$	3.66	$	4.09	$	0.43
2007	$	8.16	$	9.35	$	1.19
2016	$	3.71	$	3.72	$	0.01

Table 10: *This table calculates price differentials between U.S. and PA average annual citygate prices using data from Figure 19.*

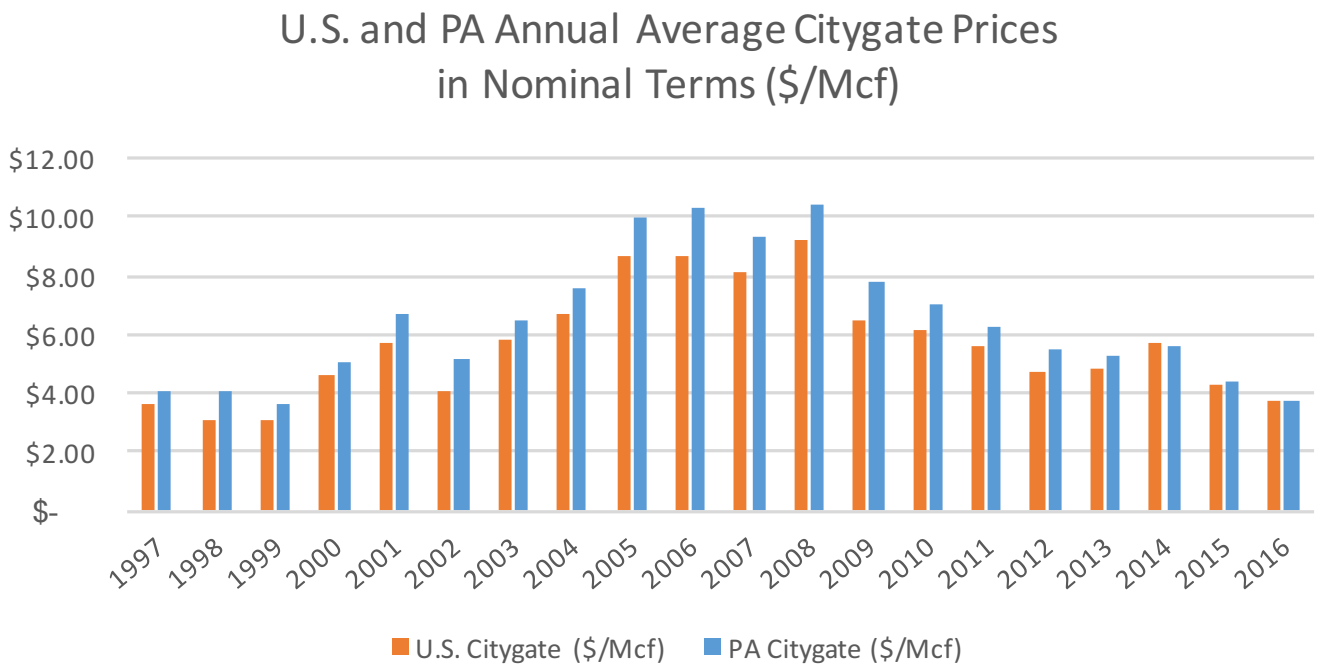

Figure 19*: U.S. and PA data for this figure was taken from the U.S. EIA's natural gas annual databases (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017).*

U.S. AND PA ELECTRIC POWER SECTOR PRICES

The prices reported in this subsection are the total delivered price of natural gas paid by the power plant, as reported to FERC and EIA.

The following observations can be made by examining the data in *Figure 20* and *Table 11*:

- **Historic Pennsylvania Prices Generally Higher than Average.** PA electric power prices fluctuated above and below the national average between 1997 and 2016, but on average were above the national average. The highest differential of $1.83 was observed in 2005.
- **Prices Converging, PA Price Now Discounted.** Since 2009, PA prices have been at or below national average prices with the lowest differential of $1.04 observed in 2016.

U.S. and PA Average Annual Delivered Electric Power Sector Prices ($/Mcf) and Differentials in Nominal Terms						
	US		PA		Differential	
1997	$	2.78	$	3.02	$	0.24
2007	$	7.31	$	8.01	$	0.70
2016	$	2.99	$	1.95	$	(1.04)

Table 11: *This table uses the data in Figure 20 to calculate differentials between U.S. and PA prices.*

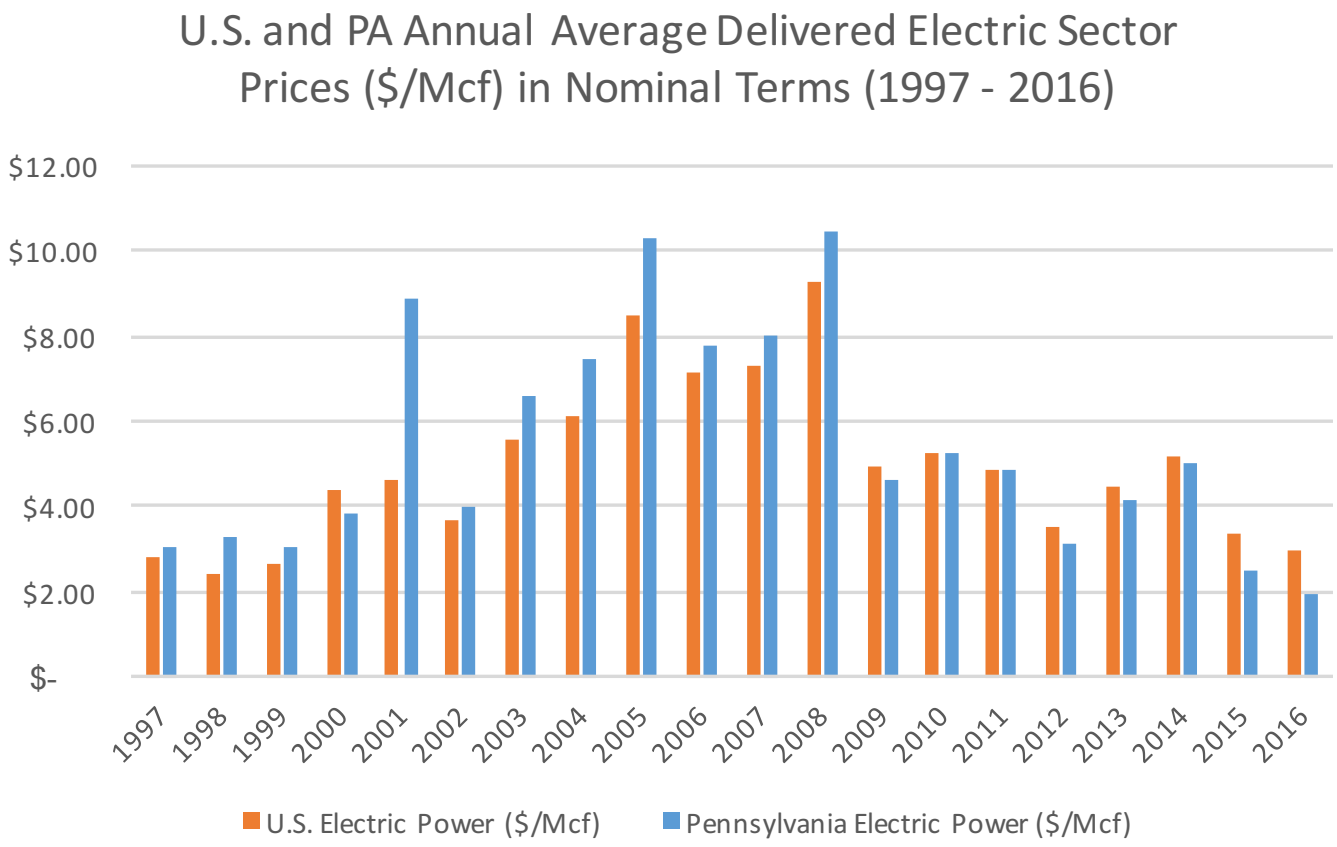

Figure 20*: U.S. and PA data for Figure 20 was taken from U.S. EIA natural gas annual database, pulling from Federal Energy Regulatory Commission (FERC) survey data (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017)*

U.S. AND PA RESIDENTIAL RETAIL PRICES

Figure 21 compares U.S. and PA average annual residential retail natural gas prices in nominal terms and identifies the percent of total residential gas volumes sales associated with calculation of that price. Between 2002 and 2010, the U.S. EIA collected Form 910 residential pricing data for Pennsylvania (and selected other states) from competitive natural gas suppliers, as well as pricing data from NGDCs. As a result, the Pennsylvania pricing data from 2002 through 2010 should accurately represent the combination of default and competitive prices. Pennsylvania pricing data before 2002 and after 2010 represents the price of only the NGDC-sold portion of total gas delivered to residential customers. Pricing for the remainder of gas volumes sold was determined by competitive natural gas suppliers, for which pricing data is not available. For example, in 2014, the $11.44/Mcf Pennsylvania retail price of gas to the residential sector was associated with 86.2% of the total volume of gas delivered to the residential sector. This represents the volume of total gas PA NGDCs sold to residential customers. The remaining 13.8% of residential gas volumes sold were supplied by third party, competitive natural gas suppliers, for which price data is not available.

Although data limitations exist, conclusions can be gleaned from *Figure 21* and *Table 12*:

- **Pennsylvania Has Higher Residential Prices.** Average annual residential retail prices were consistently higher than national averages. EIA's residential gas price data for the U.S. and PA goes back to 1967. During this time, PA's average annual residential retail price has always been higher than the national average.
- **Prices Converging, Closer than Ever.** However, the Pennsylvania to U.S. differential is narrowing from a high of $2.72/Mcf in 2006, down to just $0.13/Mcf in 2016. The $0.13/Mcf differential is the lowest observed across EIA's data spanning back to 1978.
- **Comparing Shopping Volumes.** Pennsylvania could be expected to have a higher percent volume of competitively supplied residential gas deliveries compared to the national average, since not all states have residential natural gas choice programs.[11] Excluding data from 2002 through 2010, it does seem that Pennsylvania has a greater percentage of residential shopping gas volumes than the national average.

U.S. and PA Average Annual Residential Prices ($/Mcf) and Differentials in Nominal Terms						
	US		PA		Differential	
1997	$	6.94	$	8.33	$	1.39
2007	$	13.08	$	14.66	$	1.58
2016	$	10.05	$	10.18	$	0.13

Table 12: *This table uses data from Figure 21 to calculate differentials between U.S. and PA prices.*

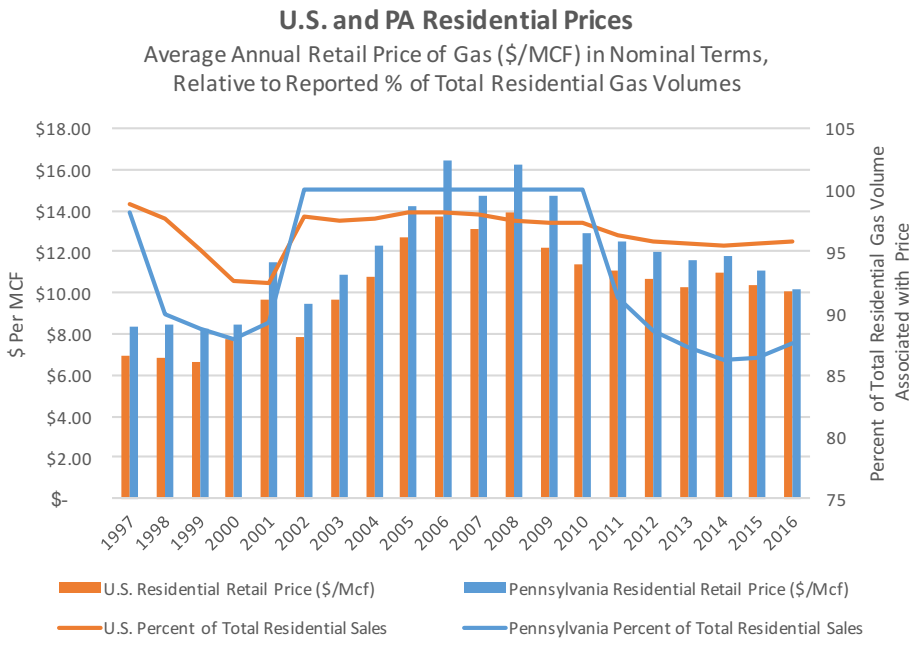

Figure 21*: Between 2002 and 2010, U.S. EIA collected Pennsylvania marketer and NGDC pricing data for natural gas sold to the residential sector. Therefore, for these years, the reported price represents 100% of total volumes delivered to Pennsylvania's residential customers. PA residential price and volume data for Figure 21 were taken from the U.S. EIA's natural gas summary annual data for Pennsylvania (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017). U.S. residential price and volume data for this figure were taken from the U.S. EIA's natural gas summary annual national data (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017).*

[11] For more information about residential retail natural gas choice programs, visit the U.S. EIA's webpage on "How customer choice programs work", (February 7, 2017) located at https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_customer_choice

U.S. AND PA COMMERCIAL AND INDUSTRIAL CUSTOMER PRICING

Commercial and industrial customers can procure gas supply from their local natural gas distribution companies (NGDCs) or competitively through third-party marketers. This section reviews pricing data for these procurement options.

The NGDC-only data provided by the EIA cannot be meaningfully extrapolated to provide market-wide insights on pricing to industrial or commercial gas users (as most industrial and many commercial customers purchase gas from third-party competitive suppliers).

Since pricing data for third-party competitive supply contracts is not publicly available, a proxy pricing approach is introduced that attempts to provide pricing guidance for the bulk of industrial customers who purchase their gas from these suppliers.

U.S. and PA Default Commercial and Industrial Pricing

Figures 22 and 23 identify U.S. and Pennsylvania annual average retail prices in nominal terms for natural gas supply and delivery to industrial and commercial customers, respectively. These data only account for natural gas that was purchased from and delivered by the NGDC. As shown on the right axis of these graphs and in *Section 3*, this represents a very small volume of gas (<5%) delivered to Pennsylvania's industrial customers, and between 20% to 60% of gas sold to Pennsylvania's commercial customers.

Competitive Commercial and Industrial Pricing

Almost all industrial customers and most commercial customers procure natural gas from third-party marketers who coordinate the process of bringing gas from the wellhead to the end user. Marketers typically offer more competitive pricing compared to NGDCs. However, data about marketer-to-customer contracting prices and terms are not publicly available.

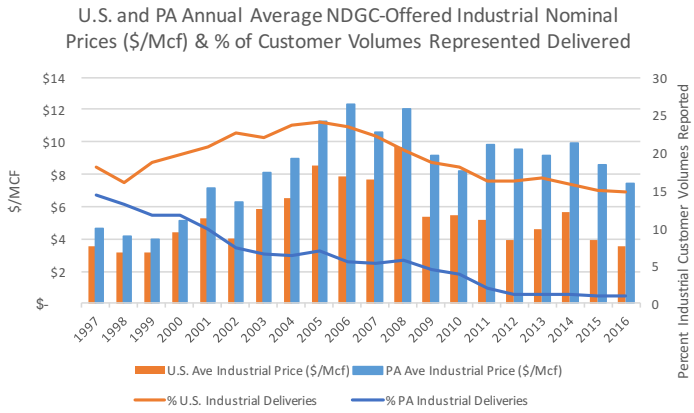

***Figure 22**: NGDC industrial pricing data for the U.S. and PA used for these figures were taken from the U.S. EIA's databases (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017). Data for the percent of total industrial volumes delivered that are associated with the pricing data were also taken from the U.S. EIA databases (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017).*

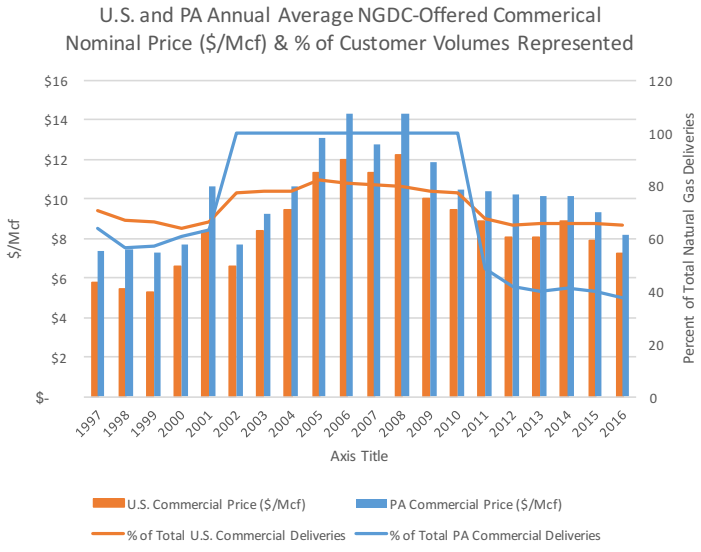

***Figure 23**: Between 2002 and 2010, U.S. EIA collected Pennsylvania marketer and NGDC pricing data for natural gas sold to the commercial sector. Therefore, for these years, the reported price represents 100% of total volumes delivered to Pennsylvania's commercial customers. NGDC commercial pricing data for the U.S. and PA used for these figures were taken from the U.S. EIA's databases (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017). Data for the percent of total commercial volumes delivered that are associated with the pricing data were also taken from the U.S. EIA databases (U.S. Energy Information Administration 2017) (U.S. Energy Information Administration 2017).*

This section constructs a proxy price to determine how shale gas has impacted pricing to these customer classes. The following background is helpful in understanding how the proxy price was constructed and why it is an appropriate approximation. The proxy pricing approach has limitations because it excludes costs to transport gas from the regional hub to the end-use customer's meter, and it does not incorporate a weighted average. A weighted average would adjust pricing to account for differences in volumes being moved through each hub.

Basics of Commercial and Industrial Competitive Gas Pricing

Marketers offer a variety of products that range from simple fixed price contracts for physical gas supply to more sophisticated financial products to hedge against financial risk. Physical gas supply contracts often bundle the gas commodity along with certain transportation services including pipeline charges, storage, scheduling, and balancing. Physical contracts also differ based on the type of delivery service, ranging from firm pipeline delivery service that is guaranteed, to interruptible delivery service that is not guaranteed.[12]

In order to minimize financial risk, large gas customers may seek to lock-in a price for a certain baseload amount of physical gas delivery for the upcoming month (called a prompt month) or other future periods, based on expected demand. Any additional supply needed can be procured from the spot market, while unused volumes can be stored or sold.

Gas can be procured on the spot market for delivery the same or next day. Gas can also be procured for delivery sometime in the future, for example the prompt month out to several years. The delivery period for a forward contract can vary, but commonly is structured as monthly, seasonal, quarterly or on annual periods. When a contract packages supply for more than one sequential month, it is called a "strip". The seasonal summer gas strip is from April to October and the winter strip is from November through March.

Most commonly, commercial and industrial customers are likely to choose fixed price or indexed price contracts for physical gas. A very basic summary of these contract structures is included below:

- **Fixed Price Contracts–** a customer issues a request for proposal to several marketers seeking a fixed price contract for a given term (e.g. one year), and will execute with the marketer that can deliver the most competitive price given the specified terms and conditions (including delivery type). With these contracts, the customer has a great degree of certainty with respect to gas costs. However, the customer risks overpaying if gas prices in the market decrease. On the other hand, if market prices increase, the customer saves as a result of locking in the fixed price.
- **Indexed Price –** Index prices are based on a subset of recently executed fixed price transactions that are reported to various price reporting companies (e.g. Platts Gas Daily, NGI, Argus) that convert these data into locational price indices. These indices serve as a mechanism to determine price for customers that choose not to enter into fixed price contracts. There are daily and monthly index prices. Index contract pricing is based off the floating index price, plus an adder to reflect transportation-related costs to deliver to the customer (excluding distribution costs that accrue to the NGDC, if applicable). Index-based pricing, combined with the use of financial products, can help customers manage risks associated with overpaying for gas (i.e. paying above the market price). On the other hand, there may be less certainty about gas costs for a customer's pro-forma budgeting.

Financial products are available to large gas-use customers to help manage price risk, especially related to index-price contracts. There are many financial products available to customers to manage risk, for example, futures, swaps, and options. For purposes of this report, only natural gas futures contracts will be discussed. The price for natural gas futures contracts are based on the New York Mercantile Exchange (NYMEX)[13] monthly pricing at the Henry Hub, then a locational differential (or basis adjustment) is added to reflect transportation costs to the applicable regional gas hub. A futures contract gives the customer the contractual right to buy or sell a standard amount of gas (i.e. 10,000 MMBTU) at a fixed price at specific delivery period in the future. A customer may purchase a futures contract to hedge against increased costs related to their indexed price contract. Futures contracts rarely result in delivery of physical products, and are mostly used as a financial risk management tool.

[12] There are a variety of pipeline services within the boundaries of firm and interruptible. For example, the highest level of firm service is "no-notice" service, followed by primary and secondary firm service, then interruptible.

[13] NYMEX is an exchange platform for commodity futures owned and operated by CME Group of Chicago. For more information visit, http://www.cmegroup.com/company/nymex.html/

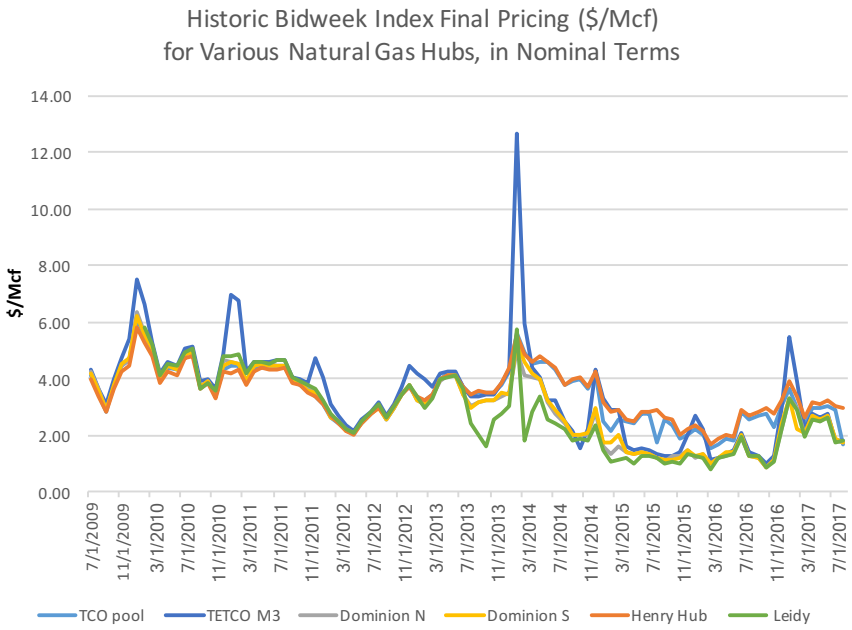

***Figure 25**: The price spike in early 2014 is related to the January polar vortex. TETCO M3's January 2014 price spike was more pronounced, likely a result of exposure to strong demand from PJM power generators and northeast markets, as well as compressor station outages and well head freeze-offs that impacted the Texas Eastern pipeline supplying TETCO M3 (Morgan Stanley 2014). This figure uses historic bidweek pricing data from July 2009 through August 2017 from SNL Energy for the Henry Hub and five Pennsylvania-area natural gas hubs, including: Dominion North, Dominion South, Leidy, TETCO M3 and TCO Pool (SNL Energy 2017).*

Proxy Pricing Approach

Commercial and industrial customer natural gas supply contracting data is not publicly available. Therefore, in order to determine how Pennsylvania shale gas has impacted pricing to these classes, a proxy price was developed to approximate these impacts.

The proxy uses available historic pricing data from July 2009 through August 2017 from SNL Energy for five Pennsylvania-area natural gas hubs, including: Dominion North, Dominion South, Leidy, TETCO M3 and TCO Pool (SNL Energy 2017). *Figure 24* shows the approximate location of various Pennsylvania-area natural gas hubs.

Although transactions for physical gas supply can happen any time of the month, the majority of physical purchasing and selling of gas for the next month's delivery happens during the last five business days of the month, known as "bidweek". As a result, the bidweek final index price data was chosen for the applicable Pennsylvania area hubs. *Figure 25* shows historic bidweek index final pricing for various natural gas hubs in the Pennsylvania area, as well as pricing for the Henry Hub from July 2009 through August 2017. Bidweek data back to 2007 was not available. The Henry Hub is the pricing benchmark for NYMEX futures and serves as the national benchmark for gas pricing.

