Wages, Employment, and STEM Education in Ohio, Pennsylvania, and West Virginia

Report No. 1 (2016)

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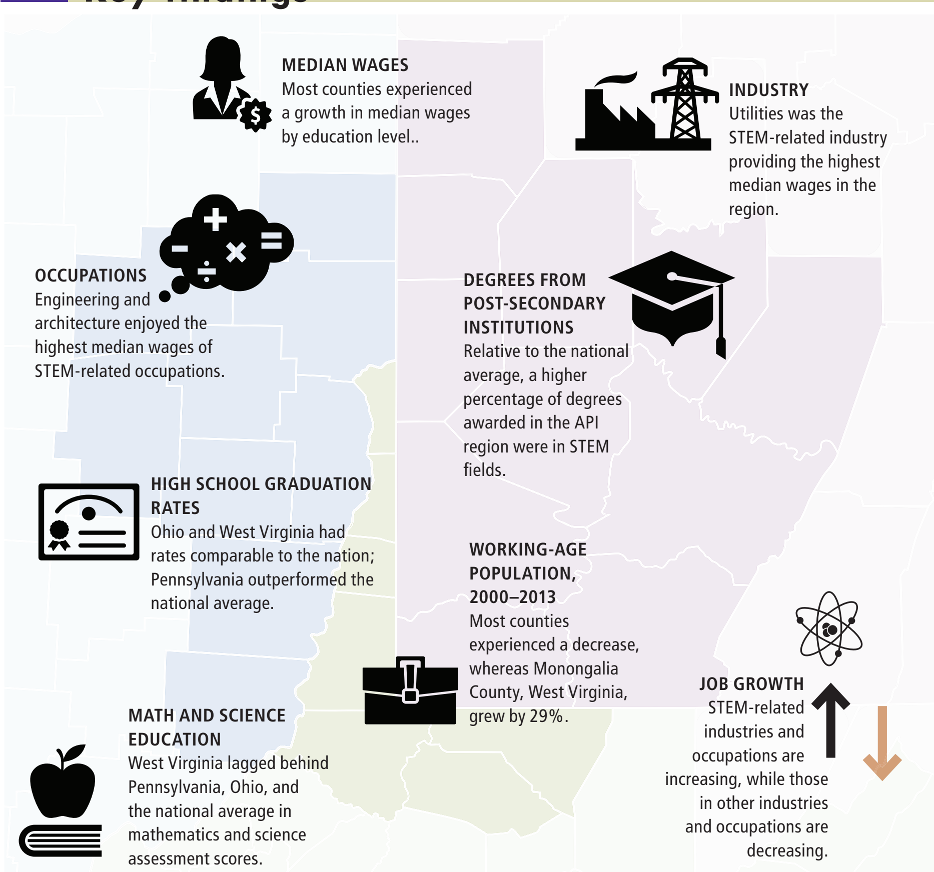
Following a decade of little growth, natural gas production in the United States grew by more than 25 percent from 2007 to 2013 (Hausman and Kellogg, 2015). The Marcellus Shale, which extends under Pennsylvania, West Virginia, New York, Ohio, and Maryland, is the largest U.S. gas field ranked by estimated proved reserves (U.S. Energy Information Administration, 2015b). Pennsylvania's, Ohio's, and West Virginia's abundant fossil fuel resources have long shaped the tristate's economy. The combination of horizontal drilling and hydraulic fracturing[1] to tap natural gas from the Utica and Marcellus shales has resulted in a burgeoning natural gas extraction industry.

Key findings



Pennsylvania is a leading supplier of natural gas to the nation: Natural gas output exceeded 4 trillion cubic feet in 2014, 15 times higher than in 2009, and made the state the second-largest natural gas producer in the nation, after Texas. Pennsylvania is also second only to Texas in estimates of proved natural gas reserves, which quadrupled from 2010 to 2013. Pennsylvania is seeing parallel growth in the production of natural gas liquids, including ethane and propane: Natural gas processing in the state grew sixfold from 2011 to 2013 (U.S. Energy Information Administration, 2015b).

