

# ICHRIE Penn State Research Report

## The Impact of Marcellus Shale Development on Hotel Revenues in Pennsylvania

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### **Abstract**

New technologies have allowed for new drilling in oil and gas deposits throughout the world. In the Northeast United States, the Marcellus Shale formation has been one of the most active regions for new wells. This new drilling activity has created a visible economic impact to communities in and around the drilling sites. The increase in hotel activity metrics such as occupancy percentage and average daily rate has been noted but there has been no research that determines the total revenue impact of the drilling activity. This research does not attempt to factor in the social and environmental costs that have been discussed with the new drilling activities.

This research studied the total revenue impact of the Marcellus Shale regions in the state of Pennsylvania. The state of Pennsylvania was chosen for this study as the state maintains detailed records on well development by county, while other states do not provide such data. Based on determinations made by a leading Marcellus Outreach Center, five distinct drilling “regions” were identified. STR provided hotel performance data. The performance indicators (demand, average daily rate, total revenue) of the hotels in the five drilling regions were tracked against the U.S. hotel industry performance indicators for comparable time periods.

It was determined that approximately \$685 million of hotel revenue has been generated by Marcellus Shale drilling activities. The incremental revenue was generated by both demand and average daily rate increases. This is a significant economic benefit to the drilling regions with increased tax collections for the taxing agencies and consumer spending by those visiting the region for drilling related activity.

Approximately 65 new hotels were added in the drilling regions beyond what could have been expected with no drilling based on U.S. hotel industry supply trends. These new hotels are, almost exclusively, select-service, branded hotels. The average room size was 82 rooms, with an average employee count of 25 employees, the drilling has accounted for approximately 1,600 new hotel jobs plus whatever new jobs were added based on the increased occupancy levels of existing hotels.

The cautionary note in the findings is that the 2012 data suggests that the demand could be stabilizing or decreasing. Demand in 2012 was flat at 0.0 percent but occupancy was down

by 4.1 percent due to the increased supply. While the regions are still experiencing increased hotel revenues compared to a “non-Marcellus” scenario, the increase in hotel supply is making for a more challenging competitive environment for individual hotels.

The findings suggest that new hotel development should begin early in a drilling environment and that hotels should have a long-term viability strategy as the long-term demand may stabilize or decrease. Sixty-two of the 65 new hotels were branded, 60 of those were select-service. Existing older and non-branded hotels will face a tougher operating environment and should have an exit strategy. Of the 14 hotels that closed in the drilling regions between 2006-2012, 9 were independents and the average age of all 14 hotels was over 38 years old.

## The Impact of Marcellus Shale Development on Hotel Revenues in Pennsylvania

### Introduction

The refinement and adaptation of new oil and natural gas drilling technologies has made accessing oil and gas from “unconventional” sources (e.g., shales, tight sands) economically feasible. As a result, a modern-day “rush” has been occurring in several regions of the United States, such as western North Dakota (Bakken formation), Texas (Barnett and Eagle Ford), and several Northeastern states (Marcellus). Social scientists have dubbed the communities experiencing this development as “boomtowns,” in the extent to which they tend to experience rapid growth, increased economic activity, and associated social problems and stress on infrastructure.<sup>1</sup> Because local community members tend not to have the requisite skills for the extractive activity, and the technical skills required are quite specialized, the industry tends to import workers. As a result, one of the most critical problems faced by boomtowns is a need for housing, particularly temporary housing in the form of hotels/motels, RV campgrounds, and mobile homes.

This study focused on the impacts of natural gas extraction on temporary housing, specifically hotels, in the Marcellus Shale region. The Marcellus Shale is a natural gas-bearing formation that lies beneath portions of Pennsylvania, New York, Ohio, Maryland, and West Virginia. Hotels in this region have noted increased occupancies, average daily rate (ADR) and revenue<sup>2</sup> but there has been no research that has quantified the total revenue impact on the hotel industry in this region. This research quantified the total revenue impact to hotels in the Marcellus Shale region and discussed the nature of the recognition of that revenue through increased demand and ADR as well as discussed the impact of the hotel demand on new hotel supply in the region.

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<sup>1</sup> Cortese, C.F., & Jones, B. (1977). The sociological analysis of boomtowns. *Western Sociological Review*, 8(1):75-90.