***Figure 24**: This map of various Pennsylvania area natural gas hubs was reproduced from SNL Energy maps (SNL Energy 2017)*

Figure 26 plots the bidweek index final price for the Henry Hub against the straight line (i.e. unweighted) average of the five selected Pennsylvania area hubs, herein referred to as the "PA Hubs Average". This figure also displays the PA Hubs Average price differential from the Henry Hub price. Hub-specific data on the volumes associated with the bidweek pricing information was not consistently available. Ideally, a weighted average price would have been constructed.

- Starting around 2013, the PA Hubs Average price began to consistently drop below the Henry Hub price, creating a significant savings for commercial and industrial customers compared to the national benchmark.
- Comparing 2010 to 2016, the annual average price at the Henry Hub dropped by 44%, while annual average prices at the PA Hubs Average dropped by 65.8%.
- On average, over the entire time period examined (July 2009 through August 2017), there was a $0.309/Mcf discount for the PA Hubs Average compared to the Henry Hub.

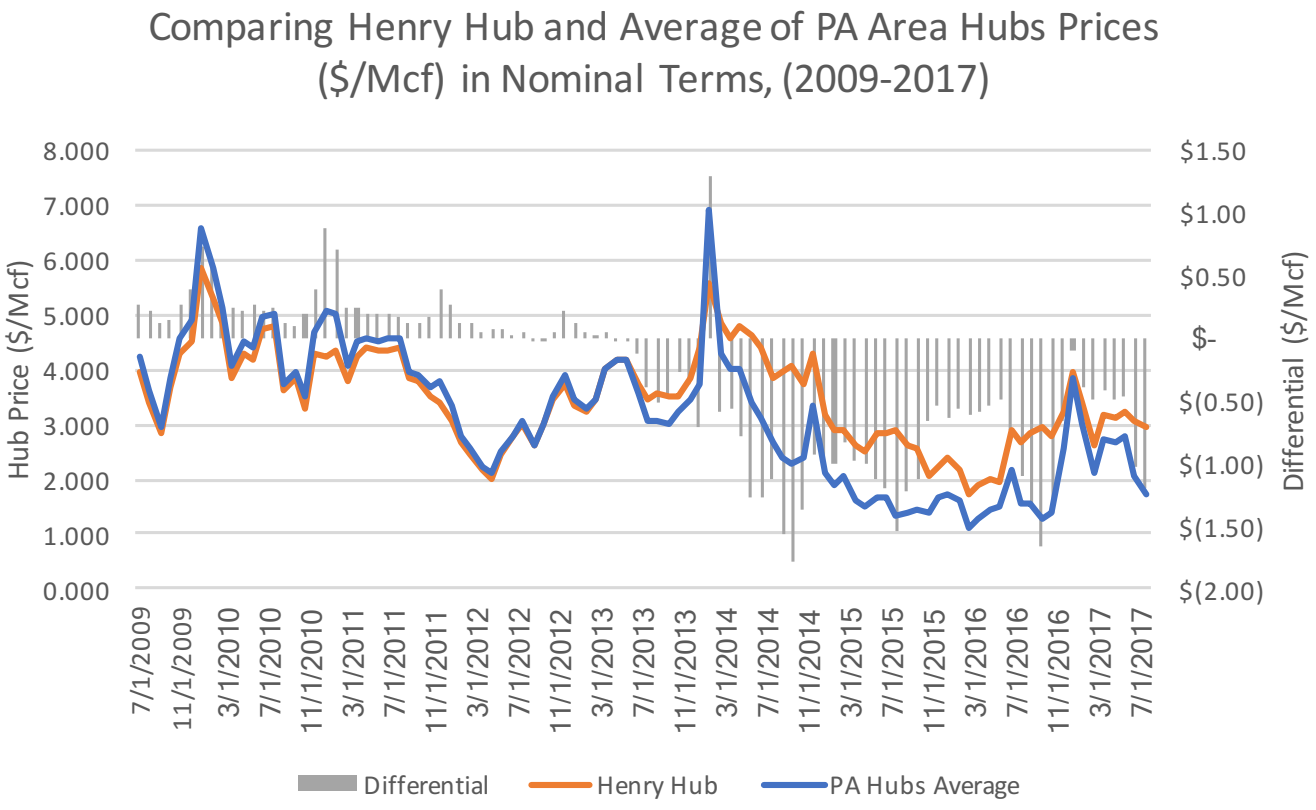

***Figure 26**: The price spike observed in early 2014 is associated with the January 2014 polar vortex that caused regional temperatures to plummet, increasing gas demand. This figure uses data from Figure 25 to calculate differentials.*

Figures 27 and 28 create a proxy for and compare Henry Hub and the PA Hubs Average winter (November through March) and summer (April through October) strip prices. This is important to better understand seasonal fluctuations in natural gas prices, as demand for gas typically increases in the winter as a result of increased space heating needs.

- Beginning in 2013, the PA discount to the Henry Hub is apparent in both summer and winter strips.
- On average, over the entire time period examined, both the PA Hubs Average summer and winter strip prices were lower than the Henry Hub strips. The $0.442/Mcf discount for PA Hubs Average summer strips is greater than the $0.143/Mcf PA Hubs Average winter strip discount to Henry Hub.

Data on volumes associated with these bidweek index final prices was not consistently available. Ideally, this analysis would have incorporated a weighted average to better understand how volumes differences at hubs impact statewide average pricing.

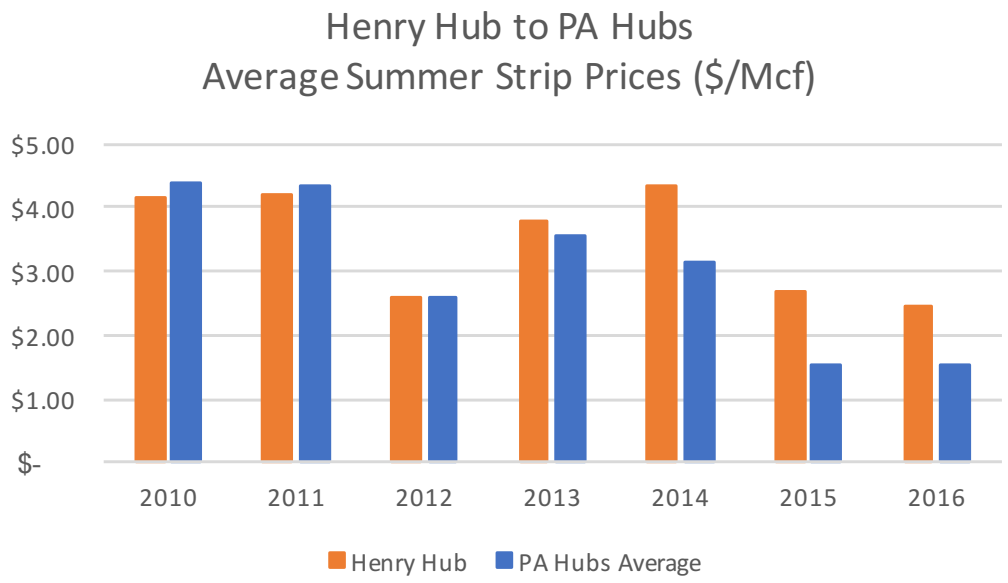

***Figure 27**: Winter strips are developed using November through March data from Figure 25. All prices are in nominal terms.*

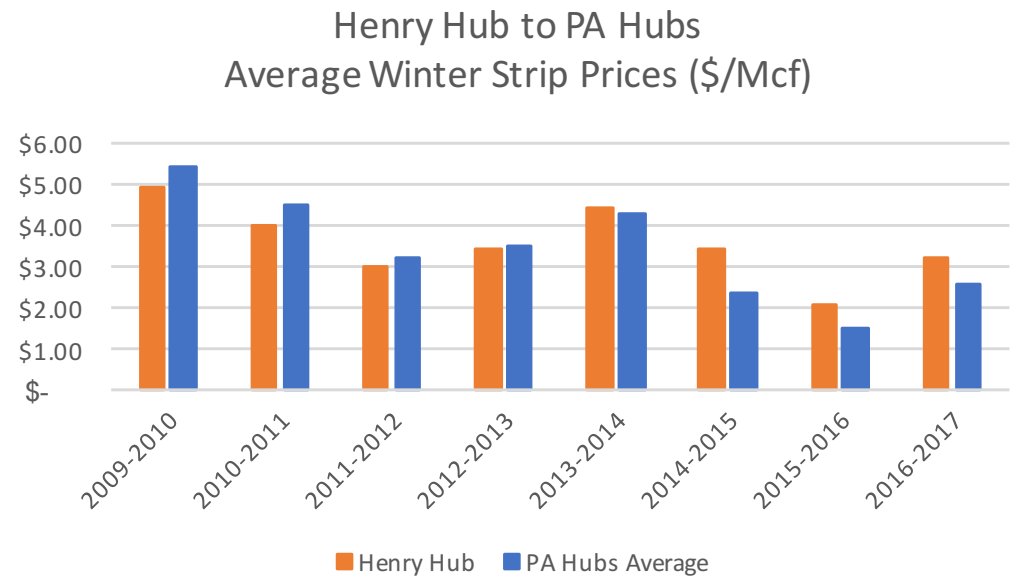

***Figure 28**: Summer strips are developed using April through October data from Figure 25. All prices are in nominal terms.*

Limitations of Proxy Price Approach

In absence of access to privately held data, the PA Hubs Average price is a useful proxy to determine how shale gas has impacted Pennsylvania commercial and industrial customer gas costs. However, the PA Hubs Average is flawed in at least two primary ways:

- **Excludes Delivery Costs from Hub to Meter.** The PA Hubs Average understates the retail cost of gas to these customer classes because it only includes commodity and transportation costs associated with bringing gas to the five Pennsylvania-area hubs. It does not include the additional costs of transporting the gas from the hub to the customer's meter. These cost may include intra-state pipeline charges and/or NGDC-delivery charges, depending on if the customer is in front of or behind the citygate. A customer behind the NGDC's citygate – typically a commercial customer - may incur additional intra-state pipeline charges, plus a "transportation-only" delivery fee from the NGDC. A customer that is in front of the citygate (also called a "bypass" customers) may only incur intra-state pipeline charges. Many industrial customers are bypass customers.
  - In theory, a more accurate approach to proxy pricing would be to include an adder for transport and delivery charges for transport-only and bypass customers to the PA Hubs Average. This would require access to enough data to develop a statewide average transport-only cost and bypass cost. Limited data is available to determine the percentage of commercial or industrial customers that are transportation-only or bypass customers. In addition, data is not available for bypass customer fees, which would include a breakdown of the more expensive firm transport and less expensive interruptible transport charges, and other potentially applicable charges (e.g. overruns, reservation, storage, etc.). Lastly, data is available from the PA PUC for industrial and commercial customer NGDC delivery charges, but these data are limited to default service rates rather than transportation-only services applicable to commercial and industrial customers that procure gas from third parties. These various limitations prevented improvement to the proxy pricing approach.
- **Excludes Weighted Average.** The PA Hubs Average is a straight line average approach that does not account for the pricing effects of gas volume differences travelling through the various hubs. In a weighted average, the overall pricing impacts from a hub that moves a greater total volume of gas would be stronger than the pricing impacts from a hub that moves a comparatively smaller volume of gas. However, bidweek index volume data was inconsistently available for the applicable hubs, preventing construction of a weighted average.

The PA Hubs Average is an imperfect approach to approximating the retail pricing impacts of shale gas to Pennsylvania commercial and industrial customers that shop, as it fails to incorporate important transportation and delivery charges, and is not a weighted average. As such, it overstates the cost savings to these customer classes. However, the PA Hubs Average is an improvement upon available EIA data that is limited to NGDC-offered gas, which represents a small volume of commercial and industrial customer purchases and overstates actual costs incurred on average to these classes.

SECTION VI
NATURAL GAS DISTRIBUTION COMPANY COMMODITY COSTS

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THIS SECTION REVIEWS HISTORIC PURCHASED GAS COST (PGC) RATES FOR PENNSYLVANIA'S TEN LARGEST NATURAL GAS DISTRIBUTION COMPANIES (NGDC).

Pennsylvania PGC rate policy helps:

- Ensure applicable NGDCs recover 100% of their prudently incurred gas costs.
- Increases public transparency on NGDC gas procurement, helping the PA PUC ensure gas is being procured on a least-cost basis.
- Enables the potential for quarterly (or even monthly) adjustments to the annual PGC rate to reflect increases or decreases in gas costs.
- Helps smooth rate impacts from gas commodity price volatility for consumers.

Per PA Title 66 Section 1307 (f) (established by PA Act 74 of 1984), NGDCs that annually generate over $40 million in revenues may (and in certain circumstances, shall) submit a PGC rate filing reflecting actual or expected increases or decreases in natural gas costs.[14] Quarterly filings can be submitted to the PA PUC reconciling (including over or under collections) and recalculating actual gas costs for the prior quarter, compared to the projected costs in the annual PGC rate filing. If approved by the PA PUC, an increase or decrease the PGC rate can be implemented through an automatic adjustment mechanism. The PGC rate applies to certain customer rate classes and schedules, as identified in each NGDC's tariff. In simplistic terms, the annual PGC rate is generally computed through a calculation of (C-E) ÷ S, as applied to relevant rate schedules, where:

- C equals the projected cost of natural gas
- E equals experienced (i.e. past) net over (under) collections
- S equals the projected volume of natural gas to be sold

Approval of the PGC rate and adjustments are conditioned upon the commission finding that the NGDC has pursued a least-cost fuel procurement strategy. PA Title 66 Section 1318 sets forth specific criteria the PA PUC must consider in determining if the NGDC has pursued a least-cost fuel procurement strategy. A positive determination must be made for at least the following criteria:

- Has the NGDC vigorously represented ratepayer interests before the Federal Energy Regulatory Commission (FERC)?
- Has the NGDC taken all prudent steps to negotiate favorable gas supply contracts and release the utility from existing contracts that might be unfavorable to ratepayers?
- Has the utility taken prudent steps to obtain lower cost gas supplies on both a short- and long-term basis, both within and outside of the Commonwealth, including the use of gas transportation agreements with pipelines and other NGDCs?
- Has the utility withheld gas from the market that should have been used as part of a least-cost procurement strategy?

[14] Section 1307 (h) defines "natural gas costs" to include the direct costs paid by a natural gas distribution company for the purchase and the delivery of natural gas to its system in order to supply its customers. Such costs may include costs paid under agreements to purchase natural gas from sellers; costs paid for transporting natural gas to its system; costs paid for natural gas storage service from others, including the costs of injecting and withdrawing natural gas from storage; all charges, fees, taxes and rates paid in connection with such purchases, pipeline gathering, storage and transportation; and costs paid for employing futures, options and other risk management tools.

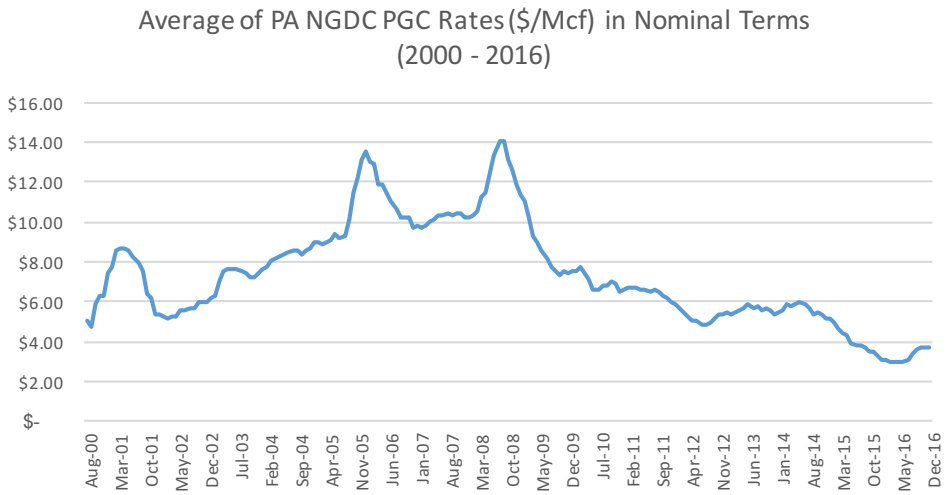

***Figure 29**: PGC rates were compiled from PA PUC data on a quarterly basis from 2000 (staring in August through December) through 2017 (ending in May through June) (Pennsylvania Public Utility Commission n.d.).*

- Has the utility contracted with affiliate interests for gas supply? If so, were these contracts consistent with a least-cost procurement strategy?[15]

PA Title 66 Section 1317 outlines specific information NGDCs must file with the PA PUC to increase transparency and aid the commission in its least-cost fuel procurement strategy determination.[16] Certain documentation is required to be made publicly available, and a hearing must be held on the PGC rate request. The PA PUC's regulations under 52 Pa. Code § 53.64 provide more specific details on the PGC rate filing and commission determination requirements.[17]

PA NGDC PURCHASED GAS COST RATES

PGC rates were compiled from PA PUC data on a quarterly basis from 2000 (staring in August through December) through 2017 (ending in May through June) (Pennsylvania Public Utility Commission n.d.). A straight line (i.e. unweighted) average rate was calculated across the ten NGDCs for each quarter, represented in *Figure 29* as the average rate.

It should be noted that PA NGDCs pass on wholesale gas costs to their customers on a dollar for dollar basis with no profit markup. Thus, as wholesale gas prices have fallen across Pennsylvania, those price reductions have flowed through to NGDC default service customers on a timely and consistent basis via implementation of the Section 1307f PGC rate process.

Most PA NGDCs report PGC rates on a dollar per one thousand cubic feet (Mcf) basis, but some report on a dollar per dekatherm (Dth) basis. Conversions for the following years were implemented using EIA conversion rates for $ per therms to $ per Mcf, assuming a heat content of natural gas of 1,037 Btu per cubic foot (U.S. Energy Information Administration 2017).

- PGC rate data for UGI Central Penn was reported on a Dth basis from the December 2000 through September 2014 reporting quarters, and on an Mcf basis thereafter.
- PGC rate data for Columbia was report on a Mcf basis from the October 2000–July 2012 reporting quarters, and reported on a Dth basis thereafter.

Figure 29 is a graphic representation of the straight line (i.e. unweighted) average of all ten large PA NGDC's PGC annual rates and quarterly adjustments from 2000 through 2016.

To examine the pricing impacts associated with differences in the number of NGDC customers, a weighted annual average PGC rate for Pennsylvania was developed. *Figure 30* compares the statewide residential weighted annual average PGC rate to the straight line average PGC rate, showing there is little difference in rate amounts. Since there was limited separation between the weighted and straight line averages, the straight line average was used in subsequent PGC rate analysis.

[15] More information on PA Title 66 Section 1318 can be found at http://www.legis.state.pa.us/cfdocs/legis/LI/consCheck.cfm?txtType=HTM&ttl=66&div=0&chpt=13&sctn=18&subsctn=0

[16] More inflation on PA Title 66 Section 1317 can be found at http://www.legis.state.pa.us/cfdocs/legis/LI/consCheck.cfm?txtType=HTM&ttl=66&div=0&chpt=13&sctn=17&subsctn=0

[17] More information on 52 Pa. Code § 53.64 can be found at http://www.pacode.com/secure/data/052/chapter53/s53.64.html

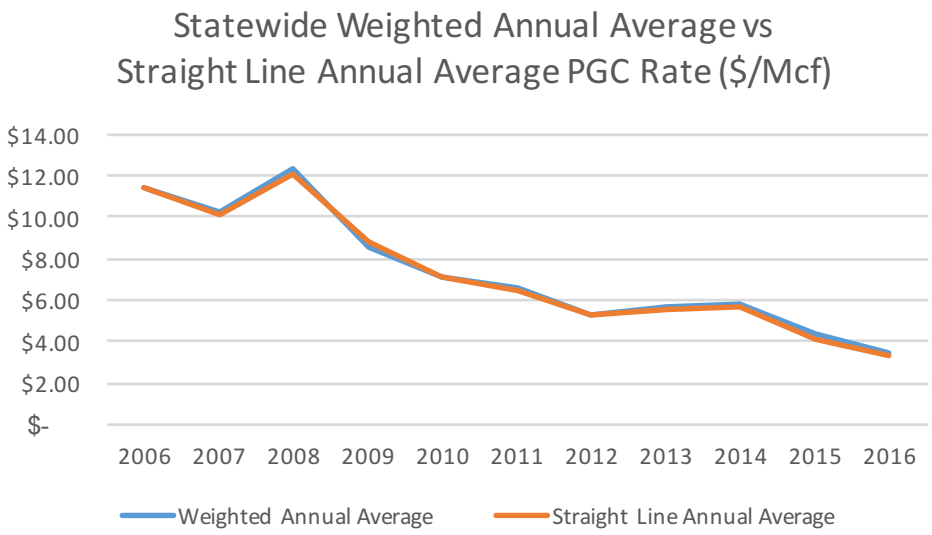

***Figure 30**: The annual number of total residential customers for each NGDC from 2007 through 2016 was compiled from the PA PUC's Rate Comparison Reports to use for the weighting (Pennyslvania Public Utility Commission 2006 - 2017). For simplicity, only the number of residential customers were used to calculate the weighted average because the PGC rate applies only to customer that purchase gas from the NGDC. Almost all Pennsylvania industrial and many commercial customers purchase gas from third party marketers and only take delivery service from the NGDC, whereas the majority of residential consumers purchase gas from the NGDC.*

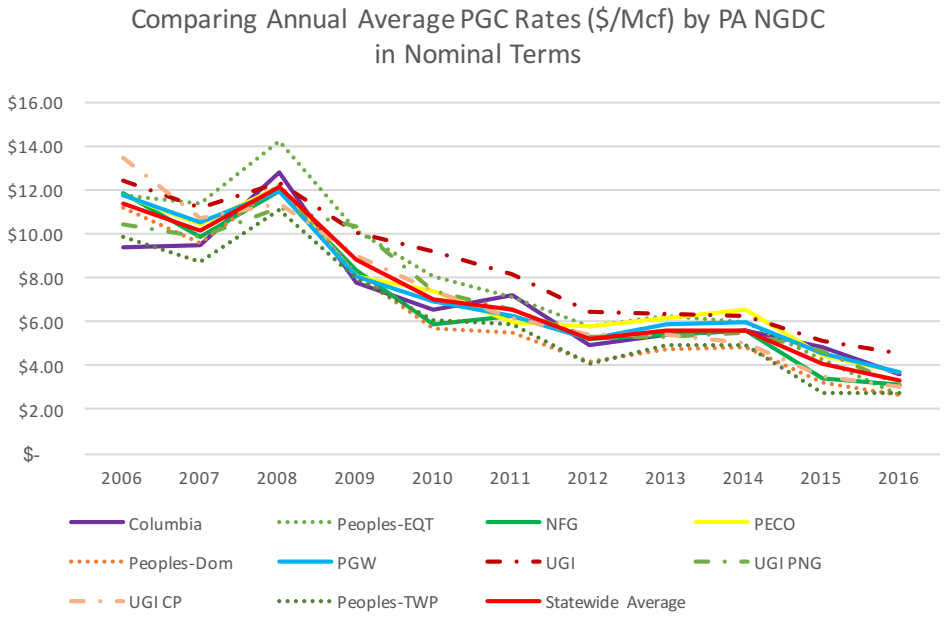

***Figure 31**: Data for Figure 31 was taken from PA PUC data on PGC rates and adjustments (Pennsylvania Public Utility Commission n.d.).*

Comparing PGC Price ($/Mcf) Changes in Real Terms				
	2007		2016	Comparing Real Terms
	Nominal	Real		2007 - 2016
Annual Average PA PGC	$ 10.16	$ 11.76	$ 3.28	-72%

***Table 13**: This table uses the statewide straight line annual average PGC rate data from Figure 30 and adjusts for inflation using the CPI-U (U.S. Bureau of Labor and Statistics 2016).*

Table 13 adjusts the nominal statewide straight line average annual 2007 PGC rate into real 2016 terms using CPI-U data, in order to compare it to the straight line average annual 2016 PGC rate. In real terms, there was a 72% decrease in the statewide annual average PGC rate between 2007 and 2016.

Figure 31 shows average annual PGC rates over time for each NGDC, as well as the statewide straight line annual average PGC rate.

Appendix C includes graphs for each PA NGDC showing the quarterly differential between the NGDC's PGC rate and the statewide straight line average PGC rate. Quarterly differentials for each NDGC were averaged over the entire time period where data was available (2000 – 2017) in order to determine if the NGDC's rate tended to be above or below the statewide average PGC rate over a long-term period.

Lower Than Average PGC Rates. Six NGDCs had negative long-term differentials, indicating lower than statewide average costs.