West Virginia is among the top energy-producing states and is ranked fifth in the nation in total energy production. The state provided about 4.7 percent of the nation's total energy in 2012. Coal is the most abundant mined product in West Virginia, but natural gas and hydrocarbon gas liquids are rapidly gaining importance in the state with the development of the Marcellus Shale.

> The increase in the extraction of natural gas in Ohio, Pennsylvania, and West Virginia has brought about a concomitant rise in the demand for workers in the energy industry.

Annual natural gas production in the state more than tripled between 2007 and 2013. Shale gas proved reserves in West Virginia have grown substantially since 2007, and, by 2013, they exceeded 18 trillion cubic feet (U.S. Energy Information Administration, 2015c).

The Utica Shale is also a growing font for natural gas: Ohio's natural gas reserves and production more than doubled from 2012 to 2013 but are still less than 1 percent of the nation's total. Ohio's primary economic activity is manufacturing; most of Ohio's manufacturing is related to the transportation sector, but the state also has strong metal and chemical-production industries (U.S. Energy Information Administration, 2015a).

THE NEED FOR A SKILLED WORKFORCE

The increase in the extraction of natural gas in Ohio, Pennsylvania, and West Virginia has brought about a concomitant rise in the demand for workers in the energy industry:

- Employment in the core occupations of the Marcellus Shale gas industry increased 130 percent—by more than 15,000 jobs—from 2009 to 2013, with average wages of Marcellus Shale–related industries reaching $90,000 per year (Center for Workforce Information and Analysis, 2014).
- According to employment projections from West Virginia's Department of Commerce, the oil and gas extraction industry in West Virginia will experience a 17-percent increase in employment from 2012 to 2022, while mining not related to oil and gas extraction will suffer a 16.4-percent decrease, a loss of almost 4,000 positions.
- As the natural gas industry matures in the Utica Shale, more local workers are projected to be hired, especially for the long-term maintenance and engineering jobs associated with production and midstream infrastructure (Lendel et al., 2015).

Across the United States, the natural gas extraction industry has brought about a need for middle-skilled positions (also referred to as semiskilled or medium-skilled jobs) that typically require only a high school education, with some additional post-secondary training or occupational certification (Porter, Gee, and Pope, 2015). According to analysis of job-posting data from across the United States, from October 2013 to November 2014, middle-skilled jobs accounted for 52 percent of new jobs related to the extraction, distribution, and refinement of oil and gas resources obtained through hydraulic-fracturing technologies. In production and supply, new job postings included positions for petroleum engineers, roustabouts, extraction helpers, drill operators, and derrick operators. New job postings also included positions in downstream occupations, such as machinists, welders, industrial-machinery mechanics, and industrial engineers. While growth has been somewhat offset by 2015 layoffs caused by the cyclical decline in oil and natural gas prices, the need for workers is expected to resume over the medium and longer term as oil and gas prices recover (Porter, Gee, and Pope, 2015). In fact, the middle-skilled occupations of machinist, welder, industrial-machinery mechanic, industrial engineer, and operator of computer-controlled machine tools accounted for two-thirds of manufacturing work in 2012 (Sirkin, Zinser, and Rose, 2013, p. 6).

Employers have reported difficulty filling jobs and attracting talent, especially for middle-skilled jobs that require science, technology, engineering, or mathematics (STEM) skills (Accenture, Burning Glass Technologies, and Harvard Business School, 2014; Gonzalez et al., 2015).[2]

Given the impending retirements of large cohorts of older workers, if the demand for middle-skilled workers remains the same, the growing need for a STEM-skilled workforce is likely to intensify (Lendel et al., 2015; Center for Energy Workforce Development, 2013; Carnevale, Smith, and Melton, 2011). The aging workforce could more deeply affect workforce needs in the energy sector, because, nationally, nearly 25 percent of workers employed in extraction and production occupations are over age 55 and nearing retirement (Porter, Gee, and Pope, 2015).