Jacquet, J. (2009). Energy boomtowns & natural gas: Implications for Marcellus Shale local governments & rural communities. NERCRD Rural Development Paper 43.

<sup>2</sup> O’Neill, J. (2012). Fracking boosts hotel business. *Lodging Hospitality*, 22, 24.

PKF Hospitality Research. (2012). Shale natural gas fueling Pennsylvania hotel industry. Retrieved 31 July 2013 from [http://www.hotel-online.com/news/PR2012\\_1st/Jan12\\_PAShale](http://www.hotel-online.com/news/PR2012_1st/Jan12_PAShale)

## Background

Much of the Marcellus Shale-related drilling and development activity in Pennsylvania has been in very rural areas of the Commonwealth, with relatively low population levels and small local economies. The combination of the highly specialized nature of the work, and the relatively few residents in these communities who have those required skills, has resulted in significant numbers of non-local workers temporarily moving into these communities. In addition, several larger communities in close proximity to the drilling activity, such as Williamsport, have become regional hubs for companies and workers, who commute from there to well pads and supporting infrastructure in neighboring counties.

The influx of non-local workers into communities where drilling is occurring, has created significant housing related problems.<sup>3</sup> Williamson and Kolb found that as workers initially arrive in Marcellus communities, they occupy temporary housing units (hotels, company sponsored residential facilities, campgrounds, and rental housing). As a “second wave” of workers arrive associated with company headquarters and regional offices (and who are more likely to stay for longer time periods), they tend to occupy rental and owner-occupied units. Anecdotal evidence from communities with Marcellus Shale development activity has suggested similar issues are arising with availability of hotel rooms, and it has been relatively common to hear complaints that hotel rooms are difficult to find within an hour or two of areas with much development. Drilling activity has been very robust across Pennsylvania, particularly in the early years of development. Since late 2011, however, dramatically falling natural gas prices have visibly slowed drilling, with the total number of wells drilled declining from 1,968 wells in 2011 to 1,362 wells in 2012.<sup>4</sup>

There has been little academic research into the specific effects of Marcellus Shale oil and gas drilling on the hotel industry. Consulting companies and academics publishing in print and online trade journals has provided most of the information available. O’Neill (2012)

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<sup>3</sup> Williamson, J. & Kolb, B. (2011). *Marcellus natural gas development’s effect on housing in Pennsylvania*. Williamsport, PA: Lycoming College Center for the Study of Community and the Economy. Institute for Public Policy and Economic Development. (2011). *Impact on housing in Appalachian Pennsylvania as a result of Marcellus Shale*. Wilkes Barre, PA: Institute for Public Policy and Economic Development.

<sup>4</sup> Pennsylvania Department of Environmental Protection (DEP). (2013). Office of Oil and Gas Management: Wells Drilled by County. 2006 through 2012. [http://www.portal.state.pa.us/portal/server.pt/community/office\\_of\\_oil\\_and\\_gas\\_management/20291](http://www.portal.state.pa.us/portal/server.pt/community/office_of_oil_and_gas_management/20291). Accessed on 21 Nov 2013.

presented data by state for the years 2009-2011 and found that RevPAR (revenue per available room) had increased in Pennsylvania Marcellus Shale regions by 8.8 percent from 2009 to 2010 and 10.0 percent from 2010-2011. More importantly, lodging demand increased in the Marcellus regions by 12.5 percent in 2010 and 7.4 percent in 2011. RevPAR numbers are insightful but incorporate added supply during the time periods studied. O'Neill stated that lodging demand in the Marcellus Shale regions of Pennsylvania has grown at higher rates than national averages (national demand increases were 7.2 percent in 2010 and 4.7 percent in 2011).

A study by PKF consulting<sup>5</sup> found that RevPAR had increased at an annual rate of 14.8 percent in the, "northeast Pennsylvania" (Bradford, Lycoming, Susquehanna and Tioga counties) shale regions. They stated that this region had achieved "significant" RevPAR growth each and every year from 2007 to 2011, even through the recession years. The study concluded that, "the surveyed northeast region of Pennsylvania is benefitting economically from the rapid growth of the natural gas industry's exploitation of the Marcellus Shale. Demand for lodging, driven by transient workforce influxes, is driving strong growth in occupancies and ADRs in a historically lackluster hotel market." PKF concluded that their research indicated a fairly consistent ration of 200 new annual room nights of lodging demand per new well. Again, this study addresses RevPAR and does not provide any information on the overall revenue benefit to hotels in the study area.