- Peoples - TWP ($1.0571/Mcf)
- Peoples - Dom ($0.5194/Mcf)
- Columbia ($0.1381/Mcf)
- UGI Penn ($0.0961/Mcf)
- UGI Central Penn ($0.0899/Mcf)
- NFG (0.0808/Mcf)

Higher Than Average PGC Rates. Four NGDCs had positive long-term differentials, indicating higher than statewide average costs.

- UGI $0.89/Mcf
- Peoples - Equitable $0.7334/Mcf
- PGW $0.1962/Mcf
- PECO $0.1746/Mcf

Recall the PGC rate includes costs to procure and transport natural gas to the NGDC's citygate. Given that the majority of gas hub infrastructure is located in southwestern Pennsylvania, it was generally expected that eastern NGDC's may have higher PGC rates related to incrementally higher pipeline transportation cost from hub to citygate. This could perhaps explain UGI, PGW and PECO's relatively higher than average PGC rates. However, this would not offer insights into why Peoples-Equitable has higher than average rates. More research is needed to understand what is driving Peoples-Equitable higher than average PGC rates, especially given the NGDC's location to gas hubs and in-state gas production.

SECTION VII
NATURAL GAS DISTRIBUTION COMPANY DISTRIBUTION COSTS

Christina Simeone, Oct 27, 2017 kleinmanenergy.upenn.edu

DATA FROM THE PA PUC'S RATE COMPARISON REPORTS BETWEEN 2006 AND 2017 WERE USED TO IDENTIFY CHANGES IN NATURAL GAS DISTRIBUTION CHARGES OVER TIME (Pennyslvania Public Utility Commission 2006 - 2017). The Rate Comparison Reports collect monthly bill rate information from NGDC's as of January 31st of each year. All rates are associated with default distribution service. Customers that procure gas from third party competitive suppliers may be subject to transportation rates (for delivery service only) by the local NGDC.

In order to provide an apples-to-apples comparison in the Rate Comparisons Reports across NGDC territories and rate classes, the PA PUC defined customer classes by thresholds below. These thresholds may or may not be consistent with the NGDC's actual tariff class thresholds.

- Residential (non-heating) customer gas use at 2 Mcf per month
- Residential heating customer gas use at 15 Mcf per month
- Small Commercial customer gas use at 150 Mcf per year

NGDC distribution rates for each of these customer classes were compared to the rate of inflation, compounded annual growth rates calculated, and long-term average costs were calculated and compared.

- **Comparing Rate Increases to Rate of Inflation.** NGDC-specific graphs for each customer class are included in *Appendices D through F*, which identify all the charges and credits that make up the distribution portion of the respective customer class' monthly bill. Distribution rates typically included a customer charge, distribution rate, universal service charge, and state tax adjustment surcharge.[18] Additional distribution charges could include customer choice cost, transition cost surcharge, education charge, distribution system improvement charge,[19] or a company-specific charge or credit. Once the different distribution charges were summed, the distribution portion of the monthly bill was plotted against annual inflation using CPI-U data (U.S. Bureau of Labor and Statistics 2016). Although plotting against inflation does not provide insights into utility-specific costs, it is useful to understand how utility costs (via rates) are changing over time.
- **Comparing Compounded Annual Growth Rates.** Comparing CAGRs provides insights into how a utilities' costs are increasing over a specific period of time, on an annual basis. CAGRs can also help identify how rates for different customer classes are changing. Compounding accounts for the interconnected nature of long term utility investments. CAGRs compare annual data, whereas rate information listed applies to monthly bills. For this analysis, it is assumed that the monthly distribution rate is constant through the 12-month year. From these data it is determined that on a statewide basis, residential heating sector distribution rates have risen at the fastest rate.

[18] The State Tax Adjustment Surcharge (STAS) permits utilities to recover portions of the Capital Stock Tax, Corporate Net Income Tax, Gross Receipts Tax, and the Public Utility Realty Tax through a surcharge on rates charged to customers.

[19] The Distribution System Improvement Charge (DSIC) is an automatic adjustment mechanism that allows a utility to recover the reasonable and prudent costs incurred to repair, improve or replace eligible property that is part of the utility's distribution system.

Statewide Average CAGR by Sector (2007 - 2016)	
Residential	2.31%
Residential Heating	2.67%
Small Commercial	1.19%

***Table 14**: This table shows compound annual growth rates for three customer classes. Each NGDC's CAGR for the respective customer class was first established, then a straight line average of these individual CAGRs was calculated for the statewide average.*

- **Comparing Long Term Average and Statewide Costs.** An average monthly distribution cost from 2007 through 2016 was calculated for each NGDC's customer class. These costs were then compared to the NGDC's 2017 monthly distribution costs, as well as a statewide (including all NGDCs) straight line (i.e. unweighted) average distribution cost from 2007–2016. These metrics enable a better comparative understanding of long term NGDC rate trends, as well as how the most recent year of rates measure up.

RESIDENTIAL (2MCF/MONTH) DISTRIBUTION COSTS

Residential (non-heating) natural gas customers are those who have gas fired appliances (e.g. hot water heater, stove), but have a non-gas fuel source for space heating (e.g. electric, oil). *Appendix D* provides NGDC-specific graphs comparing 2016 monthly residential distribution rates to 2007 inflation-adjusted monthly distribution rates. This comparison simply gives an indication of how the NGDC's costs (via rates) are increasing over time, compared to the rate of inflation, as measured through the CPI-U.

- **Costs Rising Faster than Rate of Inflation.** the following NGDCs had monthly rates in 2016 that were higher than 2007 inflation-adjusted rates: Columbia, PECO, Peoples-Dominion, Peoples-TWP, UGI Central Penn, and UGI Penn.
- **Costs Rising at or Below Rate of Inflation.** Peoples-Equitable, NFG, PGW, and UGI 2016 distribution costs increased at or below the rate of inflation.

Table 15 shows CAGRs spanning 2007–2016 for each NGDC. The statewide straight line average CAGR was 2.31% from 2007–2016. Peoples-Equitable, NFG, PGW, UGI, and UGI Penn had lower than average CAGRs for the time period examined.

Figure 32 shows the straight line statewide average (2007–2016) residential distribution cost was $21.00/month (orange line), which serves as a useful comparison point. The blue bars show each NGDC's average distribution rate for the years spanning 2007–2016, in order to get a better sense of costs over time. The green bar shows 2017 residential distribution rates, indicating how more recent costs stack up to longer-term averages.

Monthly Residential (2Mcf/Month) Compound Annual Growth Rate (2007 - 2016)	
Columbia	5.28%
Peoples - Equitable	0.96%
NFG	-0.61%
PECO	4.39%
Peoples - Dom	3.22%
PGW	1.16%
Peoples - TWP	3.78%
UGI	-0.32%
UGI Central Penn	3.22%
UGI Penn	2.02%

***Table 15**: This table uses data from the PA PUC's rate comparison reports to calculate CAGRs (Pennyslvania Public Utility Commission 2006–2017).*

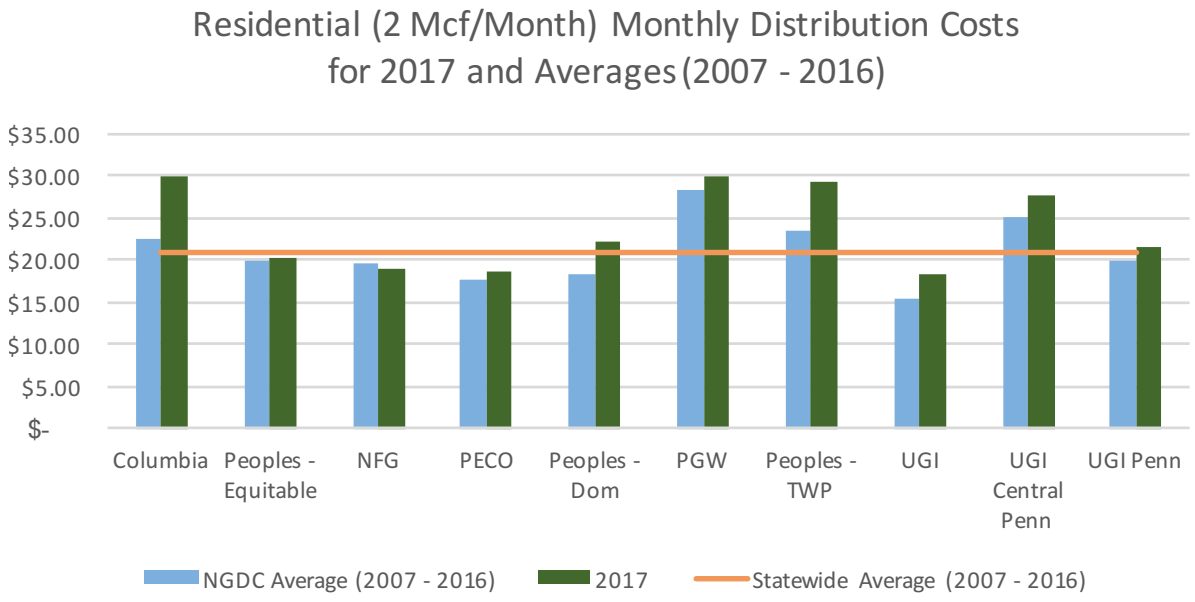

***Figure 32**: Residential (2Mcf/Month) Monthly Distribution Costs and Average Across NGDC, Nominal Terms*

RESIDENTIAL HEATING (15MCF/MONTH) DISTRIBUTION COSTS

Residential heating customers take distribution service for both space heating and gas appliances from the local NGDC. In 2015, approximately 51% of Pennsylvanians used natural gas for home heating, followed 21.6% using electricity, 18.1% using fuel oil, and the remainder using liquefied petroleum gases and other heating sources. Nationally, about 48.6% use natural gas, 37.2% use electricity, 5.6% use fuel oil, and the remainder uses LPG and other sources (U.S. Energy Information Administration 2017).

As shown in *Appendix E*, comparing 2016 monthly residential heating distribution costs to 2007 inflation adjusted monthly distribution costs.

- **Costs Rising Faster than Rate of Inflation** - the following NGDCs had monthly costs that tended to increase greater than the rate of inflation: Columbia, PECO, Peoples – Dominion, Peoples TWP, UGI Central Penn, and UGI Penn.
- **Costs Rising at or Below Rate of Inflation** - Peoples-Equitable, NFG, PGW, and UGI distribution costs increased below the rate of inflation.

Table 16 shows CAGRs spanning 2007–2016, for each NGDC. The statewide straight line average CAGR was 2.67% from 2007–2016. Peoples-Equitable, NFG, PGW, UGI, and UGI Penn all had below average CAGRs.

Figure 33 shows the straight line statewide average (2007–2016) cost was $75.86/month, represented by the orange line. The blue bars show each NGDC's average distribution rate for the years spanning 2007–2016, and the green bar shows 2017 rates.

Monthly Residential Heating (15 Mcf/Month) Compound Annual Growth Rate (2007 - 2016)	
Columbia	5.56%
Peoples - Equitable	0.91%
NFG	-1.45%
PECO	3.15%
Peoples - Dom	3.36%
PGW	1.56%
Peoples - TWP	5.49%
UGI	-0.63%
UGI Central Penn	6.15%
UGI Penn	2.61%

***Table 16**: This table uses data from the PA PUC's rate comparison reports to calculate CAGRs (Pennyslvania Public Utility Commission 2006 - 2017).*

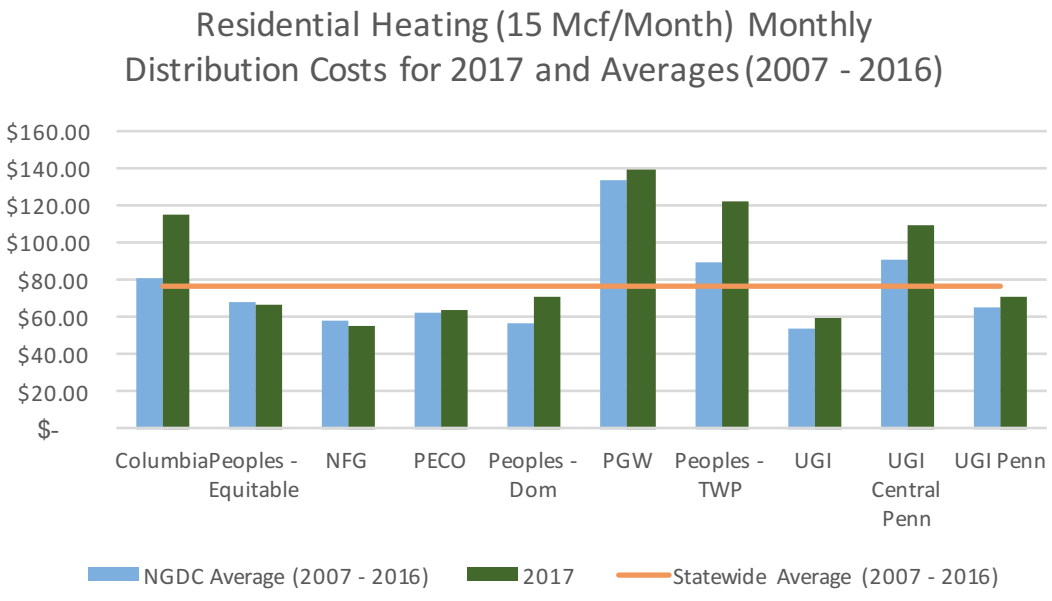

***Figure 33**: Residential Heating (15Mcf/Month) Monthly Distribution Costs and Average Across NGDC, Nominal Terms*

SMALL COMMERCIAL (150 MCF/YEAR) DISTRIBUTION COSTS

As shown in *Appendix F*, comparing 2016 monthly small commercial distribution costs to 2007 inflation-adjusted monthly distribution costs:

- **Costs Rising Faster than Rate of Inflation** - the following NGDCs had monthly costs that tended to increase greater than the rate of inflation: Columbia, PECO, Peoples TWP, and UGI Central Penn.
- **Costs Rising at or Below Rate of Inflation** - Peoples-Equitable, NFG, Peoples-Dominion, PGW, UGI and UGI Penn distribution costs increased at or below the rate of inflation.

Table 17 shows CAGRs spanning 2007–2016, for each NGDC. The statewide straight line average CAGR was 1.19% from 2007–2016. Peoples-Equitable, NFG, Peoples-Dominion, PGW, and UGI all had lower than average CAGRs.

Figure 34 shows the statewide average (2007–2016) cost was $64.50/month, represented by the orange line. The blue bars show each NGDC's average distribution rate for the years spanning 2007–2016, and the green bar shows 2017 rates.

Monthly Small Commercial (150 Mcf/Year) Compound Annual Growth Rate (2007 - 2016)	
Columbia	4.11%
Peoples - Equitable	-0.89%
NFG	-0.28%
PECO	4.43%
Peoples - Dom	-0.22%
PGW	-2.29%
Peoples - TWP	3.46%
UGI	-0.18%
UGI Central Penn	2.10%
UGI Penn	1.62%

***Table 17**: This table uses data from the PA PUC's rate comparison reports to calculate CAGRs (Pennyslvania Public Utility Commission 2006 - 2017).*

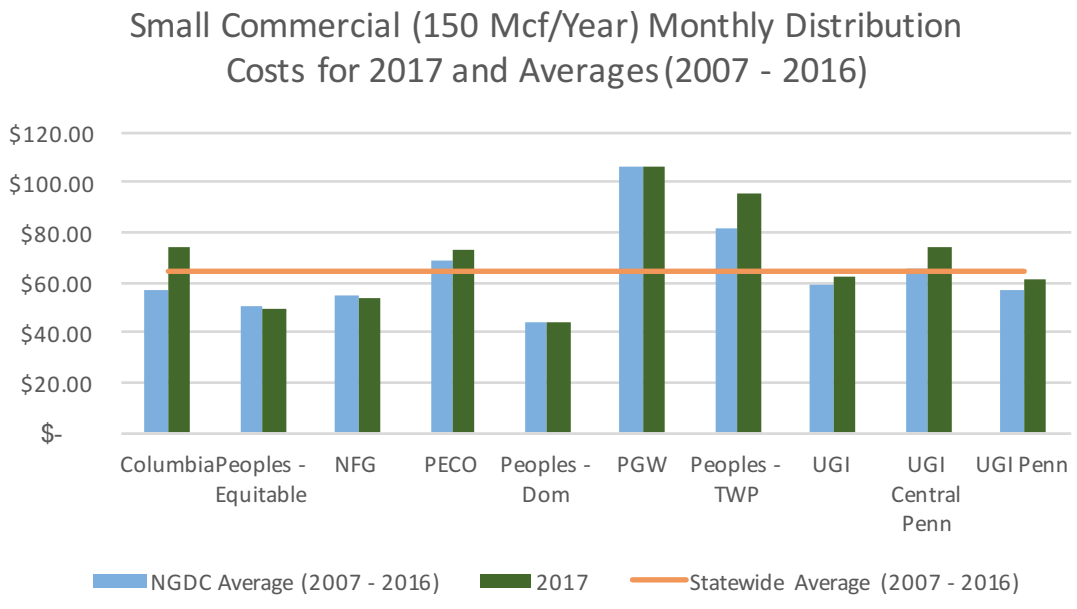

***Figure 34**: Small Commercial (150 Mcf/year) Monthly Distribution Costs and Average Across NGDC, Nominal Terms*

SECTION VIII
UNIVERSAL SERVICE IMPACTS

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WHEN PENNSYLVANIA WAS ESTABLISHING RETAIL ELECTRIC AND NATURAL GAS COMPETITION THERE WERE CONCERNS ABOUT ELECTRIC AND GAS SERVICE BEING UNIVERSALLY AVAILABLE TO ALL CUSTOMERS IN THE STATE, ESPECIALLY FOR LOW-INCOME CUSTOMERS. As a result, "universal service" programs were established that include policies, protections, and services to help low income (and other) customers maintain utility service. Universal service programs and data—which solely impact the residential customer class—were reviewed to determine if or how natural gas costs have impacted these programs. However, it is difficult to make direct correlations between universal service metrics and gas commodity or distribution costs. For example, changes in policies (e.g. termination policy, settlement agreements with NGDCs that impact program funding) or methods of tracking or calculating costs or customers may have occurred in the intervening years that may prevent a true apples-to-apples comparison.

This section explores data related to universal service programs, including the low-income usage reduction program (LIURP) that promotes energy efficiency and conservation to low-income households, and the customer assistance program (CAP) that provides payment assistance and debt forgiveness for qualifying customers. Information regarding customer debt is also explored. Data for universal service program impacts and costs were taken from the PA PUC's annual Universal Service Report for 2007 and 2015 (Pennsylvania Public Utility Commission 2007) (Pennsylvania Public Utility Commission 2015). These sources provide data for some, not all, of the NGDC's. Specifically, data for Peoples TWP and UGI Central Penn were excluded from these reports. Therefore, data was only supplied for Columbia, Peoples, Peoples-Equitable, NFG, PECO, PGW, UGI, and UGI Penn territories.

Changes in Select Universal Service Metrics from 2007 to 2015										
	Customers in Debt		Total Dollars in Debt		Terminations		LIURP Spending		Gross CAP Costs	
Columbia	6,390	$	7,905,808		(432)	$	3,520,622	$	(5,009,752)	
Peoples - Dominion	(18,148)	$	(25,415,684)		2,592	$	641,430	$	(10,160,938)	
Peoples - Equitable	(3,843)	$	(2,156,040)		(9,080)	$	246,294	$	(2,881,727)	
NFG	858	$	(596,299)		(2,113)	$	(269,908)	$	(5,105,696)	
PECO	(36,419)	$	(20,946,488)		9,474	$	1,374,985	$	(2,258,953)	
PGW	(41,130)	$	(11,916,867)		1,035	$	6,222,688	$	(49,525,189)	
UGI	12,789	$	2,768,412		(5,265)	$	(27,615)	$	(189,648)	
UGI Penn	776	$	1,392,759		(265)	$	438,803	$	2,616,358	
Total	(78,727)	$	(48,964,399)		(4,054)	$	12,147,299	$	(72,515,545)	

Table 18: *In 2015, Peoples-Equitable performed limited credit and collection activities due to a system conversion, which may have impacted (i.e. reduced) the number of terminations. Data for these calculations were taken from the PA PUC's universal service reports for 2007 and 2015 (Pennsylvania Public Utility Commission 2007) (Pennsylvania Public Utility Commission 2015). All price data are reported in nominal terms.*

- **LIURP Spending.** On a nominal basis, total LIURP spending in 2007 was just over $7.5 million (M) increasing by 162% by 2015 to over $19.65 M, representing over $12.1 M in additional spending. Most of this spending increase was attributed to the PGW territory that went from spending over $1.69 M in 2007, to over $7.9 M in 2015. The reason for PGW's significant spending increase was not investigated. All NGDC territories examined increased LIURP funding during the time period, except for NFG and UGI.
- **CAP Gross Costs.** On a nominal basis, gross CAP cost were reduced by 40 percent, from over $182.7 M in 2007 to over $110.2 M in 2015. All NGDC's reduced gross CAP costs, except for UGI Penn that saw a significant increase of 231% in CAP costs. The reduction in CAP program costs is likely a reflection of lower gas prices. The CAP customer discount fluctuates to ensure the gas utility bill does not exceed a set percentage of the customer's total income. So, assuming gas usage and customer income are constants, reductions in commodity costs will lower customer bills, lowering the per customer CAP discount amount, and reducing overall CAP program costs.
- **Number of Customers in Debt.** The total number of customers in debt decreased by 25%, a reduction of 78,727 persons in debt from 2007 to 2015. Peoples, Peoples-Equitable, PECO, and PGW all saw reductions in the total number of customers in debt, whereas Columbia, NFG, UGI, and UGI Penn all saw increases.
- **Total Dollars in Debt.** On a nominal basis, the total value of debt decreased by 30%, a reduction in customer debt of over $48.9 M between 2007 and 2015. Columbia, UGI, and UGI Penn were the only NGDC territories that did not see an overall reduction in customer debt over the time period examined.
- **Termination of Service.** Termination of a customer's natural gas service is considered a last resort when a customer fails to pay their utility bills. Annual service terminations decreased by almost 4% between 2007 and 2015, representing slightly over 4,000 customers accounts that avoided service termination.

SECTION VIIII
CONCLUSIONS AND QUESTIONS FOR THE FUTURE

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PRIOR TO THE NATIONAL SHALE REVOLUTION, PENNSYLVANIAN GAS CUSTOMER'S RETAIL GAS COSTS WERE ABOVE NATIONAL AVERAGES. In terms of price, the development of shale-based natural gas resources have been an unequivocal win for natural gas consumers.[20]

The "Pennsylvania Gas Discount". Average annual gas prices in Pennsylvania and the U.S. have decreased considerably as a result of the shale gas revolution. Since 2013, Pennsylvania gas commodity prices has dropped below the national price benchmark at the Henry Hub, creating a gas price discount for Pennsylvania consumers.

Pennsylvania prices decrease more than U.S. prices. as a result of the shale gas revolution.

- Since 2007, in real teams, PA average annual residential retail gas prices are down 40% (representing a $6.79/Mcf decrease) and average annual gas prices delivered to PA power plants are down 79% (representing a $7.32/Mcf decrease).
- Since 2007, in real terms, shale gas has driven down average annual retail natural gas prices by 34% (representing a $5.09 decrease) to U.S. residential consumers, and as much as 65% (representing $5.47/Mcf decrease) to U.S. electric power generators.

Pennsylvania residential and citygate prices still above national averages. In spite of the PA Gas Discount, average annual retail prices to PA citygates and residential retail customers are still at and above national averages, respectively.

The Pennsylvania Gas Discount to the Henry Hub has made gas use in the Commonwealth particularly attractive, increasing total in-state gas deliveries by 50.5% since 2007. During this time, large gas use customers like Pennsylvania power plants increased deliveries by almost 250% and industrial deliveries increased by 11.4%.

Distribution rates from Pennsylvania natural gas distribution utilities continue to increase, with residential heating rates rising at the fastest rate compared to other sectors.

Distribution utility commodity costs have decreased significantly. The commodity costs distribution utilities charge their customers have decreased by 72% in real terms, since 2007. Gas utilities are required to pass these costs on directly to their customers with no profit mark up, allowing wholesale gas cost reductions to be enjoyed by gas utility consumers.

Fewer service terminations, less customers in debt, and lower debt and assistance program costs. The number of residential natural gas service terminations and consumers in debt have dropped during the shale revolution, by 4% and 25%, respectively. In addition, the total dollars of customer debt and cost of customer assistance programs have dropped by over $48.9 million and $72.5 million, respectively (in nominal terms).