In light of the growth in potential employment opportunities in middle-skilled STEM jobs in the energy sector, a clear challenge facing the region comprising Ohio, Pennsylvania, and West Virginia is how to generate qualified candidates within the local talent pool to fill positions quickly and thereby support the economic development of the region.

THE APPALACHIA PARTNERSHIP INITIATIVE

Recognizing the challenges in filling middle-skilled STEM jobs in Ohio, Pennsylvania, and West Virginia, particularly those related to the energy sector and advanced manufacturing, the Social Investment Team of the Chevron North America Appalachian/Michigan Business Unit launched the Appalachia Partnership Initiative (API) in 2014.

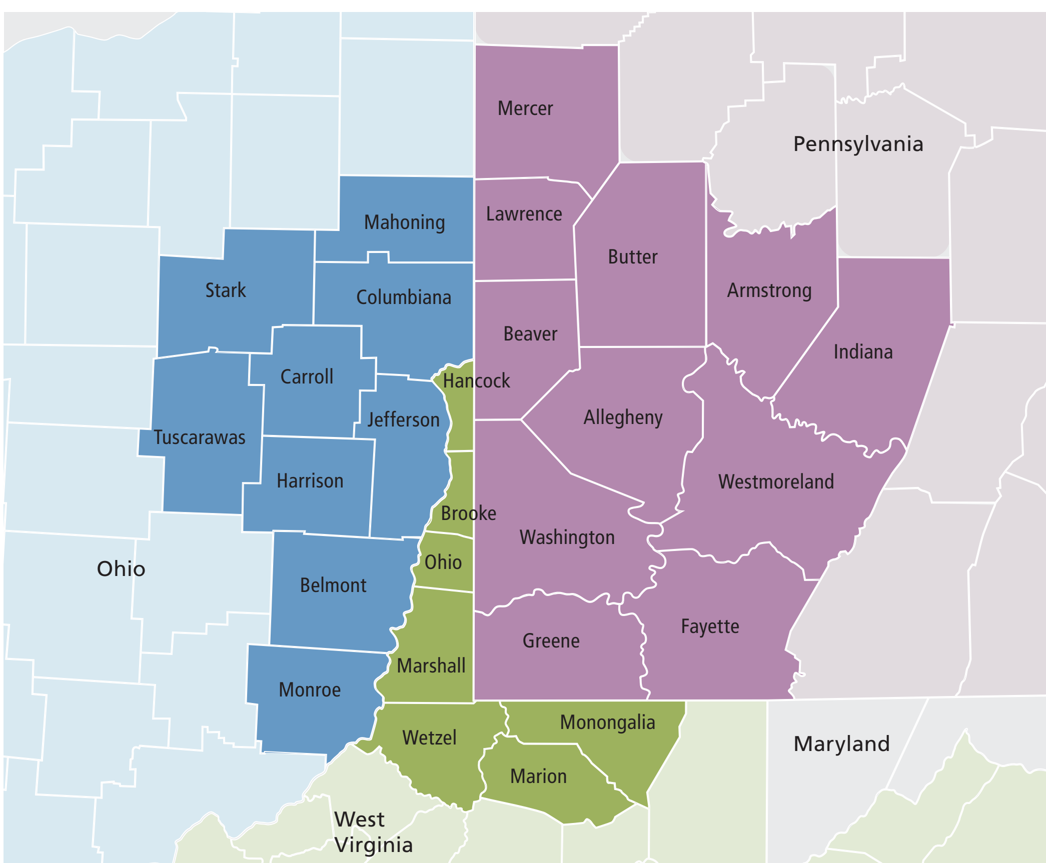
The stated goal of API is to produce a long-term, sustainable effort to build capacity of local workers for jobs in the energy and advanced manufacturing sectors in the Marcellus and Utica shale region. To meet this goal, API has committed to investing $20 million to support STEM education for kindergarten through 12th grade (K–12) programs and STEM workforce development programs that increase preparedness for, and access to, energy and advanced manufacturing jobs. API is also working to bring stakeholders in the region (e.g., education and training institutions, industry and business leaders, nonprofits, and government entities) together to collaborate on issues related to STEM education and the workforce (Chevron, 2014).