### **Research Methodology**

This research quantified the revenue benefit in dollars for the Marcellus Shale regions of Pennsylvania. Five distinct shale regions were identified by county as shown in Table 1, based loosely upon drilling patterns, geography, and local labor markets. The total number of wells in the specified areas represents 92 percent of all Marcellus Shale wells drilled in the state of Pennsylvania. Because there was limited hotel supply in many of the Pennsylvania counties due to their relatively small populations and rural locations, adjoining counties were added to the study area. For example, in the Northeast region, there were only six hotels with 385 total rooms in Susquehanna and Wyoming counties so Lackawanna County and Broome County in New York were added to the region as hotel demand is likely pushed to those adjoining counties.

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<sup>5</sup> PKF Hospitality Research. (2012). Shale natural gas fueling Pennsylvania hotel industry. Retrieved 31 July 2013 from [http://www.hotel-online.com/news/PR2012\\_1st/Jan12\\_PAShale](http://www.hotel-online.com/news/PR2012_1st/Jan12_PAShale)

The study compared actual performance data of the hotel in the five regions to national hotel trends, including total demand (defined as occupied room nights), average daily rate (total revenue divided by occupied rooms) and total rooms revenue. No specific impacts could be identified in years where there were fewer than ten wells so the base year for comparisons identified for each region was the year that the region recorded having more than ten wells drilled.

Table 1. Pennsylvania Marcellus Shale regions by county with wells and base year for study

| PA Region  | Northeast   | North Central   | Central    | West Central        | Southwest   |
|------------|---|---|------------|---------------------|---|
| Wells      | 761   | 2,667   | 147        | 322                 | 2,037   |
| Counties   | Susquehanna<br>Wyoming<br>Lackawanna<br>Broome (NY) | Lycoming<br>Bradford<br>Sullivan<br>Tioga<br>Clinton<br>Tioga (NY)<br>Chemung<br>(NY) | Clearfield | Butler<br>Armstrong | Greene<br>Washington<br>Fayette<br>Westmoreland<br>Beaver<br>Ohio (WV)<br>Brooke (WV)<br>Hancock<br>(WV)<br>Marshall<br>(WV)<br>Wetzel (WV)<br>Monongalla<br>(WV) |
| Base year* | 2007  | 2007  | 2008       | 2006                | 2005  |

\* Base year is year in which region first had over ten wells drilled.

The decision to use national trends rather than Pennsylvania trends was based on the fact that from 2007-2011, Pennsylvania RevPAR percentage changes exceeded national RevPAR percentage changes in each year, indicating that the Marcellus Shale regions were impacting the Pennsylvania data. The Pennsylvania and national annual RevPAR percentage changes are shown in Table 2.

Table 2. RevPAR percentage changes for U.S. and Pennsylvania hotels

| Location    | 2007 | 2008 | 2009  | 2010 | 2011 |
|-------------|------|------|-------|------|------|
| U.S. Hotels | 7.4  | .3   | -14.3 | 7.2  | 8.7  |
| PA Hotels   | 9.7  | 1.3  | -9.9  | 7.5  | 10.6 |

Note: data provided by STR

The baseline data for the comparison is demand, ADR and total revenue for U.S. hotels. The percentage changes in this data were then applied to the Marcellus Shale regions to establish the “non-Marcellus drilling scenario” (e.g. what would have happened in the region if hotel demand had followed national trends). The raw data for the aggregate of the five regions is shown in Table 3.

Table 3. Aggregate raw key performance indicators for each year

| Perf. Indicator | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  |
|-----------------|-------|-------|-------|-------|-------|-------|-------|
| Occupancy (%)   | 57.9  | 58.8  | 60.2  | 58.5  | 65.   | 69.9  | 67.0  |
| ADR (\$)        | 78.43 | 83.38 | 86.08 | 84.86 | 86.05 | 90.75 | 95.64 |
| RevPAR (\$)     | 45.41 | 49.05 | 51.80 | 49.63 | 55.92 | 63.44 | 64.09 |

The year 2006 was the year that total wells drilled exceeded ten wells and was also the year where the five regions, in aggregate, began outperforming the U.S. industry average. The five regions, in aggregate, had greater percentage increases than the U.S. hotel industry on occupancy, average daily rate and RevPAR every year from 2006-2011. The U.S. hotel industry year-over-year percentage change in demand, ADR, and RevPAR are shown in Table 4.