Pennsylvania has attracted significant interest in new pipeline investments. Between 2007–2016, FERC approved 53 major pipeline projects representing 12,939 MMcf/day of pipeline capacity, in addition to another 7,292 MMcf/day of pipeline projects approved by FERC in early 2017. However, not all this capacity will be realized.

[20] This report does not address other positive or negative impacts to consumers from shale gas development, such as: economic development, jobs, environmental outcomes, public health, property values, consumer product pricing, and/or other impacts.

Looking forward, there are at least two important questions to consider relating to Pennsylvania gas prices.

1. How long with the Pennsylvania Gas Discount last?

There are many factors that can impact gas prices. Policy decisions, such as imposing carbon pricing or a severance tax, are publicly debated, highly transparent, and have at least the potential to use collected funds for some public purpose (e.g. offsetting consumer cost increases, funding education, etc.). Market dynamics that impact gas prices can be more complicated and depend on a variety of supply and demand factors. Some of the policy decisions that impact supply and demand factors, are often less directly and less publicly connected to price outcomes. Specifically, the potential gas price implications of pipeline development may not be transparent to policymakers and the general public.

Pennsylvania has significant gas reserves, making it unlikely that reduced gas reserve supply will drive cost increases (barring unforeseen events). Natural gas company delivery and pipeline transportation costs also impact retail gas prices, but these costs are highly regulated and rise incrementally over time. Given the data on pipeline development interest in Pennsylvania, gas demand growth from outside the state may pose the highest probability risk to potentially increase prices.

In the time period examined, no other state has seen more interest in building major natural gas pipelines than Pennsylvania. Many of these projects seek to move cheap Pennsylvania gas to other gas demand centers outside of the state that command higher gas prices. All things being equal, shifting the demand curve out for gas (i.e. increasing takeaway pipeline capacity) would increase local gas prices in Pennsylvania, and reduce gas prices at the end of the pipeline (i.e. the new area of market demand).

Some argue that Pennsylvania's gas resources are so robust that production can easily be ramped up to meet all of this new demand, hence shifting the supply curve out and keeping prices low and steady. Given Pennsylvania's vast shale resources, this is plausible. In fact, in 2016, Pennsylvania exported (or stored) 75% of the gas it produced, and the PA Gas Discount persisted. However, it is unclear if there are practical, technical, or other limits (e.g. profit motive or rent seeking from gas producing firms) to increasing production for the purpose of moderating price, as demand continues to increase.

Just some examples of practical and technical considerations include the availability of water, wastewater treatment or injection capacity, air quality impacts, ability to secure permits, availability of sand, and other potential bottlenecks to production. Gas extraction and production firms also have a strong profit motive to increase gas prices from current low levels, as higher commodity prices improve profit margins, all things being equal. Lastly, it is unclear how production lags could affect price volatility in a higher demand environment.

A build out of new or expanded pipeline capacity has the potential to reduce the current natural gas price discount Pennsylvania consumers enjoy, compared to national averages. It does not mean consumers return to pre-shale revolution prices. However, it should be clear that PA citygate and residential retail prices in 2016 were at and above the national average, respectively, in spite of the PA Gas Discount. These sectors experienced commodity price decreases between 2007–2016, yet are exposed to expensive firm pipeline and ever-increasing NGDC delivery charges. A decrease in the Pennsylvania Gas Discount could result in residential and citygate prices continuing to be above national averages.

In addition, the connection between gas and power prices means Pennsylvania electricity consumers costs are likely to increase if the PA Gas Discount erodes.

Exploring these price dynamics are also key to understanding larger economic development questions facing Pennsylvania. Specifically, what are the benefits, drawbacks, and tradeoffs of a natural gas producer-driven versus a natural gas consumer-driven economic development strategy?

A gas producer-driven strategy relies on higher gas prices and gas demand[21] to drive economic growth, specifically incenting investments in natural gas extraction, production, refining, pipeline, and other gas-related infrastructure, as well as boosting indirectly-related business opportunities (e.g. engineering services, supply chain businesses). A gas consumer-driven strategy is dependent on lower commodity prices supporting demand-side investments in natural gas use (e.g. increasing energy-intensive manufacturing

[21] Demand for gas could decrease as prices rise, potentially reducing profitability for the gas producing firm. However, the dynamics of interstate pipelines enable the potential for gas demand to remain high in the presence of rising gas prices for the producing state. This occurs as production state prices rise, yet prices to markets at the end of the pipeline are reduced, stabilizing or increasing net demand.

or natural gas vehicle use), as well as economic growth being spurred through comparatively higher levels of consumer (e.g. households, businesses) disposable income. Macroeconomic modelling to identify potential Pennsylvania-specific outcomes for these competing strategies is needed to better inform policymakers, including net benefits or costs, to whom these benefits and cost accrue, and identification of economic transfers.

These important issues are ripe for further research and critical to understanding important choices that may face the Commonwealth.

2. How will the natural gas industry continue to evolve to better serve the electric power sector, its new number one customer?

In addition to savings for natural gas consumers, Pennsylvania's participation in PJM Interconnection's competitive wholesale electricity market has allowed natural gas commodity discounts to quickly be translated into savings for electricity consumers. Gas demand growth from Pennsylvania's new and existing gas-fired power plants has sky-rocketed as gas prices plummeted, driving reductions in electric power prices.

Low electricity prices have benefitted power consumers and challenged more traditional power generators. As new gas-fired resources continue to flourish in the current low power price environment, market participants have responded in a variety of ways. Economically challenged generators have appealed to state policymakers in pursuit of subsidies to remain in operation.[22] PJM Interconnection has maintained that a grid dominated by gas-fired resources can remain reliable (PJM Interconnection 2017). Alternatively, economically challenged generators have advanced questions about maintaining grid resilience in the face of increased gas dependency. Gas-fired resources typically rely on just-in-time, often interruptible delivery of gas to generate power (though limited dual-fuel backup is available), so if a pipeline is compromised, the plant may not be able to function for very long. In the name of promoting greater grid resilience, federal policymakers have proposed cost-of-service compensation to power plants operating in competitive markets that can store 90-days of fuel on-site.[23] These state and federal subsidy proposals face legal challenges, with uncertain outcomes.

Owing in large part to the shale revolution, the electric power sector is now the highest volume user of natural gas, both nationally and in Pennsylvania. In other words, the power sector is the gas sector's number one customer.

As the electricity grid has incorporated increased amounts of competitive gas generation capacity, evolution has occurred to improve coordination between gas and electric markets.[24] However, further enhancing gas-electric coordination and addressing the real or perceived resilience shortcomings of a more gas-reliant grid may be critical to maintaining or growing electric power gas demand.

More research is needed to identify potential reforms the natural gas industry could pursue to better serve the electric power sector as gas penetration deepens. Some examples of changes that could be considered include, but are not limited to: increased flexibility in gas contracting, development of new pipeline services, increased intra-day nomination cycles, improved gas market and index price transparency, real-time and locational gas pricing, and other innovations. On the electric side, PJM Interconnection has promoted price formation reforms that it expects will increase the value of flexibility and may promote innovation in the gas nomination cycle and advance gas-electric coordination (PJM Interconnection 2017).

[22] For example, see the Zero Emissions Credit (ZEC) programs established by Illinois' 'Future Energy Jobs Bill' located at http://www.ilga.gov/legislation/publicacts/99/PDF/099-0906.pdf , and by New York's Clean Energy Standard Order, located at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b44C5D5B8-14C3-4F32-8399-F5487D6D8FE8%7d

[23] See the U.S. Department of Energy's notice of proposed rulemaking on the 'Grid Resiliency Pricing Rule', located at https://energy.gov/sites/prod/files/2017/09/f37/Notice%20of%20Proposed%20Rulemaking%20.pdf

[24] For example, the Federal Energy Regulatory Commission (FERC) issued Order 809 in April 2015, to improve gas-electric coordination. More information on Order 809 can be found https://www.ferc.gov/media/news-releases/2015/2015-2/04-16-15-M-1.asp#.WcVbLMiGOiM

APPENDIX A
MAJOR PIPELINE PROJECTS APPROVED BY FERC, INVOLVING PA (2007 – 2017)

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Data for these appendix tables were taken from a research report from Jim O'Reilly of SNL Energy (O'Reilly 2017) and from FERC's website listing of approved major pipeline projects, located at https://www.ferc.gov/industries/gas/indus-act/pipelines/approved-projects.asp

Major Gas Pipelines Approved by FERC (2017)					
	Project Name	Company Name	Capacity (MMcf/d)	States	Certificate Issued
2017	Triad Expansion Project	Tennessee Gas Pipeline	180	PA	12/30/2016
	Leach Xpress Project	Columbia Gas Transmission	1530	OH, PA, WV	1/19/2017
	Orion Project	Tennessee Gas Pipeline	135	PA	2/2/2017
	Rover Pipeline LLC	Rover Pipeline LLC	3250	OH, PA, WV	2/2/2017
	Atlantic Sunrise Project	Transcontinental Pipeline Co.	1700	MD, NC, PA, SC, VA	2/3/2017
	Northern Access 2016 Project	National Fuel Gas Supply	497	NY, PA	2/3/2017
			7,292	Total	

Appendix Table 1: *Major Pipeline Projects Involving PA and Approved by FERC in 2017. FERC lists the Triad project, approved on 12/30/2016 in its table of projects approved in 2017.*

Major Gas Pipelines Approved by FERC (2007 - 2016)						
	Project Name	Company Name	Capacity (MMcf/d)		States	Certificate Issued
2016	Leidy South Project	Dominion Transmission		155	MD,PA,VA	8/29/2016
	Sunbury Pipeline Project	UGI Sunbury, LLC		200	PA	4/29/2016
	Susquehanna West Project	Tennessee Gas Pipeline Company		145	PA	9/6/2016
	Tri-County Bare Steel Replacement Project	Columbia Gas Transmission Co	N/A		PA	2/1/2016
	NY Bay Expansion Project	Transcontinental Gas Pipeline Co		115	NJ, NY, PA	7/7/2016
	TP-371 Pipeline Replacement Project	Equitrans, L.P.	N/A		PA	4/6/2016
	White Oak Mainline Expansion	Eastern Shore Natural Gas Compar		45	PA	7/21/2016
	N/A	First Midstream, LLC		152	PA	6/1/2016
	N/A	Paulsboro Natural Gas Company		20	PA	9/7/2016
2015	Lebonon West II Project	Dominion Transmission		130	OH, PA	11/19/2015
	Rock Springs Expansion Project	Transcontinental Gas Pipeline Co		192	MD, PA	3/19/2015
	West Side Expansion and Modernization Project	National Fuel Gas Supply Corp.		175	PA	3/2/2015
	Tuscarora Lateral Project	Empire Pipeline/National Fuel Gas		55	NY, PA	3/10/2015
	Niagara Expansion Project	Tennessee Gas Pipeline Company		158	NY, PA	2/27/2015
	Bailey East Mine Panel 2L Project	Texas Eastern Transmission	N/A		PA	3/9/2015
2014	Constitution Pipeline Project	Constitution Pipeline Company		650	NY, PA	12/2/2014
	Leidy Southeast Expansion Project	Transcontinental Gas Pipeline Co		525	MD, NC, NJ, PA, VA	12/18/2014
	East Side Expansion Project	Columbia Gas Transmission Co		312	MD, NJ, NY, PA	12/18/2014
	U2GC Project	Texas Eastern Transmission		425	IN, OH, PA	12/18/2014
	Northeast Connector Project	Transcontinental Gas Pipeline Co		100	NJ, PA	5/8/2014
	Jefferson Compressor Station Expansion Project	Equitrans, L.P.		600	PA	4/11/2014
	Emerald Longwall Mine Project	Texas Eastern Transmission	N/A		PA	1/29/2014
	Line 1655 North Project	Columbia Gas Transmission Co		16	PA	8/22/2014
2013	Smithfield III Expansion Project	Columbia Gas Transmission Co		444	PA, WV	12/19/2013
	Tioga Area Expansion Project	Dominion Transmission		270	NY, PA	3/8/2013
	Natrium to Market Project	Dominion Transmission		185	PA	9/3/2013
	Rose Lake Expansion Project	Tennessee Gas Pipeline Company		230	PA	9/19/2013
	Sabinsville to Morisville Project	Dominion Transmission		92	PA	3/8/2013
2012	Northeast Upgrade Project	Tennessee Gas Pipeline Company		636	NJ, PA	5/29/2012
	Northeast Supply Link Expansion	Transcontinental Gas Pipeline Co		250	NJ, NY, PA	11/2/2012
	Allegheny Storage Project	Dominion Transmission		125	MD, OH, PA	12/20/2012
	MPP Project	Tennessee Gas Pipeline Company		240	PA	8/9/2012
	Line N 2012 Expansion Project	National Fuel Gas Supply Corp.		163	PA	3/29/2012
2011	Appalachian Gateway Project	Dominion Transmission		484	PA, WV	6/16/2011
	Sunrise Project	Equitrans, L.P.		314	PA, WV	7/21/2011
	LLC MARC I Project	Central New York Oil & Gas Co.		550	PA	11/14/2011
	N/A	Central New York Oil & Gas Co.		288	NY, PA	1/20/2011
	Team 2012 Expansion Project	Texas Eastern Transmission		190	OH, PA	11/17/2011
	Northeast Expansion Project	Dominion Transmission		200	PA	8/24/2011
	Northeast Access Expansion Project	National Fuel Gas Supply Corp.		320	NY, PA	10/20/2011
	Northeast Supply Diversification Project	Tennessee Gas Pipeline Company		250	NY, PA	9/15/2011
	Tioga County Extension Project	Empire Pipeline Inc.		350	NY, PA	5/19/2011
	Ellisburg to Craigs Project	Dominion Transmission		150	NY, PA	9/15/2011
	Station 230 C Project	Tennessee Gas Pipeline Company	N/A		NY, PA	10/20/2011
2010	Line 300 Expansion	Tennessee Gas Pipeline Company		350	NJ, PA	5/14/2010
	Line N Compressor Installation Project	National Fuel Gas Supply Corp.		150	PA	12/16/2010
2009	TEMAX and TIME III Project	Texas Eastern Transmission		455	PA	11/19/2009
	Sparrows Point Project	AES Sparrows Point and Mid Atlant		1500	MD, PA	1/15/2009
	Dominion Hub III Project	Dominion Transmission		224	PA, WV	10/6/2009
	Delta Lateral Project	Transcontinental Gas Pipeline Co		209	PA	10/28/2009
2008	Sentinel Expansion Project	Transcontinental Gas Pipeline Co	N/A		PA, NJ	8/14/2008
2007	TIME II Project	Texas Eastern Transmission		150	OH, PA	6/8/2007
	Leidy to Long Island Expansion	Transcontinental Gas Pipeline Co	N/A		NJ, NY, PA	1/11/2007
				12,939	Total	

Appendix Table 2: *Major Pipeline Projects Involving PA and Approved by FERC between 2007–2016*

APPENDIX B
PRICING DATA SOURCES AND LIMITATIONS

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Primary Pricing Data Sources. National and state natural gas pricing data for various customer sectors were taken from U.S. EIA's natural gas annual database, which pulls data from a variety of monthly and annual survey input sources, depending on the sector. These survey forms include:

- **Form EIA-176** "Annual Report of Natural and Supplemental Gas Supply and Disposition" is a mandatory survey completed by inter- and intra-state pipeline operators, investor and municipally-owned local distribution companies, underground storage operators, certain natural gas processing plants, liquefied natural gas storage operators, and other entities. According to EIA, the response rate on the surveys is very high, only 30 of the 2,034 respondent were non-responsive. Where possible, EIA cross-references data for accuracy with data collected by other federal agencies, such as the Federal Energy Regulatory Commission and U.S. Department of Energy.
- **Form EIA-857** "Monthly Report of Natural Gas Purchases and Deliveries to Customers" is submitted by inter- and intra-state pipeline companies and local distribution companies.
- **Form EIA-910** "Monthly Natural Gas Marketer Survey" is completed by marketers or companies that sell, but do not distribute gas. This survey captures, among other things, data needed to determine gas pricing offered from competitive gas suppliers (e.g. third-party marketers). EIA-910 survey data for Pennsylvania was only collected from 2002 through 2010 and not all data was available online. After 2010, EIA reduced the number of states for which it collected EIA-910 survey data to Georgia, New York, and Ohio.

Pricing Data Limitations. EIA pricing data are generally limited to pricing information for gas sold by NGDCs (i.e. default supply). The majority of available pricing data from EIA does not reflect prices for gas sold by competitive natural gas suppliers (i.e. third-party marketers or producers). EIA does track total gas volumes moving through the NGDC's system, which includes default and competitively supplied gas. For example, competitively supplied gas volumes may be tracked as transportation customer gas, meaning the gas is only transported through (not purchased from) the NGDC's delivery system. Given these data limitations, it is important to pay attention to the percent of total gas volume that is represented by the reported price.

- **Default Pricing Available for All Years.** NGDCs that both deliver and sell gas report associated revenues to EIA. NGDCs provide default service (i.e. supply and deliver gas) and can report both volumes and revenues as on-system sales. Average NGDC pricing is determined by dividing the reported revenue by its associated volume. NGDCs can also report total gas volumes delivered through its system, not associated with default supply (i.e. supplied by a third-party).
- **Complete Residential and Commercial Pricing Data for 2002–2010.** During these years, EIA collected Form 910 data for Pennsylvania and other U.S. states, which includes default and competitive gas supply pricing. As a result, for Pennsylvania between 2002 and 2010, pricing information for these sectors reflects both default and competitive prices. EIA pricing data before 2002 and after 2010 for the residential sector will cover the majority of gas volumes delivered.

- **Incomplete Commercial and Industrial Pricing Data.** The majority of EIA's pricing data for the commercial and industrial sectors is associated with only a small volume of total gas delivered, as it is limited to default service prices. These larger volume gas use consumers tend to procure gas from third-party competitive suppliers. Commercial data for 2002 – 2010 is complete due to the EIA Form 910 data, but prior to 2002 and after 2010 is incomplete. For all years, industrial pricing data are incomplete and reflects only a small volume of gas delivered to the in sector. It is expected that the EIA data overstates the actual cost of gas supply to this overall sector.

Commercial and Industrial Proxy Price for Pennsylvania. As a result of the above-referenced EIA pricing data limitations, the report develops a proxy price approach - called the PA Hubs Average - to provide a more accurate approximation of commercial and industrial natural gas pricing for Pennsylvania. A national commercial and industrial proxy price was not constructed. The PA Hubs Average is a straight line average of Bidweek Index Final prices from five major Pennsylvania area natural gas hubs, including TCO pool, TETCO M3, Dominion N, Dominion S, and Leidy (SNL Energy 2017). The primary limitation of the PA Hubs Average is it excludes costs to move the gas from hub to meter, which may include pipeline and NGDC delivery charges, for example. As such, the PA Hubs Average understates the cost to commercial and industrial customers, whereas the EIA data overstates costs to these customer classes (aside from commercial customer data from 2002 – 2010). In addition, the PA Hubs Average is a straight line average rather than a weighted average, and therefore does not accurately reflect how hubs with higher volume throughput may impact average prices. Bidweek Index Final volume data was not available for all of the relevant hubs, preventing establishment of a weighted average.

Delivered Electric Power Sector Pricing Data. For this sector, the database relies on Form EIA-423 "Monthly Report of Cost and Quality of Fuels for Electric Plants Report" for volume deliveries to non-regulated power producers, and FERC Form 423 "Monthly Report of Cost and Quality of Fuels for Electric Plants" for volume deliveries to regulated power producers, for data from 2003 to 2006. Beginning in 2007, Form EIA-923, "Power Plant Operations Report" provides data for these plants. Data is limited to generating plants with 50 megawatts or greater of nameplate capacity. Form 923 requires all natural gas purchases to be reported annually by new and existing contracts, along with spot purchases in aggregate, and fuel received under tolling agreements. The cost information reflects total delivered cost, including penalties and premiums, reported on a cent per million BTU basis. The commodity costs are reported on a "free on board" basis at the point of first loading, along with the following natural gas pipeline charges: fuel losses, transportation reservation charges, balancing costs, and distribution system costs outside of the plant. For purchases associated with a hedging contract, the actual fuel supply contract is reported, not the hedge contract. Costs net of gains/losses as a result of the contract are also reported. More information on the EIA Form 923 is available at:

https://www.eia.gov/survey/form/eia_923/instructions.pdf

Complete Citygate. These prices represent the total cost paid by local distribution companies for gas received at the physical point where the gas is transferred from the pipeline company or transmission system to the distribution system. The price reflects all charges for acquisition, storage, transportation and other charges the local distribution company pays to obtain gas to sell to customers. Prices for gas delivered to the citygate represent all of the volumes of gas purchased by LDCs for subsequent sale and delivery to consumers in their service area.

More information on the referenced EIA sources and limitations can be found in the appendices to the EIA's Natural Gas Annual and Monthly reports:

- Monthly - May 2017 https://www.eia.gov/naturalgas/monthly/pdf/appendix_c.pdf
- Annual 2015 https://www.eia.gov/naturalgas/annual/pdf/appendix_a.pdf

APPENDIX C
NGDC PURCHASED GAS COST RATE DIFFERENTIALS

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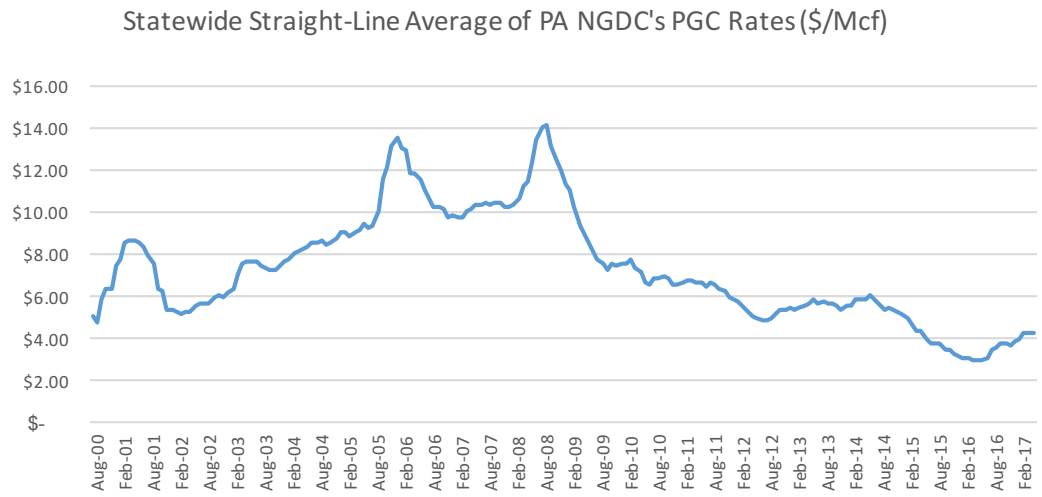
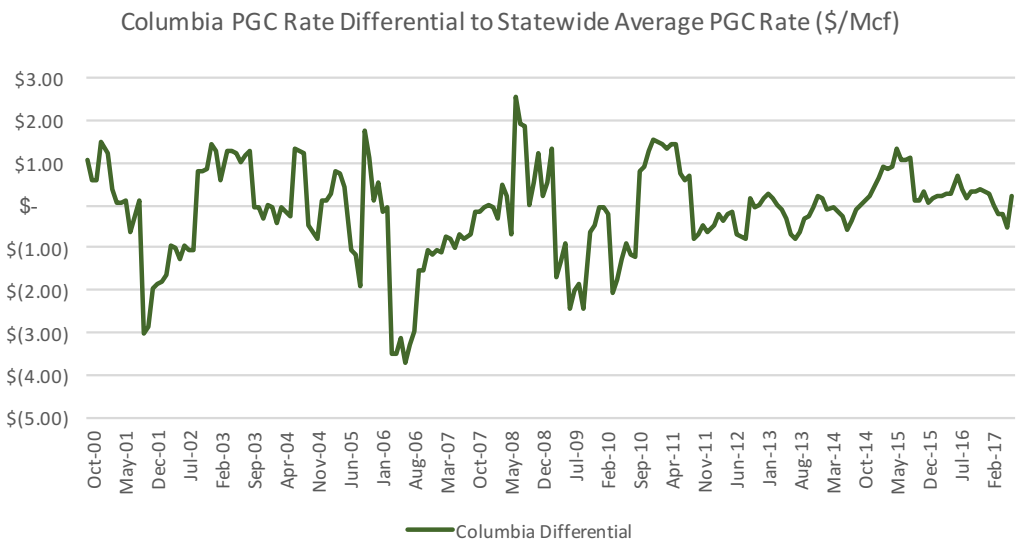
Appendix C presents information on Pennsylvania Natural Gas Distribution Company (NGDC) purchased gas cost (PGC) rates, approximately ranging between 2000 and 2017, unless otherwise noted. All dollar values are presented in nominal terms.