API focuses its investments in the 27 counties in Ohio, Pennsylvania, and West Virginia that are illustrated in Figure 1. RAND's role is to provide objective evidence to assess API's progress toward its goals.[3]

OBJECTIVES AND USES OF THIS REPORT

Given the potential economic transformations brought about by the burgeoning natural gas extraction and production in the API region, it is important to gauge and monitor the region's

Figure 1. The 27 Counties Composing the API Region



economic well-being. For example, by asking: What types of jobs and occupations are in high demand? Is there sufficient talent with the requisite skills to fill those jobs? Are education and training providers producing a qualified workforce that can succeed in the region's evolving STEM labor market?

To meet this need, RAND, as the Monitoring and Evaluation lead of API, was asked to produce five annual descriptive reports that document and summarize the 27-county region's STEM workforce, employment, and wages in energy and advanced manufacturing–related industries, as well as STEM education. This is the first of the five reports. These reports will shed light on transformations under way in the 27-county region. To date, this type of descriptive portrait of the 27 counties does not exist, although there is ample published information specific to each state, metropolitan areas within each state, and the broader Appalachian region.[4] Together, the regional reports will track progress and capture trends in the region's energy and advanced manufacturing sectors through 2019. This information can be used to inform the regional stakeholder community across the 27-county region about which localities might have greater demand for educating or employing local talent in STEM careers. In turn, API can use the reports to guide investments and collaborative work, helping API pinpoint where collaborations across government, education providers, and nonprofits could be enhanced or promoted.

These reports ask the following questions:

- Is there evidence that local labor markets are adjusting to increases in demand for workers to fill STEM positions?
  - Which areas within the region are experiencing the most growth in working-age population, employment, and wages?
  - Which STEM occupations and jobs are garnering the highest wages?
- Is the local talent pool graduating from high schools and colleges with skills and in fields that could be utilized in the STEM labor market?

Because these digests are descriptive snapshots, our analyses are intended to be a barometer of economic well-being in the region. Therefore, they should not be used to make causal inferences about the relationships between or among indicators or to draw conclusions about how well a particular county is meeting skill demands of employers.

DATA SOURCES

To inform the analyses presented in this report, we use publicly available data from the U.S. Census Bureau's decennial census and the American Community Survey (ACS), the 2011 and 2013 results from the National Assessment of Educational Progress (NAEP), the U.S. Department of Education's National Center for Education Statistics Integrated Postsecondary Education Data System (IPEDS), and each state's Department of Education. From these sources, we document trends in regional working-age populations, wages, employment, eighth-grade test scores in mathematics and science, high school graduation rates, and the number of higher-education degrees granted in STEM-related fields. The appendix provides more details on our data and methods.