Table 4. U.S. hotel industry demand, ADR and total revenue annual percentage change, 2005-2012

| U.S. Hotel Ind. Data | 2006 | 2007 | 2008 | 2009  | 2010 | 2011 | 2012 | <b>2005-2012</b> |
|----------------------|------|------|------|-------|------|------|------|------------------|
| Demand               | .5   | .7   | -2.5 | -6.2  | 7.2  | 4.7  | 2.9  | <b>6.8</b>       |
| ADR                  | 7.5  | 6.7  | 3.   | -8.7  | 0    | 3.8  | 4.2  | <b>16.7</b>      |
| Total revenue        | 8.0  | 7.4  | .3   | -14.3 | 7.2  | 8.7  | 7.3  | <b>24.6</b>      |

*Note:* data provided by STR

The national hotel industry annual percentage changes were applied to each regions’ base year data to provide annual numbers going forward from the base year for the “no-Marcellus drilling” scenario. These numbers were then compared to the actual data for each region from STR, a hotel industry analytics company that obtains data from hotels and provides competitive operations statistics. Seventy-nine percent of all hotel rooms in the study areas participated in the STR data collection during the time of this study. When working with large industry segments, STR will model the data for non-participating hotels so that the numbers presented

represent 100 percent of the hotels in areas studied. Table 5 presents the U.S. percentage changes in demand, ADR, and RevPAR compared to the same actual measures for each region. The first column shows the U.S. trend numbers for the measures from the base year of each region through 2012. For example, for South West PA, the base year was 2005 so the percent change in U.S. demand from 2005-2012 was 6.8 percent. As can be seen in the table, all five regions studied had experienced occupancy, ADR, and revenue increases significantly higher than the U.S. trend over the applicable time periods.

Table 5. Total Percentage changes in Demand, ADR and RevPAR by region from base year through 2012.

|                        | U.S. | Southwest | West<br>Central | Northeast | North<br>Central | Central |
|------------------------|------|-----------|-----------------|-----------|------------------|---------|
| Base year              |      | 2005      | 2006            | 2007      | 2007             | 2008    |
| U.S. Base Year<br>2005 | .    |           |                 |           |                  |         |
| Demand                 | 6.8  | 47.0      |                 |           |                  |         |
| ADR                    | 16.7 | 37.2      |                 |           |                  |         |
| Total Revenue          | 24.6 | 101.7     |                 |           |                  |         |
| U.S. Base Year<br>2006 | .    |           |                 |           |                  |         |
| Demand                 | 6.3  |           | 32.4            |           |                  |         |
| ADR                    | 8.6  |           | 25.9            |           |                  |         |
| Total Revenue          | 15.4 |           | 66.7            |           |                  |         |
| U.S. Base Year<br>2007 | .    |           |                 |           |                  |         |
| Demand                 | 5.5  |           |                 | 21.9      | 41.2             |         |
| ADR                    | 1.8  |           |                 | 9.2       | 37.0             |         |
| Total Revenue          | 7.4  |           |                 | 33.1      | 93.5             |         |
| U.S. Base Year<br>2008 | .    |           |                 |           |                  |         |
| Demand                 | 8.3  |           |                 |           |                  | 13.7    |
| ADR                    | -1.1 |           |                 |           |                  | 17.9    |
| Total Revenue          | 7.1  |           |                 |           |                  | 34.1    |

The total revenue effect, in dollars, is presented in Table 6. The first row, “Total revenue if followed national trends,” is the, “no-Marcellus drilling” scenario. Total revenue was

calculated by applying U.S. hotel industry annual changes to the study areas. The second row is the actual revenue reported by STR for the study areas for the applicable years indicated in the column headings for each region. The total revenue increase for all the five study regions totaled just over \$684.5 million as shown in the table.