Appendix Figure 1 shows a straight line average of all PA NGDC PGC rates over time. Subsequent NGDC-specific appendix figures show how individual utility PGC rates compare to the statewide average rate. On these graphs the x-axis at zero represents the statewide average. For example, when the utility-specific PGC rate drops below zero, it means the that utility's PGC rate was below the statewide average PGC rate, at that specific time period. When the utility-specific rate is above zero, it means the utility's rate is higher than the statewide average.

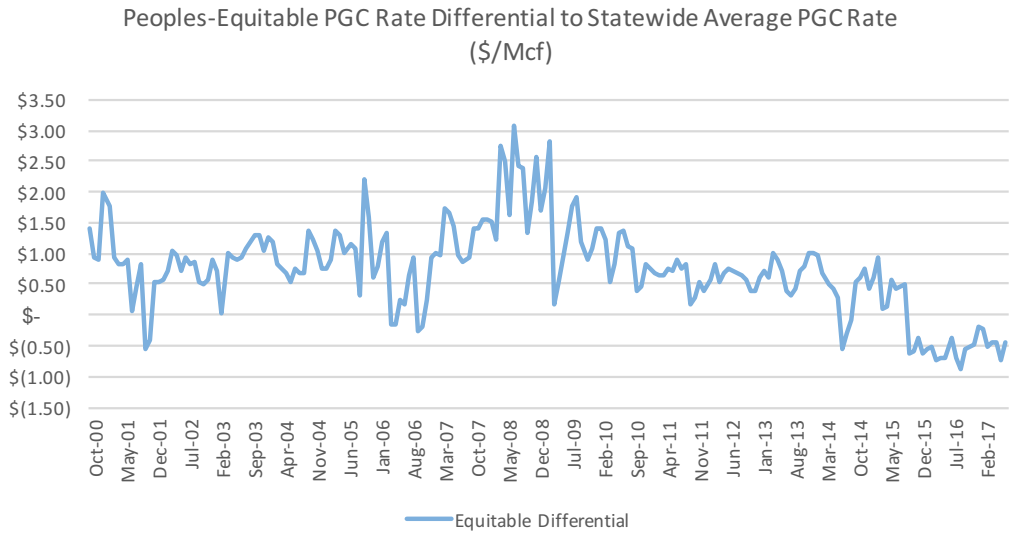
Data for these figures were taken from the PA Public Utility Commission's archive of purchased cost gas rates (Pennsylvania Public Utility Commission n.d.)



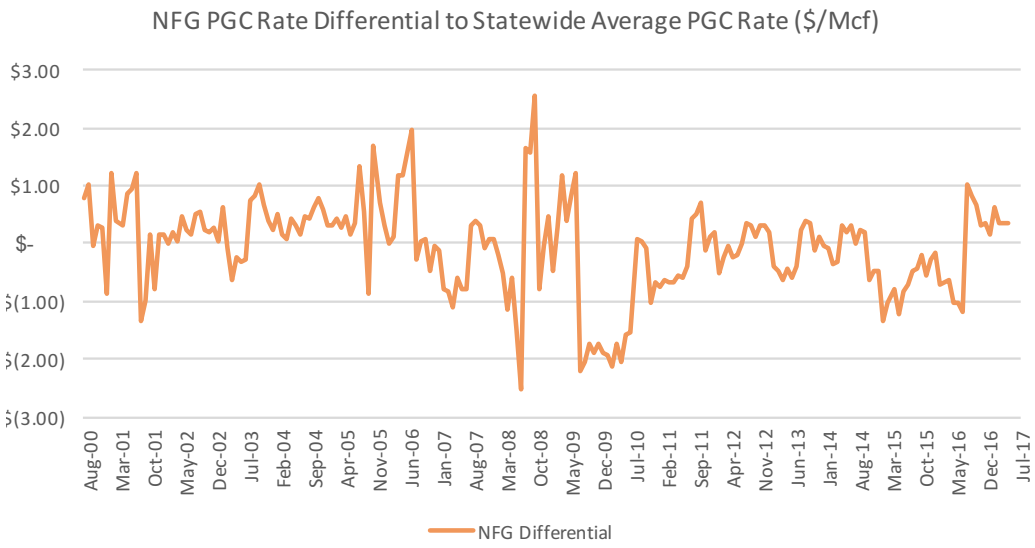
Appendix Figure 1: *Statewide Straight Line Average of PA NGDC's PGC Rates ($/Mcf)*



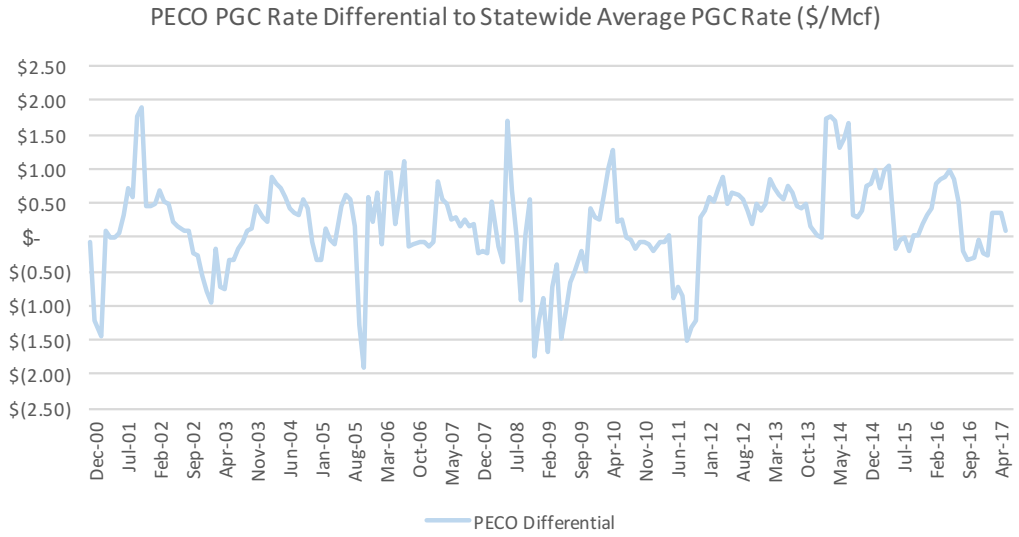
Appendix Figure 2: *Columbia PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



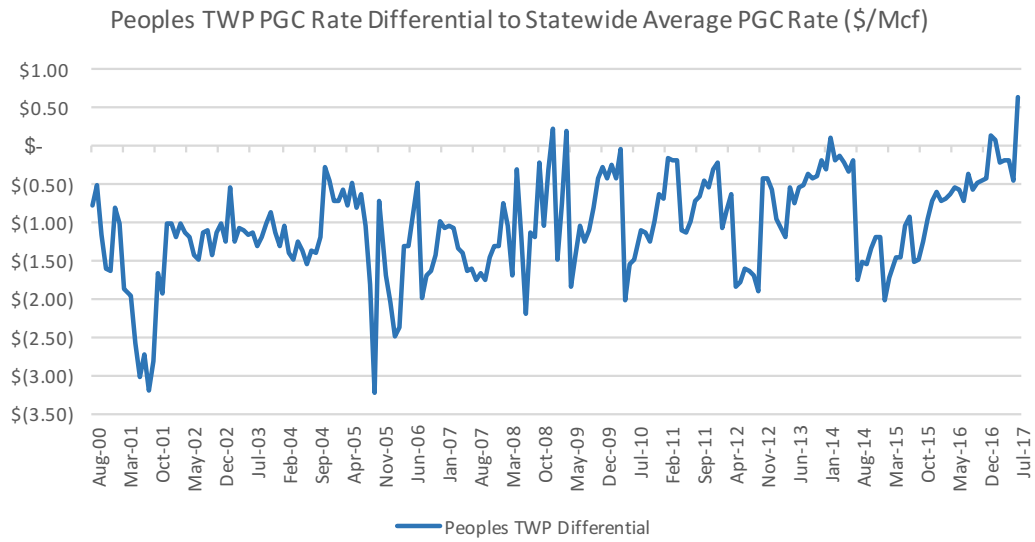
Appendix Figure 3: *Peoples-Equitable PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



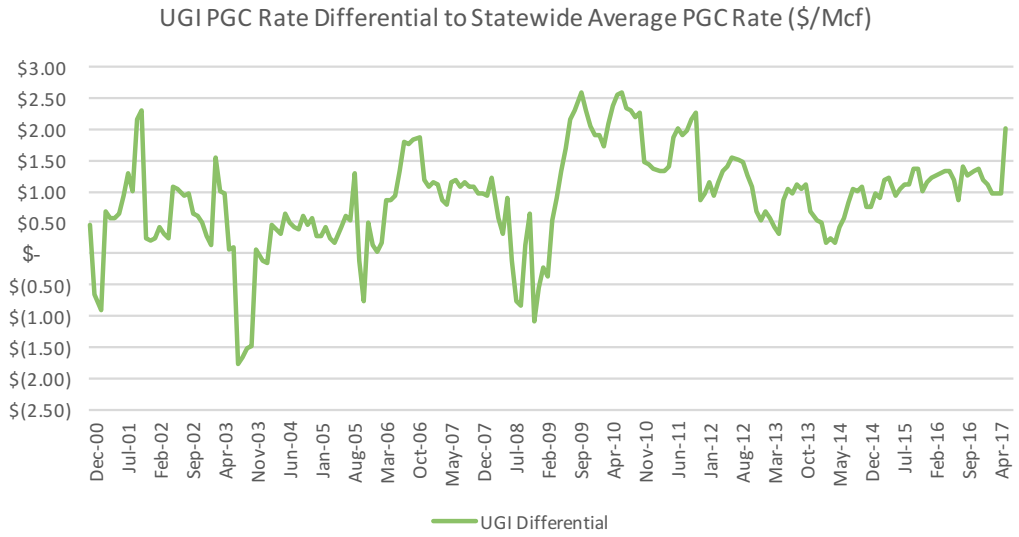
Appendix Figure 4: *NFG PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



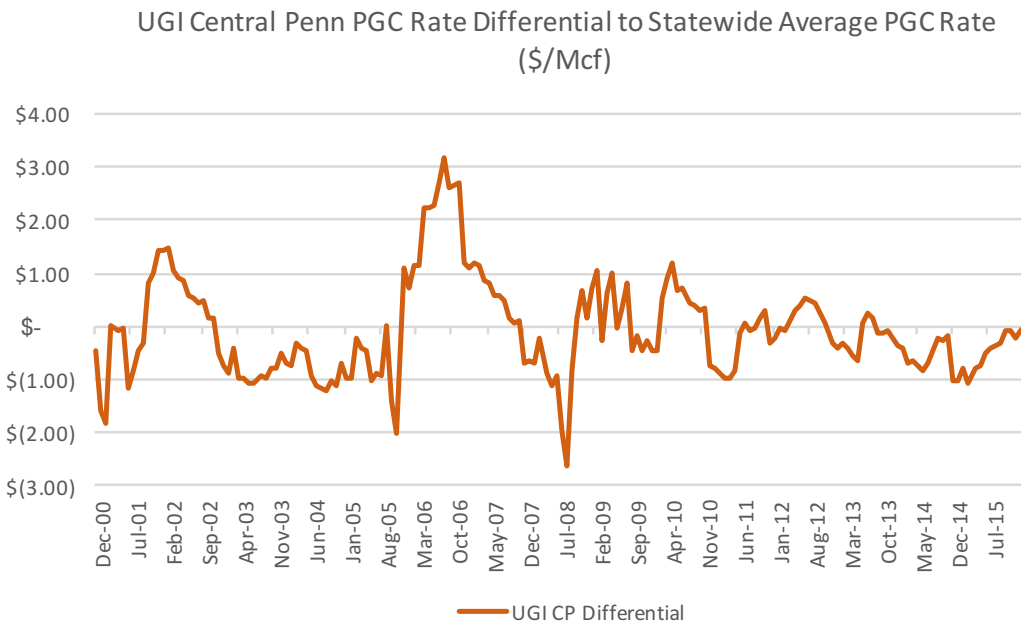
Appendix Figure 5: *PECO PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



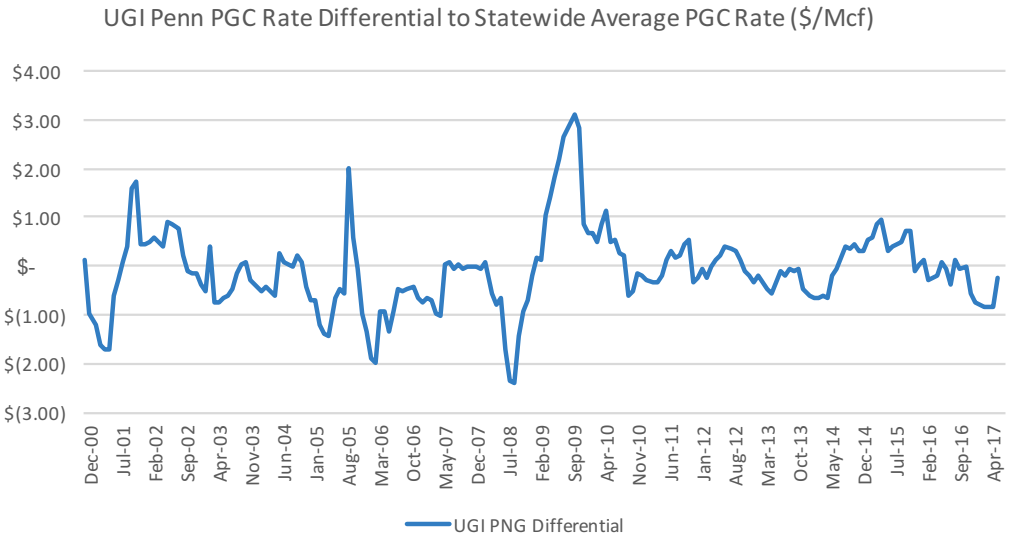
Appendix Figure 8: *Peoples TWP PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



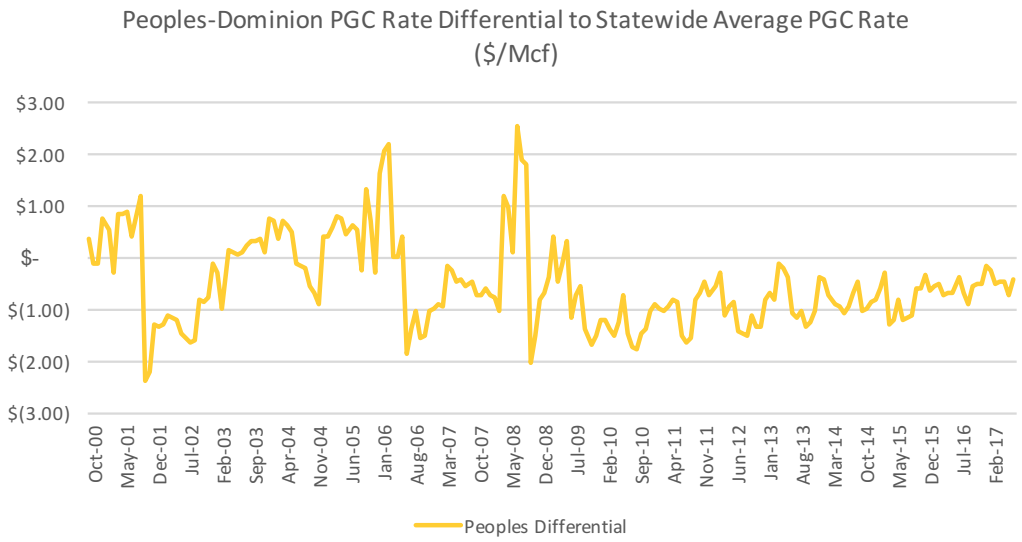
Appendix Figure 9: *UGI PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



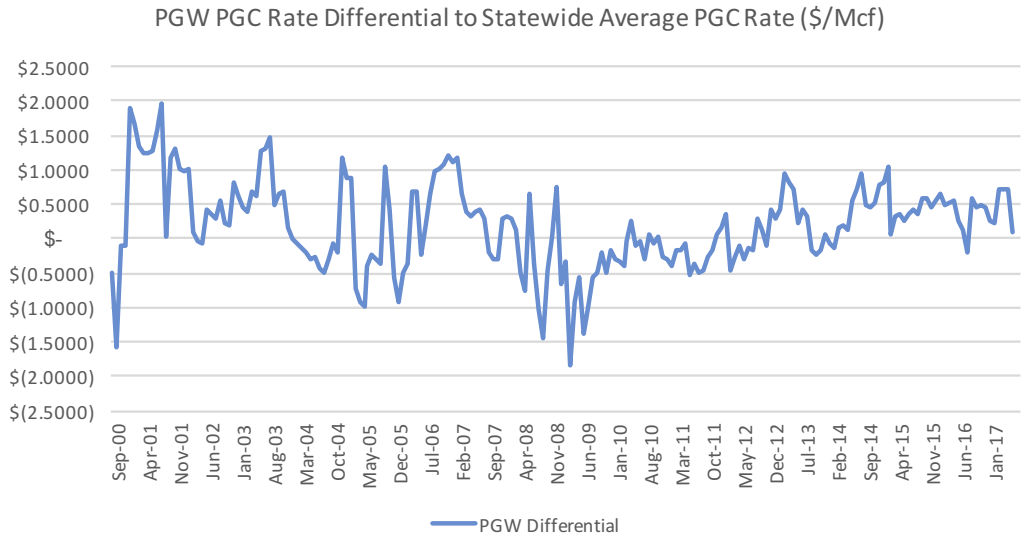
Appendix Figure 10: *UGI Central Penn PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



Appendix Figure 11: *UGI Penn PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



Appendix Figure 6: *Peoples-Dominion PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*



Appendix Figure 7: *PGW PGC Rate Differential to Statewide Average PGC Rate ($/Mcf)*

APPENDIX D
CHANGES IN MONTHLY RESIDENTIAL NON-HEATING (2 MCF/MONTH) DISTRIBUTION COSTS

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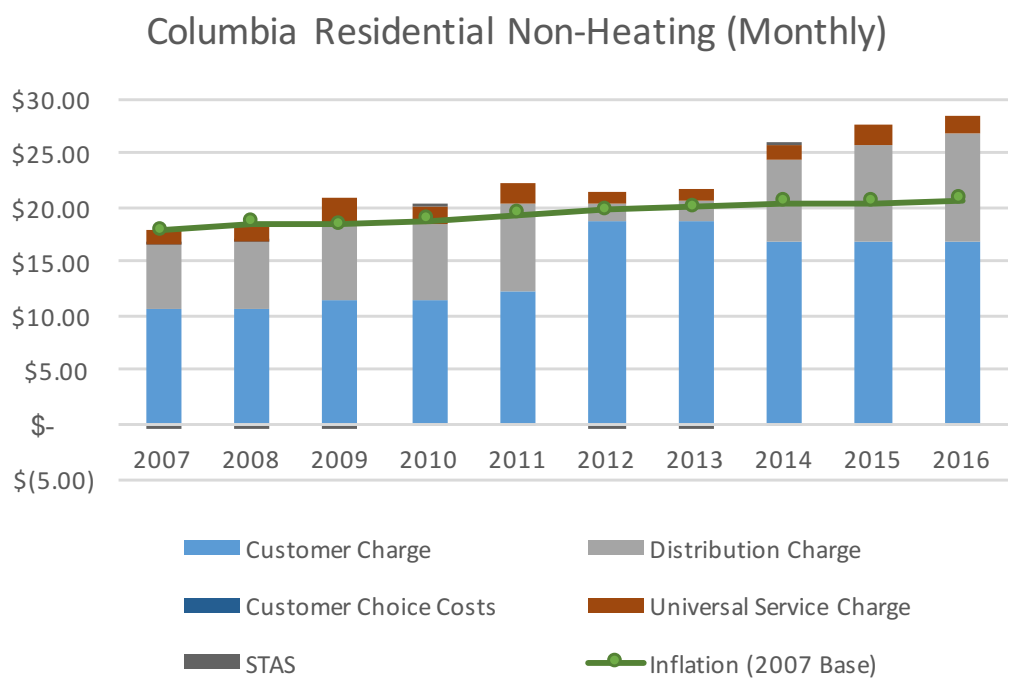
Historic data for monthly residential non-heating (2 Mcf/month) distribution rates charged by PA NGDCs was made available by the PA Public Utility Commission in its annual rate comparison reports (Pennyslvania Public Utility Commission 2006 - 2017). All charges are for default service as of January 31 of the applicable year.

The following distribution charges may commonly be listed on the following appendix figures, along with NGDC-specific charges that will be explained in the notes section under the applicable appendix figure. Below is a very brief description of the nature of these charges.

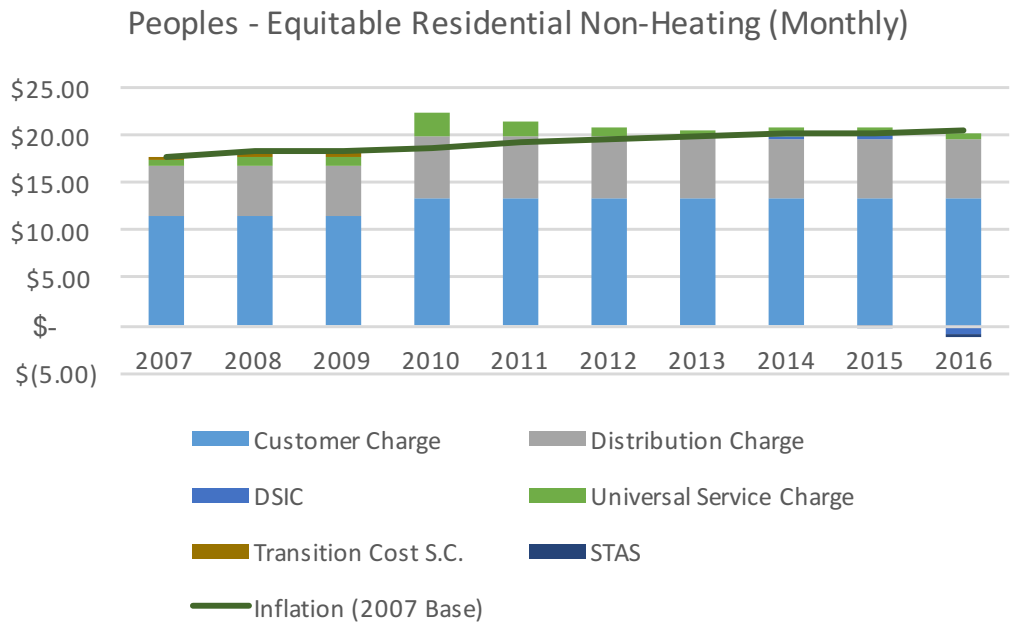
- **Customer Charge.** A flat monthly charge to cover costs related to maintaining meters and preparing bills.
- **Distribution Charge.** A rate that typically varies with the amount of gas used. Covers costs associated with delivering gas to a customer's meter.
- **Distribution System Improvement Charge (DSIC).** This charge enables the NGDC to recover costs - between rate cases - associated with improvements, replacement, or repair of eligible property needed to serve customers.
- **Education Charge.** This charge enables recovery of costs generally associated with communicating changes in the NGDC industry (e.g. restructuring) to customers.
- **State Tax Adjustment Surcharge (STAS).** A charge or credit to reflect changes in state taxes applicable to the NGDCs, as apportioned to the customer.
- **Universal Service Charge.** This charge is established to cover costs associated with the NGDC's universal service programs (e.g. low-income usage reduction program, customer assistance program, etc.).
- **Customer Choice or Transition Costs.** Generally associated with recovery of costs to the NGDC associated with transitioning to and facilitating retail competition.

Some of these charges may (or may not) be incorporated into the variable distribution charge.