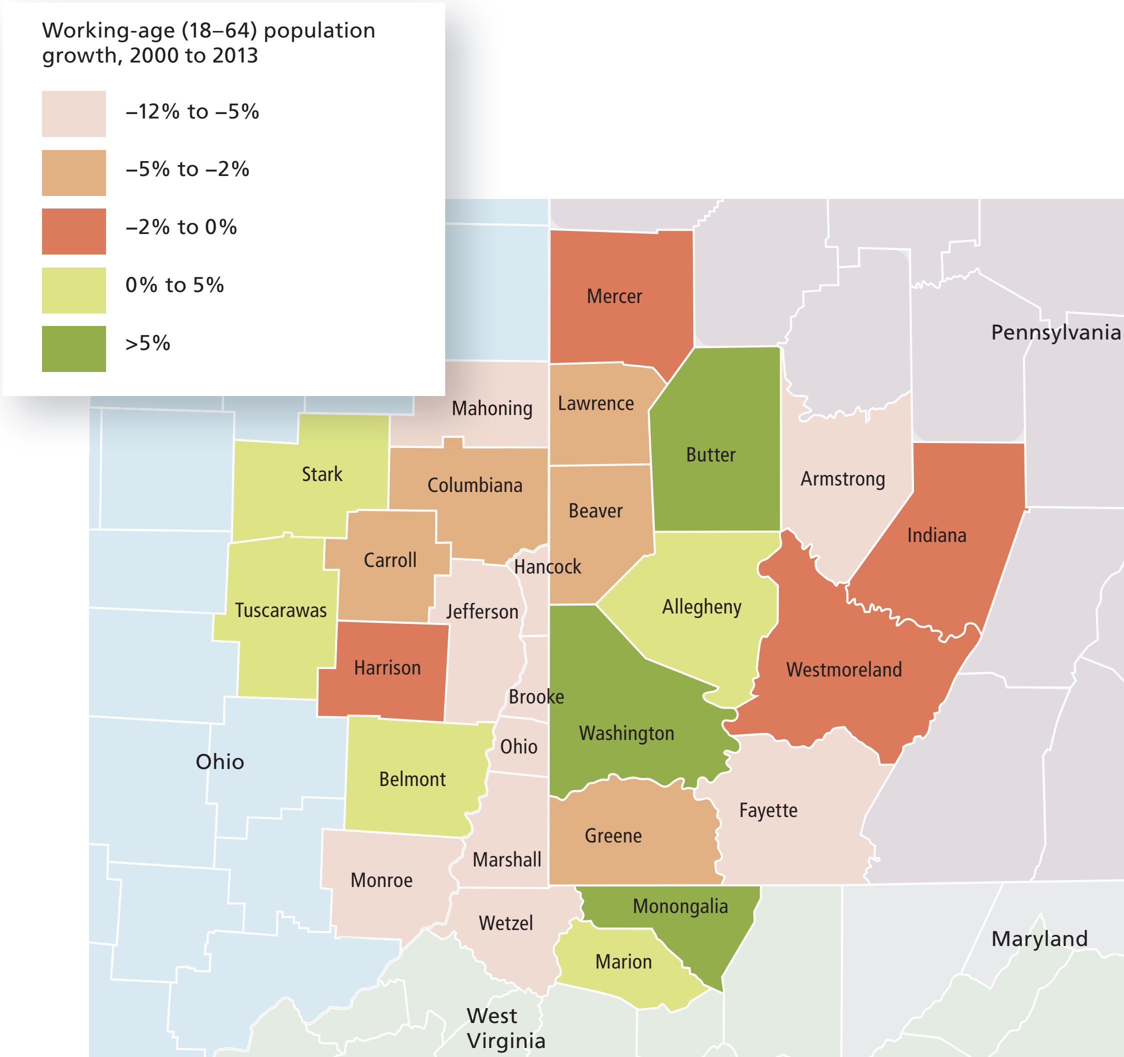
WORKFORCE, WAGES, AND EMPLOYMENT TRENDS IN ENERGY AND ADVANCED MANUFACTURING

This section documents API regional trends in the working-age population and in wages and employment in energy and advanced manufacturing sectors. These indicators are typically used to gauge the economic development and well-being of a locality. In recent years, the size of the working-age population has decreased in all but five of the region's counties. Median wages in industries and occupations related to energy and advanced manufacturing are highest in portions of a single county in West Virginia—one that has experienced comparatively high growth in its working-age population. Utilities is the STEM-related industry category that provides the highest median wages in the region. Engineering and architecture is the STEM-related occupation category that offers the highest median wages. Within the region, the number of jobs in STEM-related industries and occupations is increasing, even as the number of jobs in other industries has shrunk. We review each of these patterns and trends in more detail.