Table 6. Total revenue increase by region

|  | Southwest | West<br>Central | Northeast | North<br>Central | Central |
|--|-----------|-----------------|-----------|------------------|---------|
| Total revenue if region followed national trends | 1,031.1   | 172.9           | 388.3     | 252.7            | 55.6    |
| Actual total revenue for region                  | 1,452.9   | 210.2           | 451.7     | 397.8            | 72.3    |
| Revenue difference by region                     | 421.8     | 37.3            | 63.4      | 145.1            | 16.7    |
| Total revenue difference for all regions         | 684.3     |                 |           |                  |         |

### Findings and Discussion

It is obvious that Marcellus Shale drilling has had a significant effect on hotel revenues in the study area. In Table 6, the total increase in revenue was just over \$684.5 million. The total revenue hotels without Marcellus Shale drilling, following the national trends, would have been approximately \$2.1 billion, which thus suggests that Marcellus Shale activity had raised hotel revenues in the study areas by 32.6 percent. Based on a variance analysis to determine the price variance and the volume variance (calculating increased revenues with new demand based on existing rate, and calculating increased revenues with existing demand and new average rate), it is estimated that 60 percent of the increase in revenue was from demand, 40 percent was from an increased average daily rate, driven by high demand.

### Hotel Room Supply Impact

All of the regions studied were experiencing impacts on the supply of hotel rooms by 2009. The total U.S. demand, measuring from 2008 was up 8.3 percent while the occupancy percentage was up 2.6 percent. The difference between the two numbers is explained by a 5.6 percent increase in hotel room supply over the same period. In the Marcellus Shale regions, in total, demand was up by 26 percent and occupancy was up by 11.4 percent. Again, the

difference is explained by the increase in supply, much higher in the Marcellus Shale regions than the U.S., on average, as shown in Table 7. The first column shows the U.S. trend numbers for the measures from the base year of each region through 2012. For example, for South West PA, the base year was 2005 so the percent change in U.S. supply from 2005-2012 was 9.7 percent. In the Marcellus Shale regions, in aggregate, there were 65 new hotels with 5,347 rooms. Fourteen hotels closed during the study period. If the closed hotels were, on average, the same size in terms of hotel rooms as the newly opened hotels, the net gain was 4,131 rooms, or 1,507,815 new rooms to rent on an annual basis. The increased demand in the area for the same time period was 1.6 million rooms on an annual basis. In combination with the fact that the majority of new hotels opened in that last two years, the occupancy for the study area increased from 56.6 percent in 2005 to 67.0 percent in 2012 compared to 60.4 percent in 2012 in the non-Marcellus drilling scenario. The occupancy increase was particularly strong in 2010 (increasing from 58.5 percent to 65 percent) and 2011 (increasing from 65.0 percent to 69.9 percent) as active wells more than doubled in number from 2009-2011 and the U.S. economy recovered as well.

Table 7. Total percentage change in supply by region from base year.

| Supply % change | U.S. | Southwest | West<br>Central | Northeast | North<br>Central | Central |
|-----------------|------|-----------|-----------------|-----------|------------------|---------|
| Base year       |      | 2005      | 2006            | 2007      | 2007             | 2008    |
| 2005-2012       | 9.7  | 17.5      |                 |           |                  |         |
| 2006-2012       | 9.4  |           | 16.4            |           |                  |         |
| 2007-2012       | 8.1  |           |                 | 12.6      | 20.9             |         |
| 2008-2012       | 5.6  |           |                 |           |                  | 14.5    |

## 2012 Trending

It was previously noted that the occupancy in the study area was 69.9 percent in 2011 and 67.0 percent in 2012. The data for 2012, when drilling had slowed from earlier years due to falling natural gas prices, indicates that the Marcellus Shale regions are starting to show more stabilized numbers. The total demand for the region was flat with a 0.0 percent change over 2011. Four of the five regions did not achieve the U.S. average of a 2.9 percent positive demand change and three of the regions saw a decrease in demand. The occupancy change percentages, incorporating the new supply, were all negative for 2012. Though it must be noted all of the

regions except Central PA still have an occupancy percentage higher than the U.S. average for 2012. It is clear in Table 8 that the revenue increases in the Marcellus Shale region for 2012 were solely due to continuing average daily rate increases.