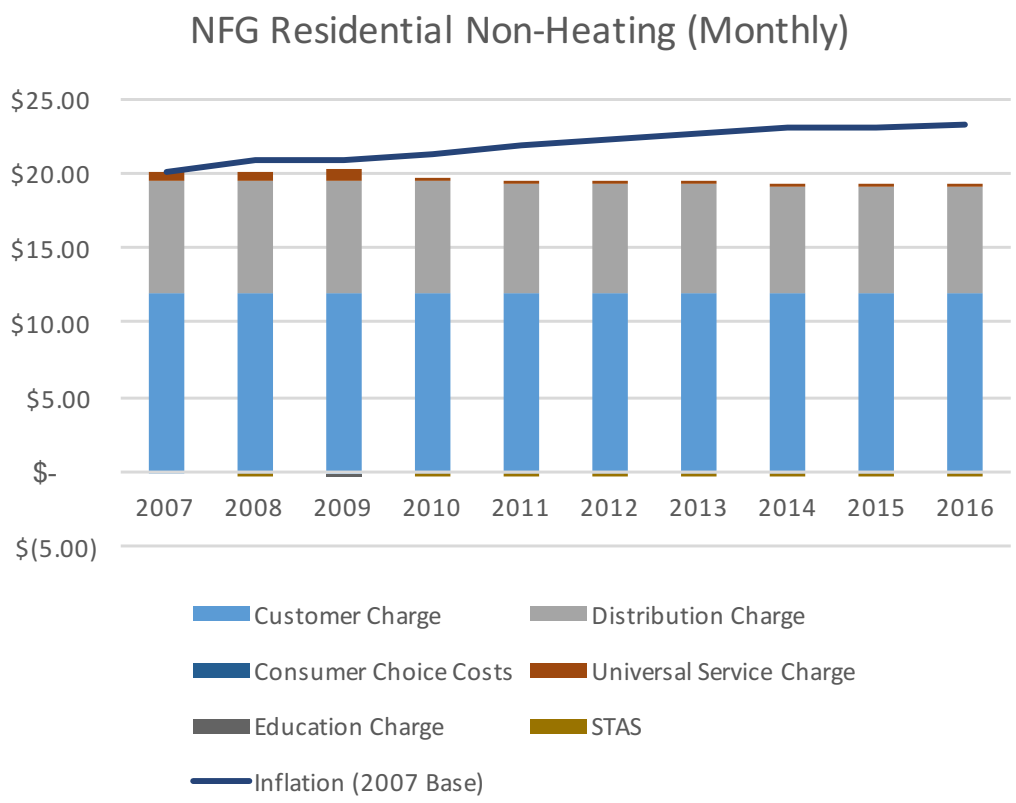
Inflation adjustments from the 2007 base year are performed using the CPI-U from the U.S. Bureau of Labor and Statistics (U.S. Bureau of Labor and Statistics 2016).



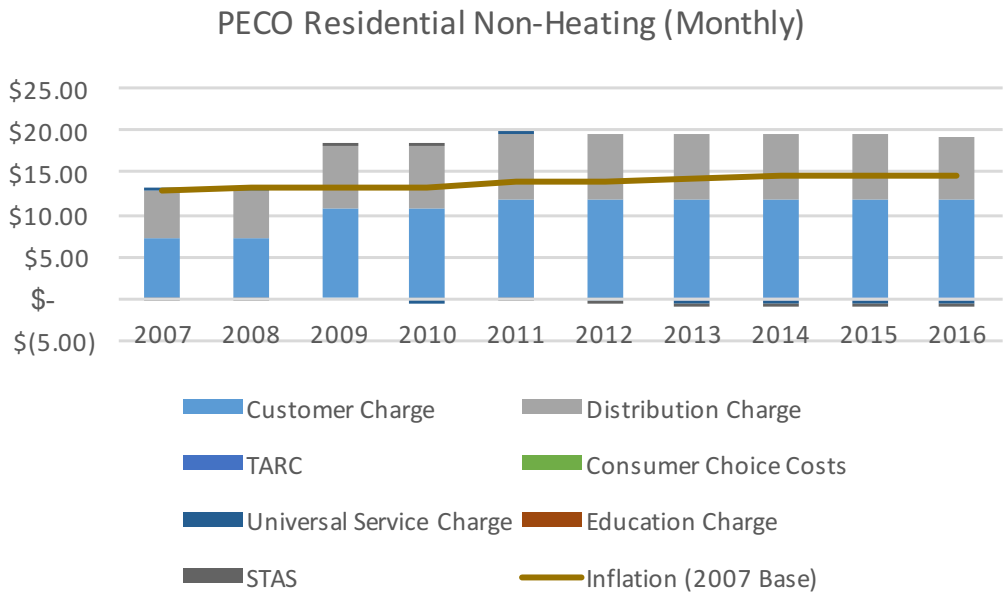
Appendix Figure 1: *Columbia Residential Non-Heating (Monthly)*



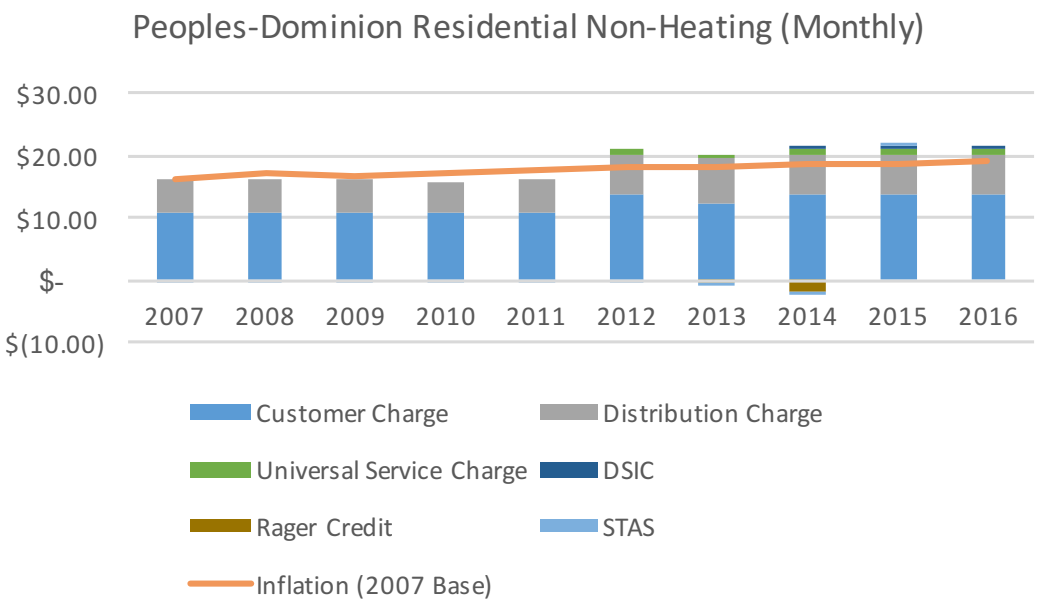
Appendix Figure 2: *Peoples-Equitable Residential Non-Heating (Monthly)*



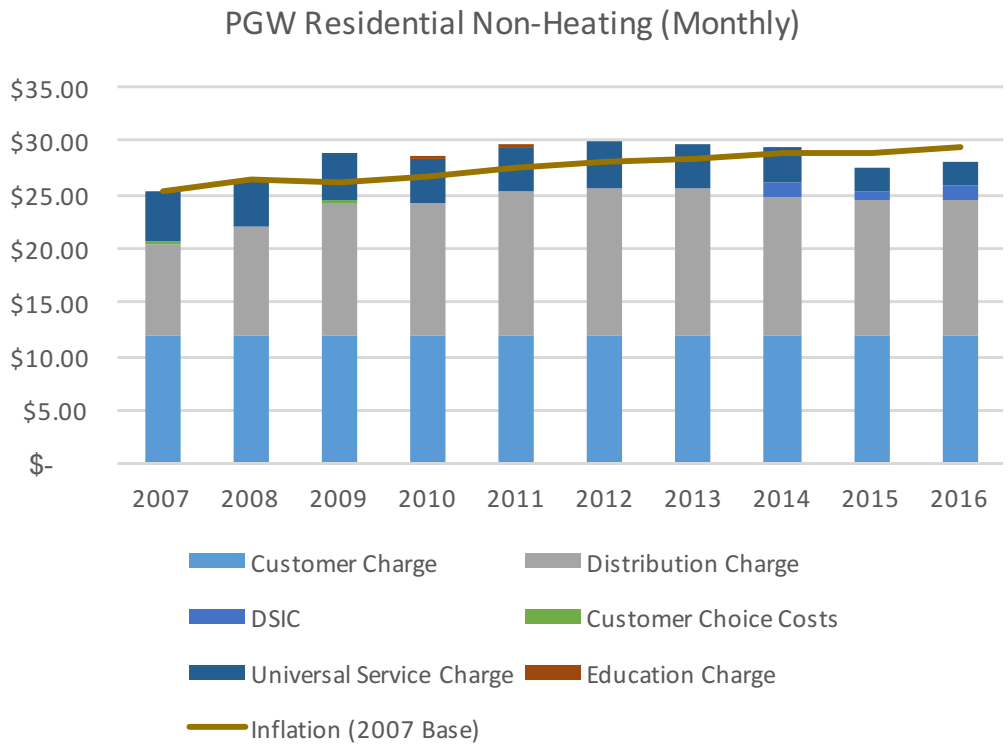
Appendix Figure 4: *PECO's Monthly Residential Non-Heating (Monthly). The Tax Accounting Repair Credit (TARC) is a credit to customers as a result of tax benefits gained from a change in tax accounting methods for certain expenditures.*



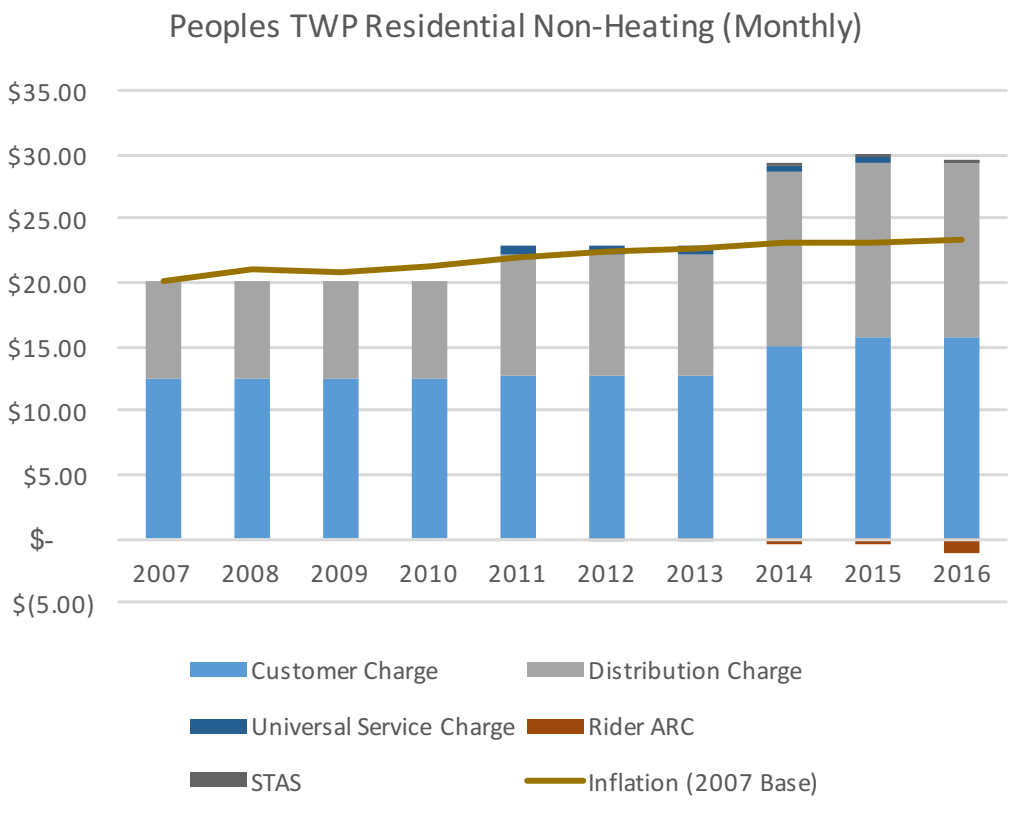
Appendix Figure 3: *NFG Residential Non-Heating (Monthly)*



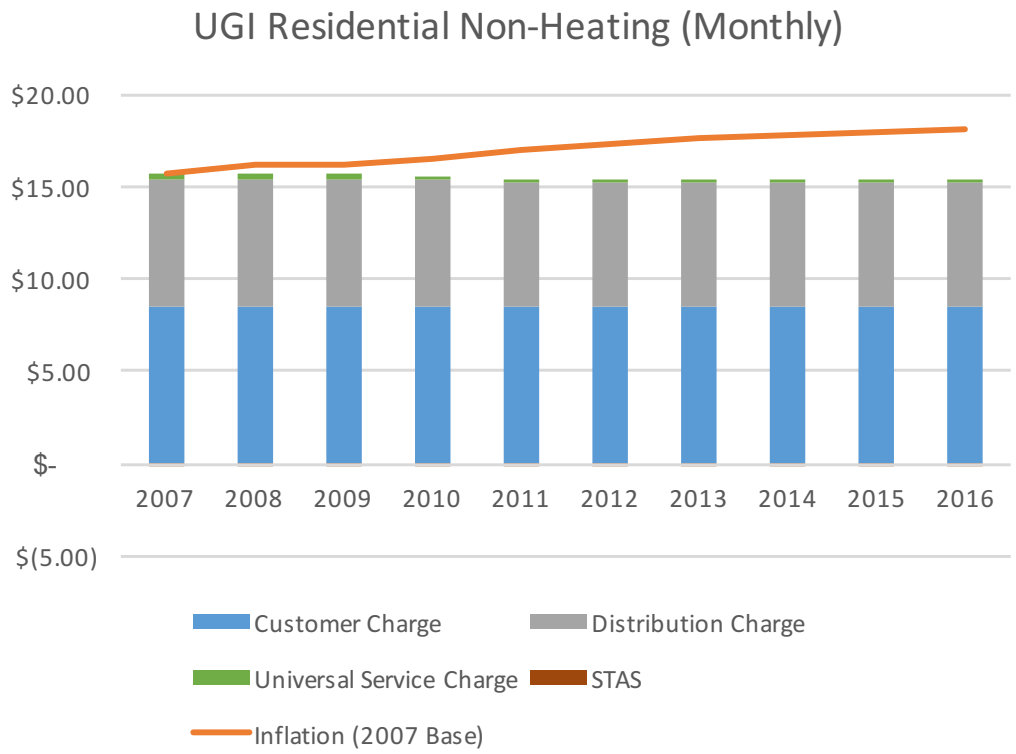
Appendix Figure 5: *Peoples-Dominion Residential Non-Heating (Monthly). The Rager Credit is credit to customers related to Peoples-Dominion's lease of storage capacity at the Rager Mountain Storage Facility.*



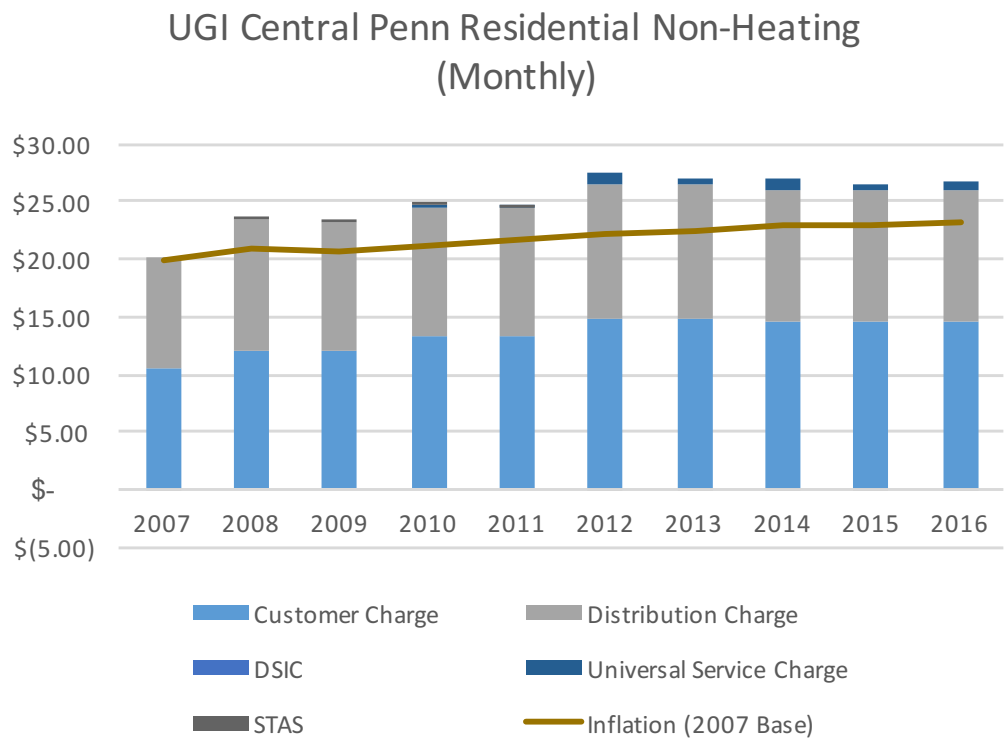
Appendix Figure 6: *PGW Residential Non-Heating (Monthly)*



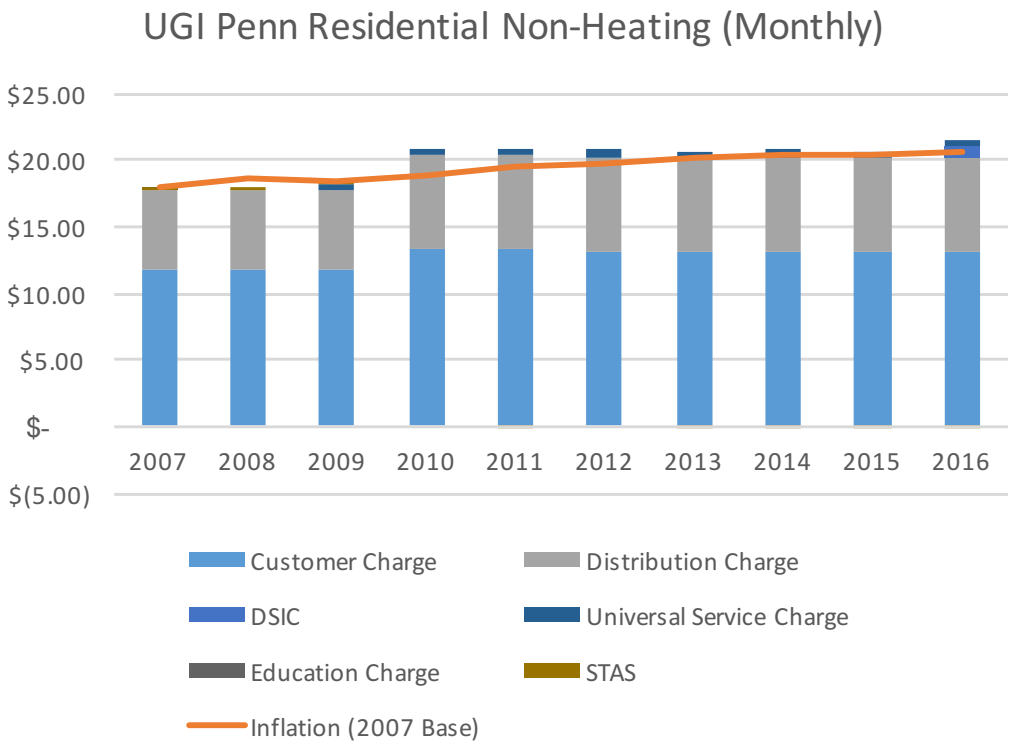
Appendix Figure 7: *Peoples TWP Residential Non-Heating (Monthly). The Acquisition Rate Credit (Rider ARC) was established as part of the Base Rate Case settlement at Docket No. R-2013-2355886 to provide a $10,000,000 credit to ratepayers over a five-year period pursuant to the settlement of the Company's acquisition proceeding at Docket No. A-2010-2210326.*



Appendix Figure 8: *UGI Residential Non-Heating (Monthly)*



Appendix Figure 9: *UGI Central Penn Residential Non-Heating (Monthly)*



Appendix Figure 10: *UGI Penn Residential Non-Heating (Monthly)*

APPENDIX E
CHANGES IN MONTHLY RESIDENTIAL HEATING (15 MCF/MONTH) DISTRIBUTION COSTS

Christina Simeone, Oct 27, 2017 kleinmanenergy.upenn.edu

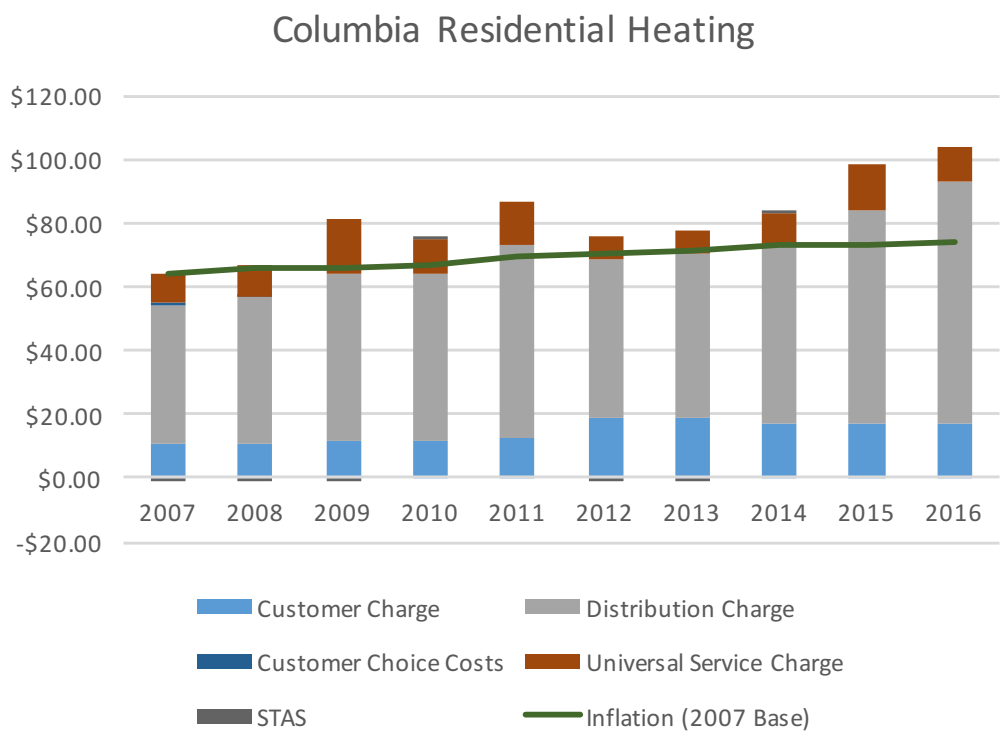
Historic data for monthly residential heating (15 Mcf/month) distribution rates charged by PA NGDCs was made available by the PA Public Utility Commission in its annual rate comparison reports (Pennyslvania Public Utility Commission 2006 - 2017). All charges are for default service as of January 31 of the applicable year.

The following distribution charges may commonly be listed on the following appendix figures, along with NGDC-specific charges that will be explained in the notes section under the applicable appendix figure. Below is a very brief description of the nature of these charges

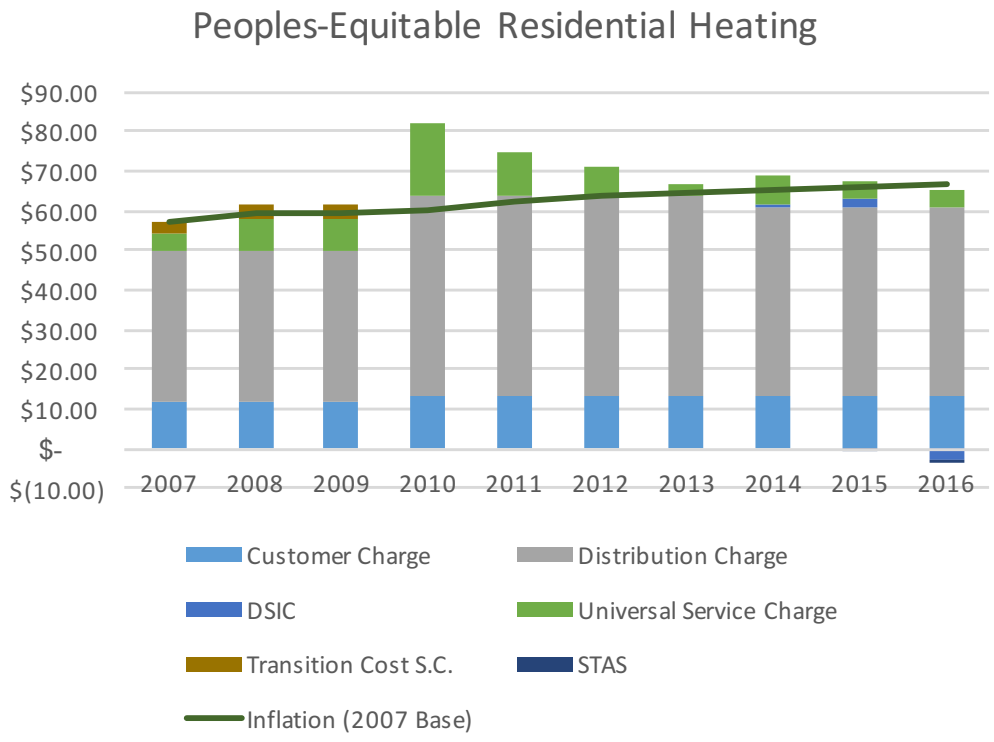
- **Customer Charge.** A flat monthly charge to cover costs related to maintaining meters and preparing bills.
- **Distribution Charge.** A rate that typically varies with the amount of gas used. Covers costs associated with delivering gas to a customer's meter.
- **Distribution System Improvement Charge (DSIC).** This charge enables the NGDC to recover costs - between rate cases - associated with improvements, replacement, or repair of eligible property needed to serve customers.
- **Education Charge.** This charge enables recovery of costs generally associated with communicating changes in the NGDC industry (e.g. restructuring) to customers.
- **State Tax Adjustment Surcharge (STAS).** A charge or credit to reflect changes in state taxes applicable to the NGDCs, as apportioned to the customer.
- **Universal Service Charge.** This charge is established to cover costs associated with the NGDC's universal service programs (e.g. low-income usage reduction program, customer assistance program, etc.).
- **Customer Choice or Transition Costs.** Generally associated with recovery of costs to the NGDC associated with transitioning to and facilitating retail competition.