Working-Age Population

Figure 2 documents the changing size of the working-age population (i.e., the population between 18 and 64 years of age) in each of API's 27 counties from 2000 to 2013. We used data from the 2000 Decennial Census and two waves of data from

Figure 2. Change in Working-Age Population by County, 2000–2013



SOURCES: 2000 U.S. Census, 2005–2009 ACS five-year estimates, and 2009–2013 ACS five-year estimates.

the ACS. Together, these data allow us to make three successive comparisons: as of April 1, 2000; during the 2005–2009 period; and four years thereafter, during the 2009–2013 period.[5]

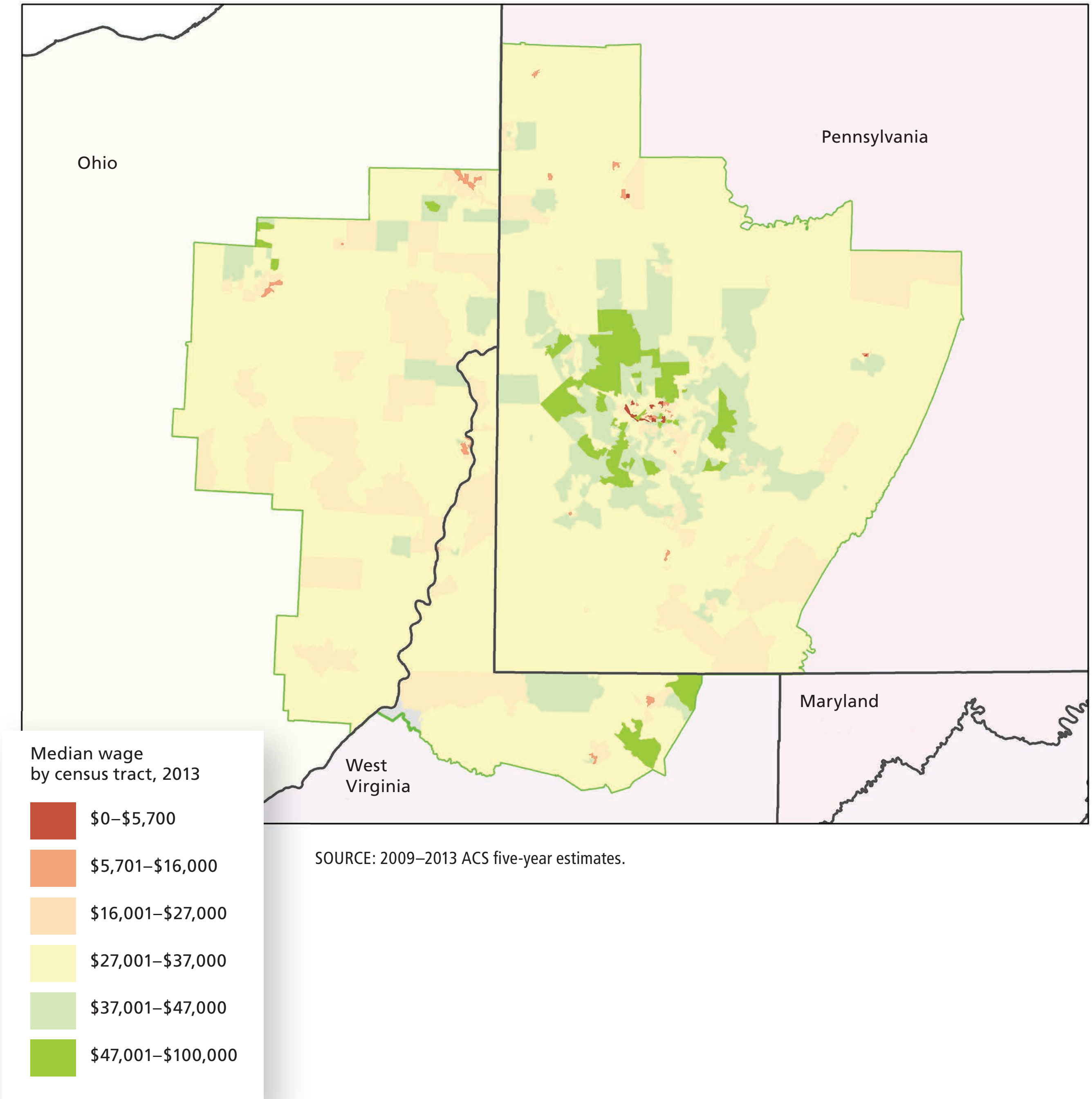
At a time when the working-age population in the United States grew by 13.6 percent, Monongalia County, West Virginia, experienced a 29.2-percent increase. This was followed by Butler County, Pennsylvania (8.6 percent), and Washington County, Pennsylvania (5.4 percent). Five other counties experiencing a modest growth of less than 5 percent in their working-age populations: Marion County, West Virginia; Allegheny County, Pennsylvania; Stark County, Ohio; Belmont County, Ohio; and Tuscarawas County, Ohio. The remaining 19 counties in the region experienced a decrease in their working-age populations.