Table 8. Changes in key performance indicators by region.

|                        | Demand | Occupancy | ADR | Total revenue |
|------------------------|--------|-----------|-----|---------------|
| U.S.                   | 2.9    | 2.5       | 4.2 | 7.3           |
| Southwest              | 2.0    | -.8       | 6.0 | 8.2           |
| West Central           | 11.9   | -1.5      | 4.4 | 16.9          |
| North Central          | -6.0   | -11.2     | 6.5 | .1            |
| Northeast              | -1.0   | -5.5      | 3.3 | 2.2           |
| Central                | -10.6  | -11.3     | 4.6 | -6.5          |
| Marcellus<br>aggregate | 0.0    | -4.1      | 5.4 | 5.4           |

### Implications for Practice or Policy

The impact of Marcellus Shale drilling has had a significant revenue impact on the hotel industry in Pennsylvania. The state, as a whole, experienced RevPAR growth higher than the U.S. average from 2007-2011. The estimated hotel total revenue impact in the Marcellus Shale region was just over \$900 million between 2005-2012. As this total is calculated from 92 percent of the wells in Pennsylvania, the total statewide revenue impact may be closer to \$1 billion. This increase has been driven primarily by a demand increase of 1.6 million hotel rooms, approximately 1.3 million more room than if all the hotels in the region studied had experienced growth at matching national trends. The secondary driver of revenue has been the increase in the average daily rate achieved by hotels in the study.

Although not a revenue impact, it is noted that the net gain in hotel supply was 51 hotels in our study region, approximately 40 more than if the area had experienced growth at the U.S. industry average during the study period. The average size of the new hotels was approximately 82 rooms and they were nearly all select-service, branded hotels (hotels providing complimentary breakfast with no other foodservice). This type of hotel will generally employ around twenty-five employees so this new supply added a net jobs gain of approximately 1,000 new hotel jobs (accounting for the loss of closed hotels).

The key indicators for 2012 show, that there may be a downturn in demand in the years ahead for the Marcellus Shale regions. The U.S. demand went from a 4.7 percent increase in 2011 to a 2.9 percent increase in 2012. The Marcellus Shale study area demand went from an 11.1 percent increase in 2011 to a 0.0 percent flat in 2012. While the revenue percent increase still outperformed the U.S. average due to increases in the average daily rate, it would be expected that the rate of change for the average daily rate would slow as occupancy declines.

The risk/return discussion is a difficult discussion. The total risk/return of drilling is an ongoing discussion that must incorporate social and environmental risk and is beyond the scope of this work. For the hotel industry, the high returns are obvious for the existing hotels with little risk as they have experienced previously unseen revenue levels. The increasing risk comes from new hotel supply coupled with new demand that may be stabilizing or decreasing. The 2012 data indicates that, while overall hotel revenues are still increasing, the operating performance of individual hotels would be of concern. For example, in the Central Pennsylvania region, while demand was still higher than the non-Marcellus scenario, individual hotel occupancies were now actually lower than the non-Marcellus scenario because of the increased supply. The new hotels could struggle with debt service though there was no evidence of that as occupancies were at least 58 percent in each of the five regions. The older, independent hotels were facing the greatest risk with the “new” supply as 64 percent of the hotels closed during the period were independents and the average age of all hotels closed was over 38 years.

It is clear that the hotel industry in the regions studied have been positively impacted by Marcellus Shale drilling. The increase in demand has created an increase in supply and these hotels have performed well. The downturn in 2012 would indicate that any hotel development should happen early in the oil and gas development of a region to gain the most benefit. Select-service hotels are the obvious choice for new development with quicker build times and better operating efficiencies to support financing. These hotels should also have a clear business plan for weathering any downturns in the oil and gas drilling activity.

### **Future Research**

Future research should focus on several aspects of the continued study of hotel performance. First, the 2013 hotel performance indicators should be studied to better understand the 2012 downturn as to whether this downturn will continue and to what degree. Second, it is

important to examine the long-run impact of the new hotels built within the Marcellus Shale region, particularly as drilling activity slows; to what extent may the short-run need for hotel rooms lead to a long-run surplus of hotel supply, particularly in very rural communities. In addition, the impact of additional housing in the regions should be studied as the regions have had time to develop residential housing options and this development may add to the observed downturn in the hotel industry performance indicators. This additional research will help hotel developers in the viability and timing of new hotel development in a drilling region.