Some of these charges may (or may not) be incorporated into the variable distribution charge.

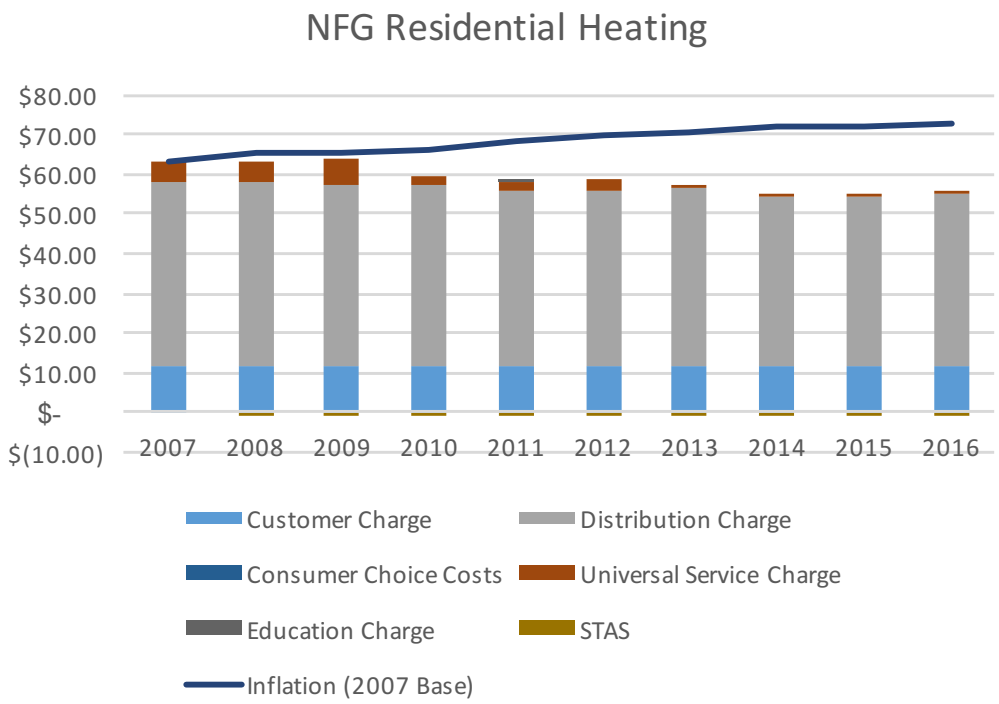
Inflation adjustments from the 2007 base year are performed using the CPI-U from the U.S. Bureau of Labor and Statistics (U.S. Bureau of Labor and Statistics 2016).



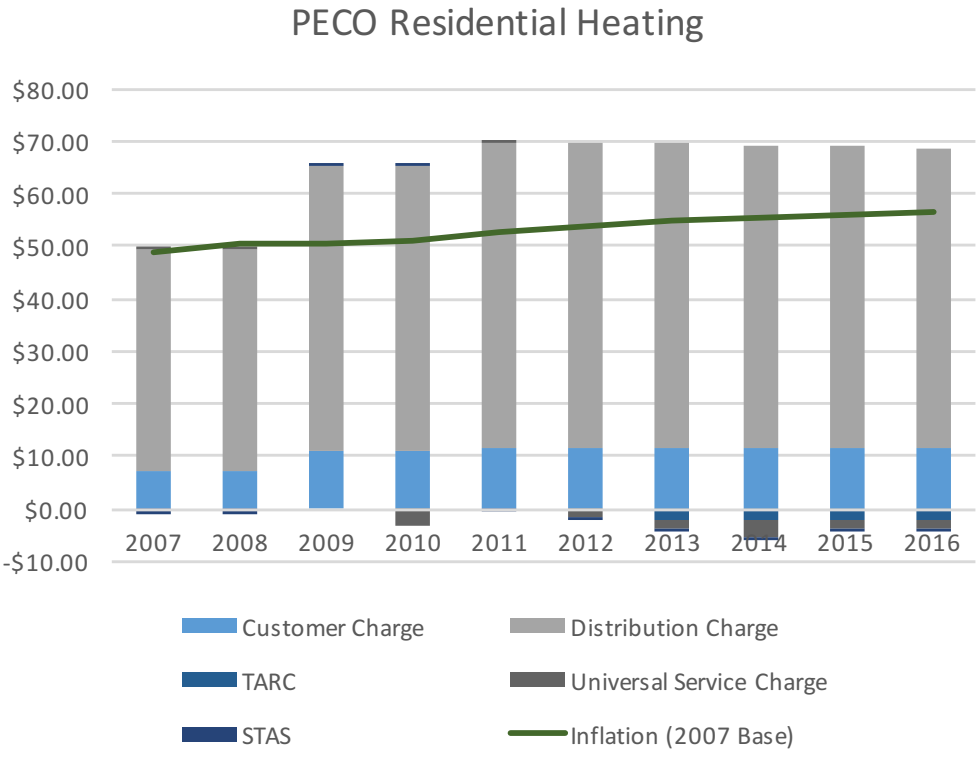
Appendix Figure 1: *Columbia Residential Heating (Monthly)*



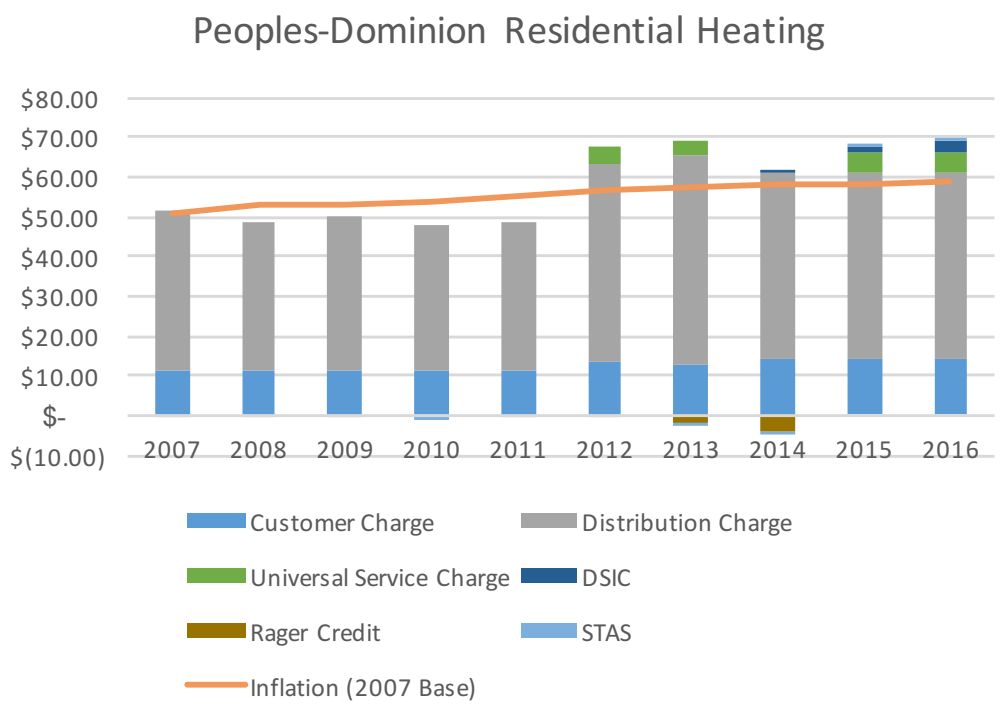
Appendix Figure 2: *Peoples-Equitable Residential Heating (Monthly)*



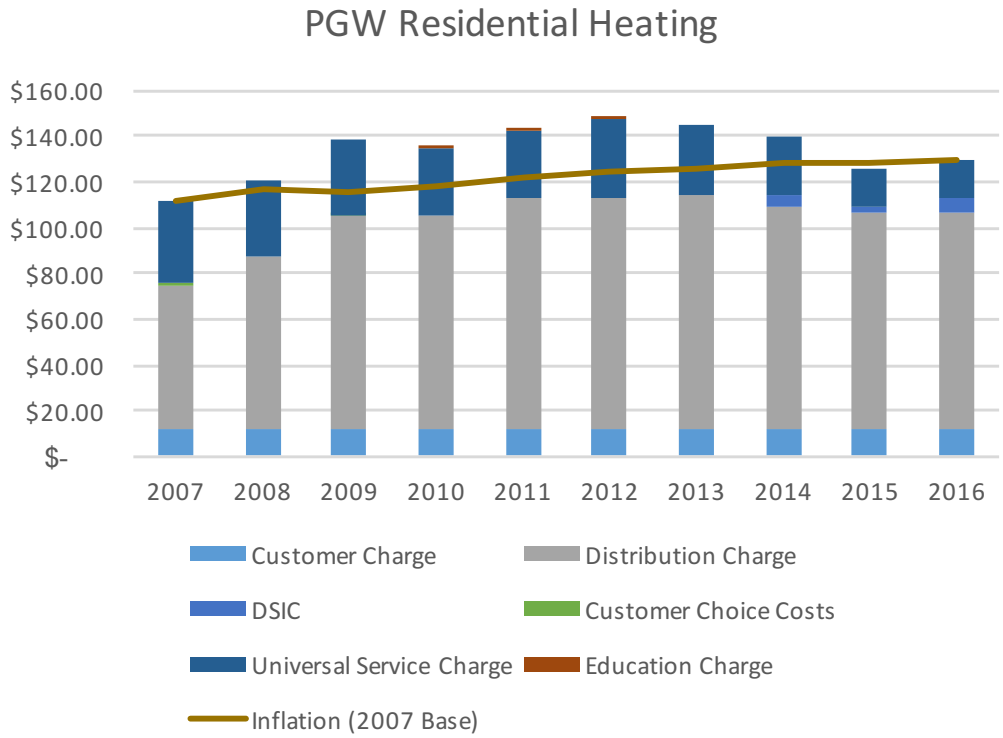
Appendix Figure 3: *NFG Residential Heating (Monthly)*



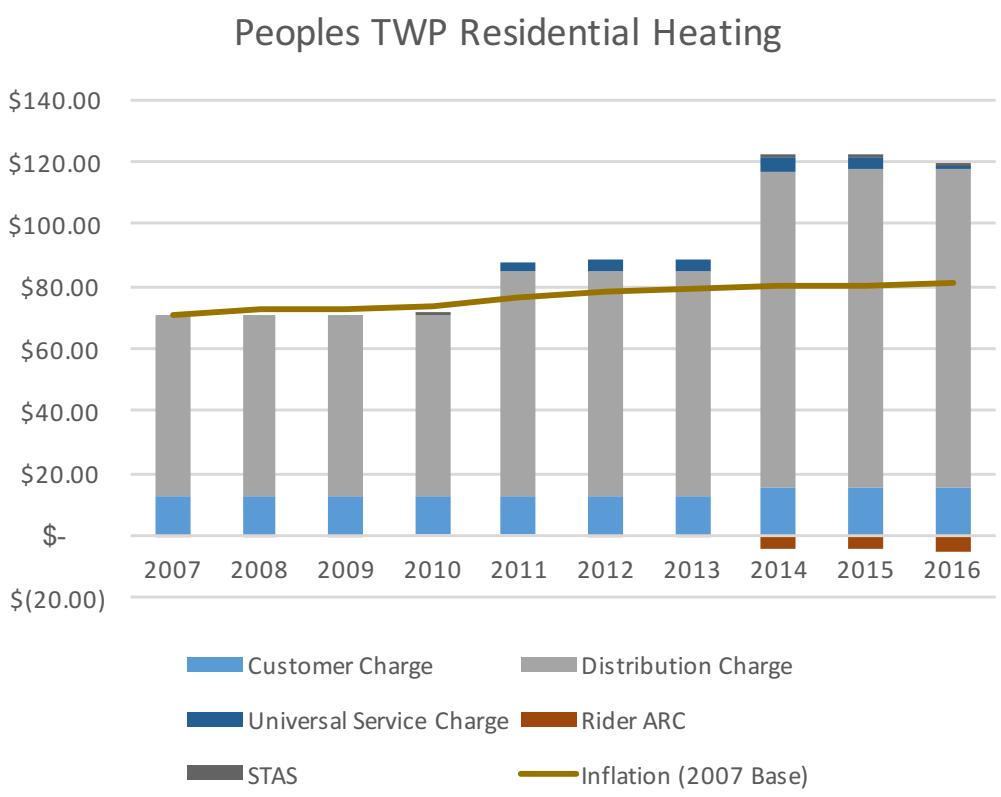
Appendix Figure 4: *PECO Residential Heating (Monthly). The Tax Accounting Repair Credit (TARC) is a credit to customers as a result of tax benefits gained from a change in tax accounting methods for certain expenditures.*



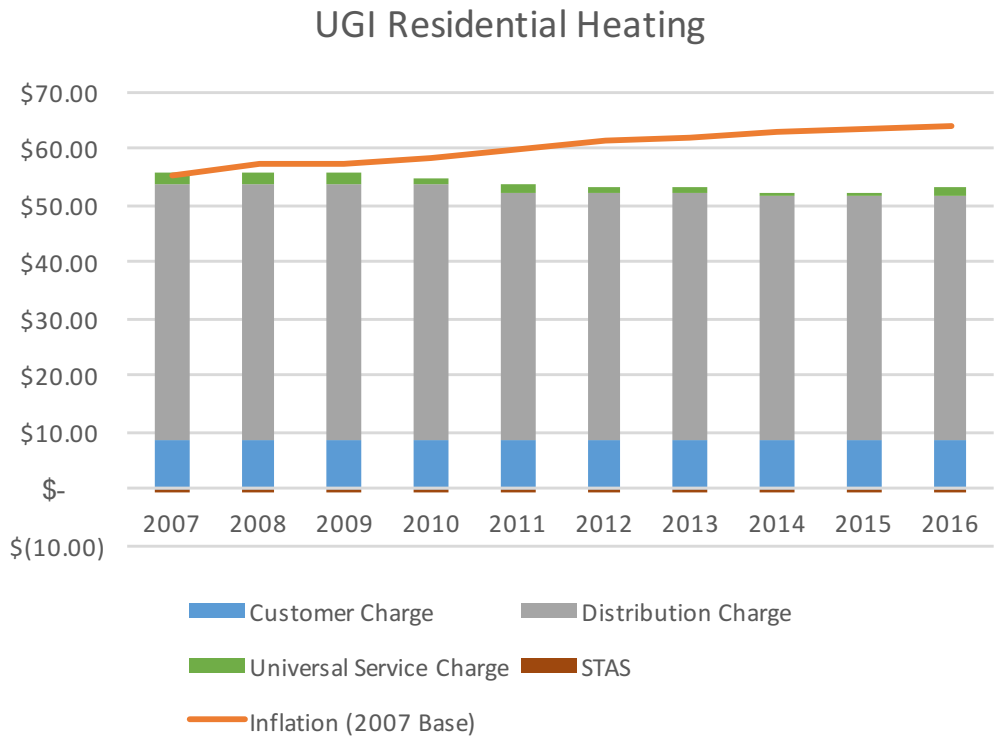
Appendix Figure 5: *Peoples-Dominion Residential Heating (Monthly). The Rager Credit is credit to customers related to Peoples-Dominion's lease of storage capacity at the Rager Mountain Storage Facility.*



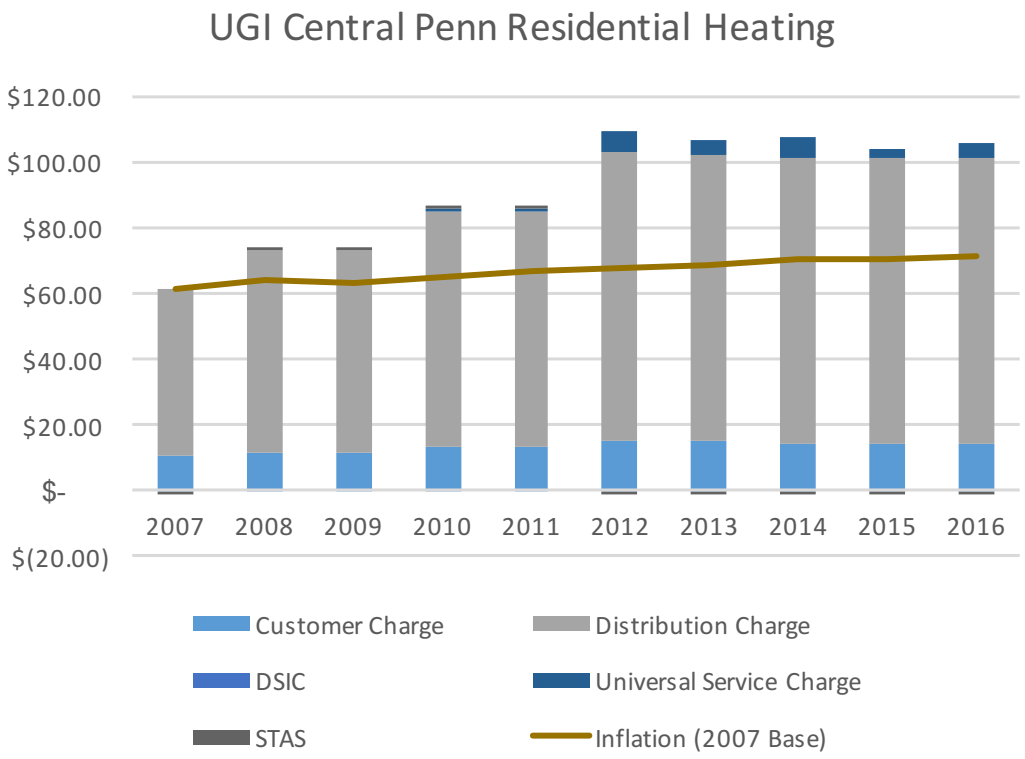
Appendix Figure 6: *PGW Residential Heating (Monthly)*



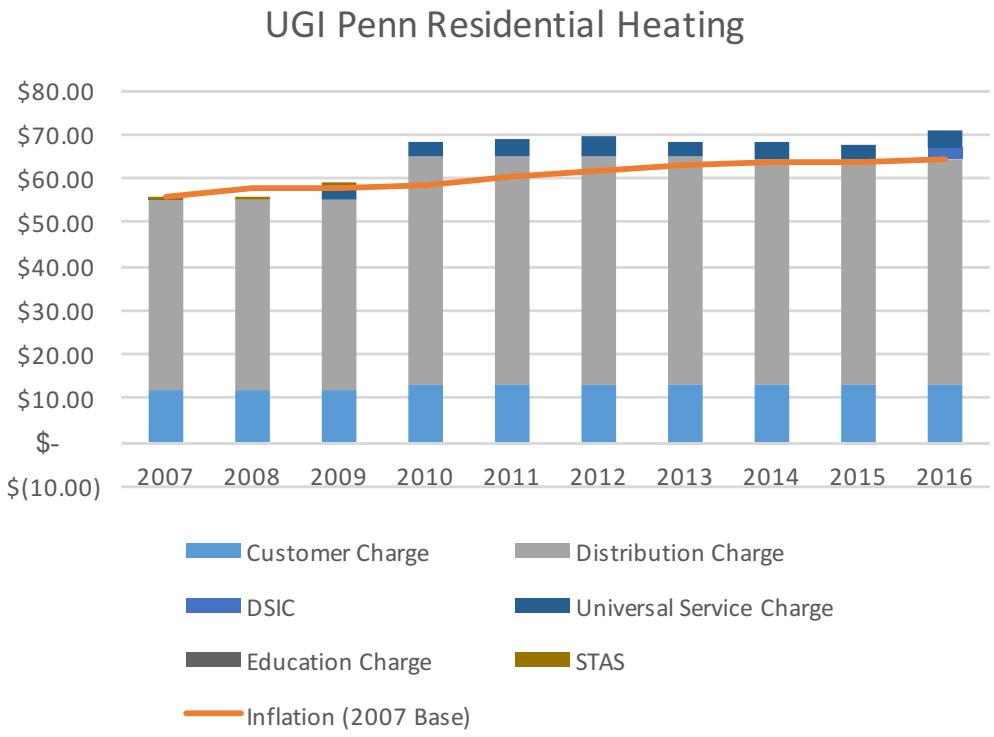
Appendix Figure 7: *Peoples TWP Residential Heating (Monthly). The Acquisition Rate Credit (Rider ARC) was established as part of the Base Rate Case settlement at Docket No. R-2013-2355886 to provide a $10,000,000 credit to ratepayers over a five-year period pursuant to the settlement of the Company's acquisition proceeding at Docket No. A-2010-2210326.*



Appendix Figure 8: *UGI Residential Heating (Monthly)*



Appendix Figure 9: *UGI Central Penn Residential Heating (Monthly)*



Appendix Figure 10: *UGI Penn Residential Heating (Monthly)*

APPENDIX F
CHANGES IN MONTHLY SMALL COMMERCIAL DISTRIBUTION (150 MCF/YEAR) COSTS

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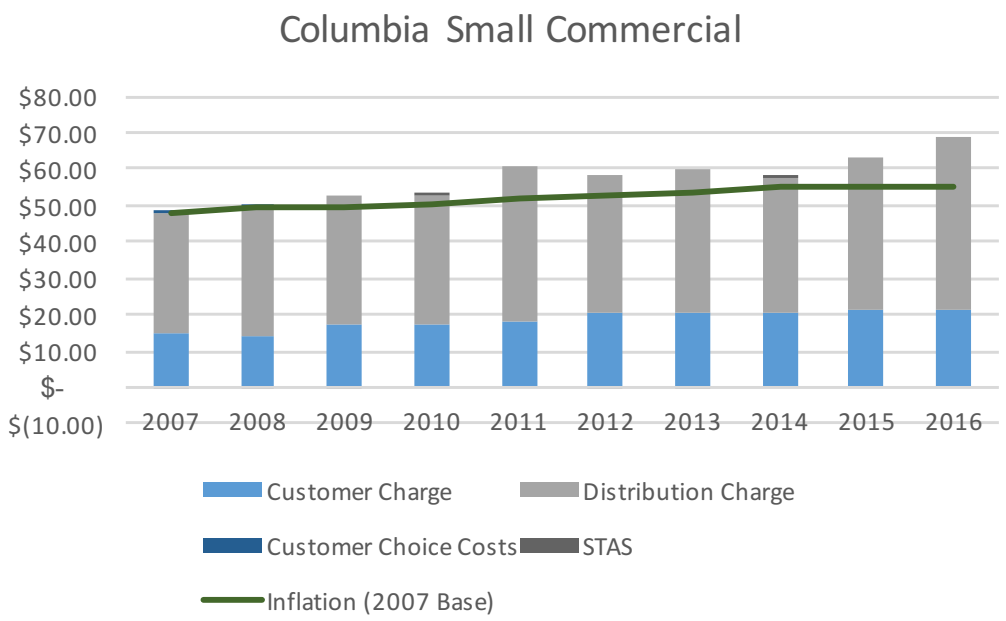
Historic data for monthly small commercial (150 Mcf/year) distribution rates charged by PA NGDCs was made available by the PA Public Utility Commission in its annual rate comparison reports (Pennyslvania Public Utility Commission 2006 - 2017). All charges are for default service as of January 31 of the applicable year.