Median Wages

Figure 3 compares median wages by census tract for the API region in the five-year period from 2009 to 2013, the most recent period for which wage data by census tract are available. The two tracts that had the highest median wages are located in Monongalia County, West Virginia, which experienced 29.2-percent growth in its working-age population between 2000 and 2013. This suggests that the strong wages in this county might have attracted more working-age persons.

Average wages mask within-county or within-tract differences in the composition of a labor force: Counties with more occupations that require higher skills and where more highly educated employees live are likely to produce higher wages overall. In other words, it is not necessarily the case that workers in a particular county are compensated more gener-

Figure 3. Median Wages by Census Tract, 2009–2013



SOURCE: 2009–2013 ACS five-year estimates.

ously than workers in a neighboring county. To get a clearer understanding of variability in the composition of the local labor force, we next examine wages by STEM-related industry, STEM-related occupations, and education level.

Wages for STEM-Related Industries and Occupations and Educational Attainment

Table 1 lists median wages for STEM industries and occupations, as well as the level of educational attainment in the API region and in the United States, from 2009 to 2013 period. The education categories are inclusive of the entire workforce over the age of 25, while the industry and occupational categories are specific to the working-age population. We provide the average county median wage, the lowest median wage, and the highest.[6] We then compare those wages with the U.S. median. Given the data available, we were unable to examine median wages by education level for each industry or occupation by county.

Table 1. Median Annual Wages by STEM-Related Industry, Occupation, and Educational Attainment for All Workers in the API Region and the United States, 2009–2013

Industry, Occupation, or Educational Attainment	Lowest County Median Wage ($)	Average County Median Wage ($)	Highest County Median Wage ($)	National Median Wage ($)
Industry				
Utilities	44,688	***60,845***	72,557	61,750
Mining, quarrying, oil, and gas extraction	32,157	***56,551***	85,714	60,471
Manufacturing	34,283	***43,150***	62,137	42,204
Professional, scientific, management, and administrative	21,989	***30,510***	46,443	41,297
Health care and social assistance	19,830	***27,745***	36,108	34,567
Occupation				
Engineering and architecture	44,118	***62,262***	77,639	72,813
Computer and mathematics	32,344	***52,715***	75,472	72,460
Life, physical, and social science	31,563	***50,443***	82,115	54,791
Health care practitioners and technicians	40,494	***44,985***	51,034	53,616
Extraction and construction	27,139	***41,837***	58,625	32,189
Health care support	14,663	***20,011***	24,785	22,157
Educational attainment (age 25 and over)				
Graduate or professional degree	34,853	***54,058***	69,937	66,493
Bachelor's degree	32,721	***42,441***	53,457	50,254
Associate's degree or some college	26,908	***30,626***	35,804	33,702
High school diploma	22,409	***26,290***	28,569	27,528
Less than high school diploma	10,810	***17,892***	25,856	19,652

SOURCE: 2009–2013 ACS five-year estimates.
NOTE: Education-attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to the working-age population (age 25–64).