## Annex 1

### Marcellus Shale gas development

The Marcellus Shale formation has long been known to contain significant amounts of natural gas but was considered unattractive economically because of the cost of extraction. However, the feasibility of extracting unconventional natural gas changed in the early to mid-2000s with the refinement and combination of hydraulic fracturing and horizontal drilling techniques. While both technologies had been in use by the oil and gas industry for decades, the adaptation and refinement of both technologies for use in extracting unconventional gas was successfully employed in the early 2000s in Texas in the Barnett Shale near Dallas-Fort Worth (Waples 2012; Wilber 2012). The combination of horizontal drilling and high volume hydraulic fracturing has vastly increased the technical and economic feasibility of unconventional gas extraction. In the case of the Marcellus Shale layer, while as recently as the early 2000s geologists estimated that less than two trillion cubic feet (TCF) of gas could feasibly be extracted, that figure increased to nearly 500 TCF by the mid-2000s, representing approximately 20 years' worth of domestic consumption. The Marcellus Shale was subsequently recognized as the largest unconventional gas reserve in the United States, and one of the largest worldwide (Coleman et al. 2011; Engelder, 2009; Milicy & Swezey, 2006). These new estimates spurred the rapid development of unconventional gas extraction in Pennsylvania in the second half of the 2000s, and by July 1, 2013, 6,833 unconventional gas wells had been drilled across the Commonwealth (PA DEP, 2013). Recent declines in natural gas prices, combined with continued relatively high oil prices, has slowed development in Pennsylvania as companies have shifted some drilling rigs into other states with oil shale. Yet development continues.

Shale gas development involves several distinct phases, each with its own unique labor requirements. Much of the work is done by very specialized national or international independent businesses, hired by the production company to perform a narrow segment of the work. Due to the unique skills and knowledge required, many of these firms employ non-resident workers, who must find temporary housing during their working "tours."

The initial phases of development include the initial leasing activity, during which companies obtain permission to explore for and develop the gas resource on individual properties. The leasing work can be intense upfront, as the companies compete to sign mineral owners, and then decline as the proportion of land under lease increases. Leasing is typically

followed by seismic testing across a geographic region to identify the areas with the highest potential for gas development, though both leasing and seismic testing can occur simultaneously. The seismic work can take about four months, and is used by gas companies to select the specific locations for individual wells.

Preparing the well site includes the creation of a well pad, which entails clearing and grading approximately five acres, as well as constructing or upgrading roads leading to the well pad. Local firms can do much of this construction work because it is similar to other construction activity, and typically lasts approximately four weeks. Once the drilling rig arrives, the drilling process itself can last several weeks, and requires very specialized crews to work the drilling rig. Once drilled, the well completion process, which includes horizontal fracturing, can last one to two weeks. As with the drilling, it requires very specialized work crews. Stabilizing the site and reestablishing vegetation lasts several more weeks.

In addition to this on-site activity, each well is connected to market via pipelines, which need to be laid, and which involve their own specialized welders and other workers. Once hooked into the pipeline network, the active well requires some maintenance and monitoring. Supporting all of this development activity are additional workers and companies who service equipment, transport supplies and water, and provide logistical and planning assistance.

Once drilled, completed, and producing, an individual well requires regular maintenance. The labor requirements during this production phase are much lower than during the development phases. Brundage et al (2010), for example, found that each wet gas well in southwest Pennsylvania required the equivalent of 13.1 full time jobs, spread across almost 150 occupations and 420 individuals, during the year when it was drilled and completed. During each well's subsequent producing years, it only required the equivalent of 0.18 full time jobs. Labor requirements (and therefore most of the employment-based economic development) are highest during the active drilling years and largely are driven by the number of wells drilled per year.

Gas development in a community is not quite this linear, however, because the wells being developed typically are all at different stages of construction to allow the equipment, drilling rigs, and work crews to be actively working simultaneously at different locations (down time costs money). The pace of drilling activity, and particularly the number of drilling rigs active in a region, affects how many workers are active in the region. It also has important

consequences for other impacts of gas development, including the need for worker housing, the number of trucks on the road, other infrastructure requirements, the quantity of water used and requiring disposal, and other environmental effects.

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