The following distribution charges may commonly be listed on the following appendix figures, along with NGDC-specific charges that will be explained in the notes section under the applicable appendix figure. Below is a very brief description of the nature of these charges.

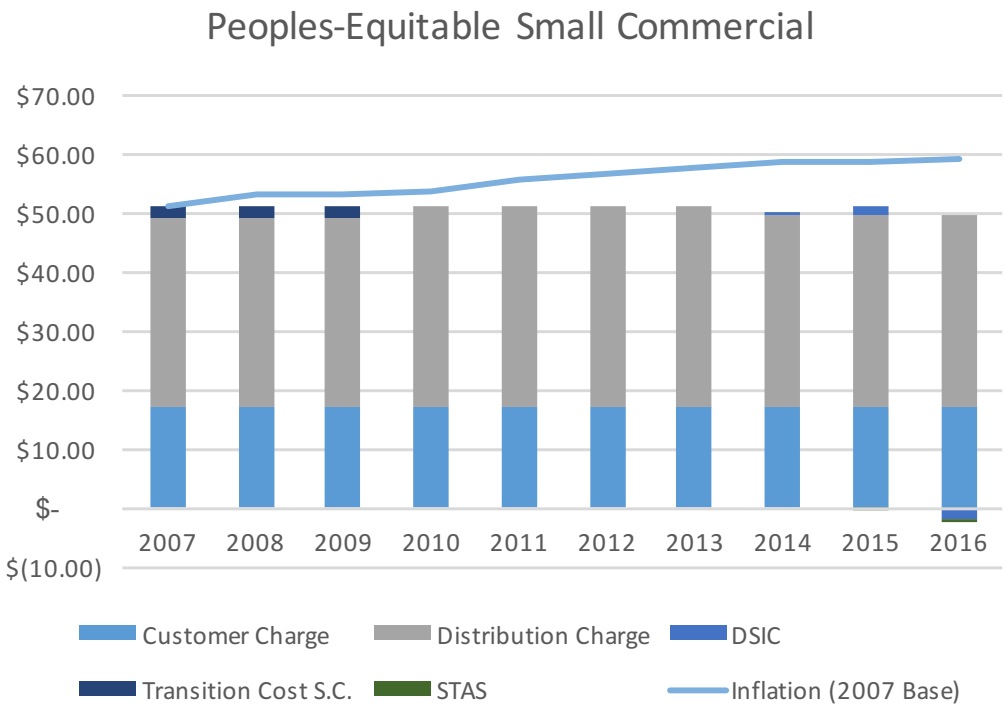
- **Customer Charge.** A flat monthly charge to cover costs related to maintaining meters and preparing bills.
- **Distribution Charge.** A rate that typically varies with the amount of gas used. Covers costs associated with delivering gas to a customer's meter.
- **Distribution System Improvement Charge (DSIC).** This charge enables the NGDC to recover costs - between rate cases - associated with improvements, replacement, or repair of eligible property needed to serve customers.
- **Education Charge.** This charge enables recovery of costs generally associated with communicating changes in the NGDC industry (e.g. restructuring) to customers.
- **State Tax Adjustment Surcharge (STAS).** A charge or credit to reflect changes in state taxes applicable to the NGDCs, as apportioned to the customer.
- **Universal Service Charge.** This charge is established to cover costs associated with the NGDC's universal service programs (e.g. low-income usage reduction program, customer assistance program, etc.).
- **Customer Choice or Transition Costs.** Generally associated with recovery of costs to the NGDC associated with transitioning to and facilitating retail competition.

Some of these charges may (or may not) be incorporated into the variable distribution charge.

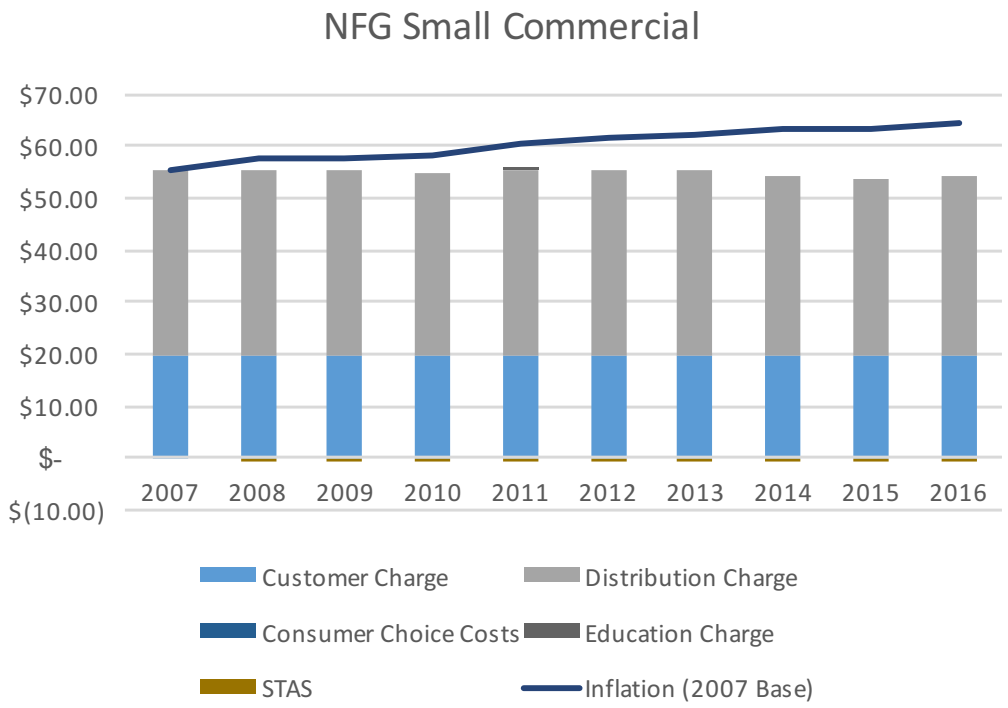
Inflation adjustments from the 2007 base year are performed using the CPI-U from the U.S. Bureau of Labor and Statistics (U.S. Bureau of Labor and Statistics 2016).



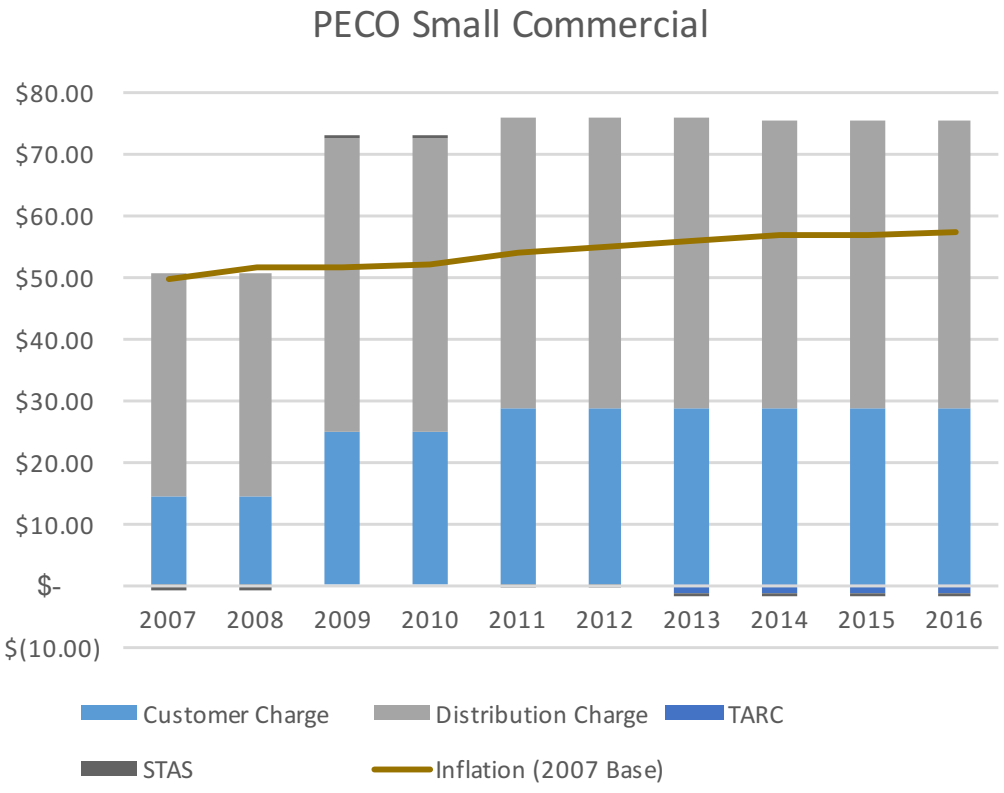
Appendix Figure 1: *Columbia Small Commercial Monthly Distribution*



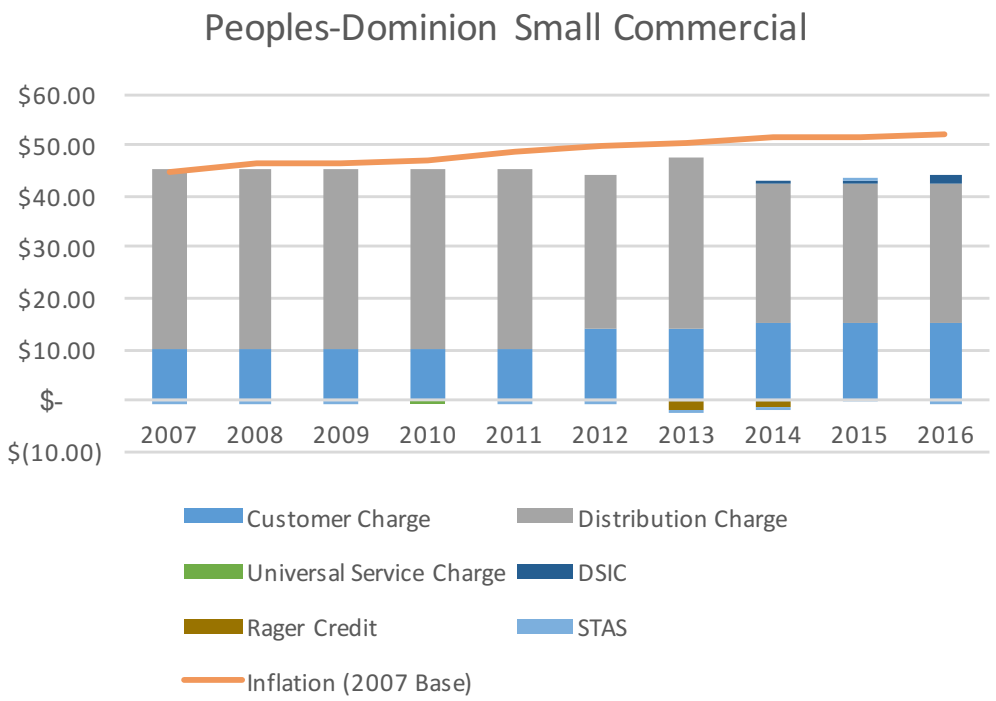
Appendix Figure 2: *Peoples-Equitable Small Commercial Monthly Distribution*



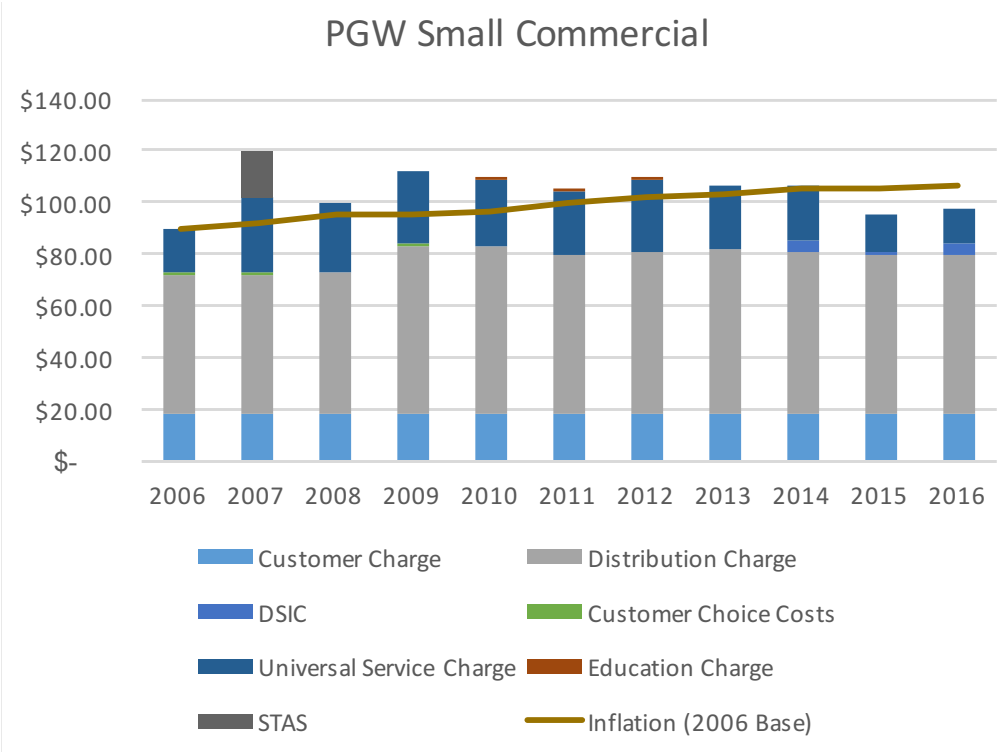
Appendix Figure 3: *NFG Small Commercial Monthly Distribution*



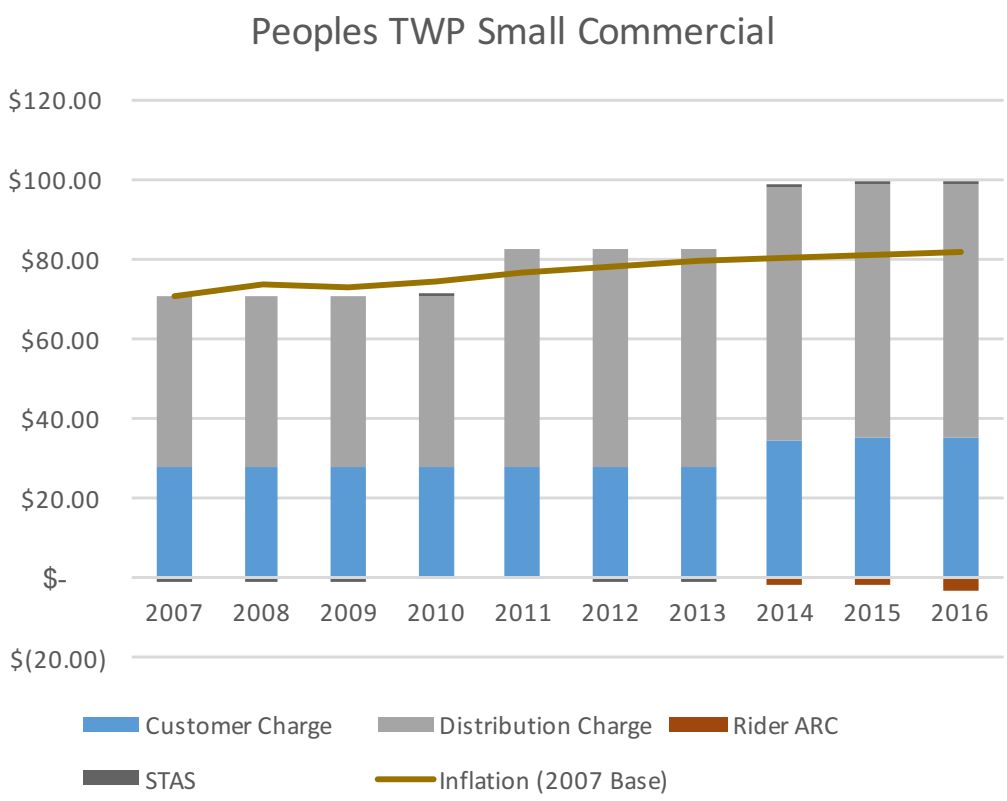
Appendix Figure 4: *PECO Small Commercial Monthly Distribution. The Tax Accounting Repair Credit (TARC) is a credit to customers as a result of tax benefits gained from a change in tax accounting methods for certain expenditures.*



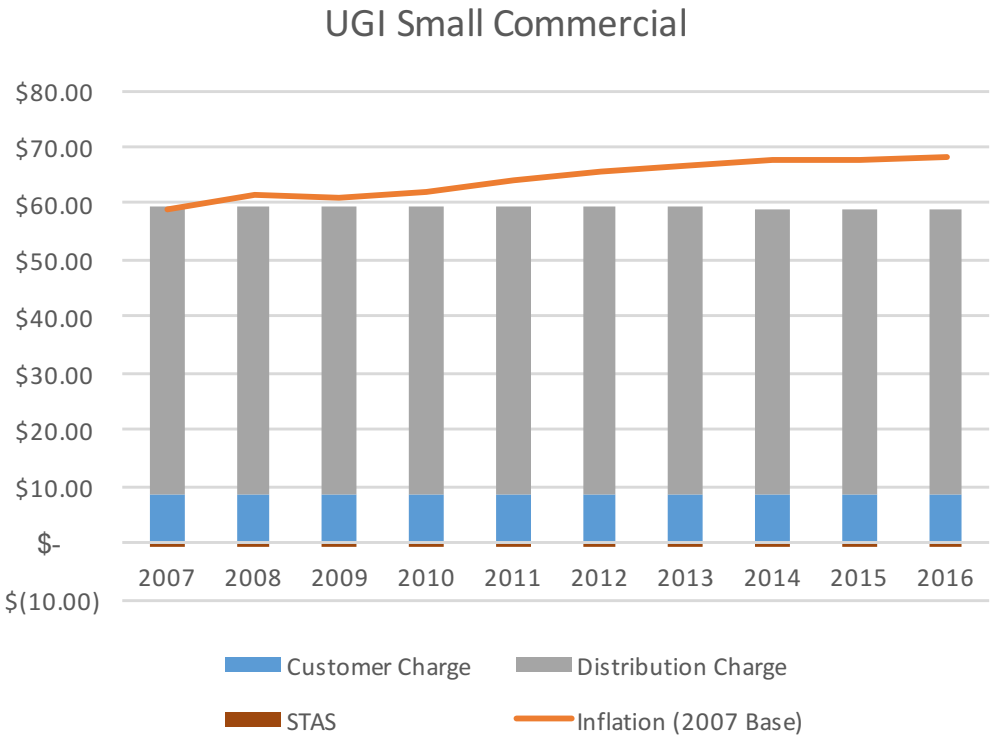
Appendix Figure 5: *Peoples-Dominion Small Commercial Monthly Distribution. The Rager Credit is credit to customers related to Peoples-Dominion's lease of storage capacity at the Rager Mountain Storage Facility.*



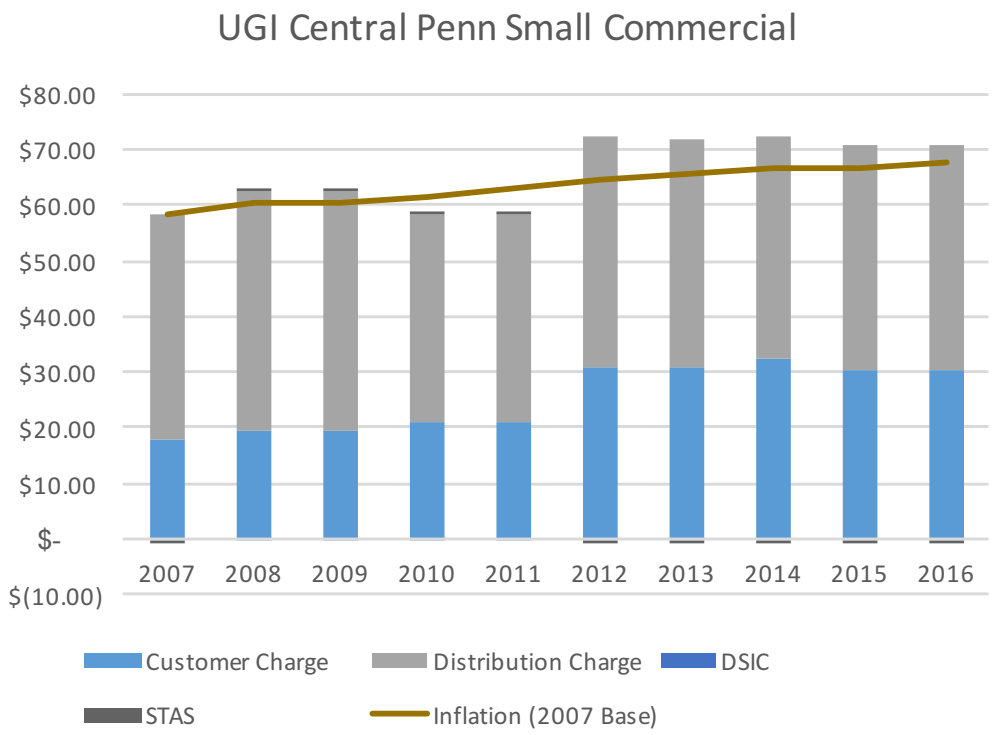
Appendix Figure 6: *PGW Small Commercial Distribution Monthly. A 2006 base year was used for PGW's inflation adjustment as a result of the large and anomalous STAS charge in 2007.*



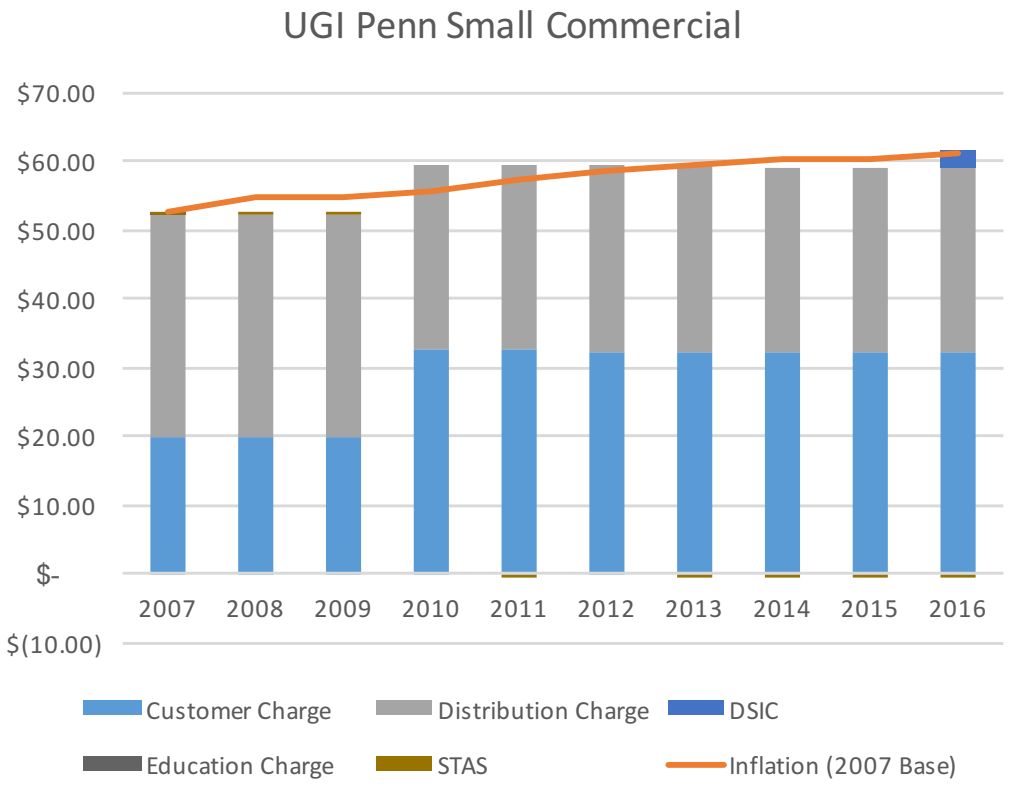
Appendix Figure 7: *Peoples TWP Small Commercial Distribution Monthly. The Acquisition Rate Credit (Rider ARC) was established as part of the Base Rate Case settlement at Docket No. R-2013-2355886 to provide a $10,000,000 credit to ratepayers over a five-year period pursuant to the settlement of the Company's acquisition proceeding at Docket No. A-2010-2210326.*



Appendix Figure 8: *UGI Small Commercial Distribution Monthly*



Appendix Figure 9: *UGI Central Penn Small Commercial Distribution Monthly*



Appendix Figure 10: *UGI Penn Small Commercial Distribution Monthly*

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