Among the five STEM-related industries examined, the utilities industry offered the highest average median wage in the region ($60,845). Mining, quarrying, and oil and gas extraction also offered high average median wages ($56,551), but the county medians ranged from $32,157 to $85,714, suggesting that there is great diversity in the type of wages one can garner within this industry category.

We defined STEM-related occupations as traditional STEM fields and health care fields requiring STEM-related skills, as well as the energy-specific field of extraction and construction. Among STEM-related occupations, engineering and architecture occupations enjoyed the highest median wages ($62,262), while health care support had the lowest ($20,011). Life, physical, and social science had the third-highest average median wages ($50,443)—but the widest range of wages across the API counties (from $31,563 to $82,115). This is indicative of the geographic clustering and sorting of occupations.[7]

Differences in average median wages by educational attainment for all workers follow a pattern typical throughout the United States: Workers with more years of schooling tended to have higher wages. However, the average median wage in API counties was slightly lower than that for the nation, across all education levels. County medians were relatively more diverse among the most educated, ranging from $34,853 to $69,937, and among the least educated, ranging from $10,810 to $25,856. However, without data on the median wages for industries or occupations by education level, it is difficult to determine the possible reasons for this pattern.

Median wages for extraction and construction occupations exceeded the national median.

Figure 4 presents a closer look at the median wages for the 27 counties in the API region as compared with national median wages, taking into consideration the size of the working-age population in each county. The figure illustrates the extent to which median wages differ across the 27 API counties by industries (red bubbles), occupations (blue bubbles), and education levels (purple bubbles) examined. Each column of circles in the figure represents each county's median wage as an individual bubble. The size of each bubble corresponds to the total working-age population in each county: The larger the bubble, the larger the size of the county's working-age population. The largest bubble in each column represents Allegheny County, Pennsylvania, which has the largest working-age population in the API region. The black dot in each column provides a benchmark for comparison: the national median wages for the industry, occupational group, or education level. The bubbles appearing above the black dots indicate counties that have median wages above the national median for the given category. Conversely, bubbles appearing below the black dot imply that, nationally, most workers earn more money in positions within the given category than workers in the region.

Two important patterns emerge from Figure 4. First, median wages for extraction and construction occupations exceeded the national median. Workers in this occupation group earned wages well above their counterparts nationally. For health care technicians and practitioners, engineering and architecture, and computer and mathematics occupations, the opposite is occurring: Workers in these groups earned less than the national median. Second, median wages were more dispersed across the counties for workers with higher levels of education. Median wages were clustered slightly more around the national average for workers with less than a high school diploma, a high school diploma, or an associate's degree. Difference in median wages by educational attainment for all workers followed a pattern typical throughout the United States, which was also noted in Table 1: Workers with more years of schooling had higher wages. However, in most API counties, median wages were slightly lower than those for the nation. Again, without data on the median wages for industries or occupations by education level, it is difficult to determine the possible explanation for this pattern. It is plausible that the education-level demands for certain occupations drove the differences in wages.

Figure 5 illustrates the change in median wages across the 27 API counties by industries, occupations, and education levels, from the 2005–2009 to 2009–2013 periods. A few interesting trends emerge. First, nationally, the mining, quarrying, oil, and gas extraction industry experienced the greatest percentage increase in median wages, at 5.7 percent. About half of the counties in the region were on pace with the national average, experiencing a growth in median wages in this industry, and 12 counties experienced increases in median wages above the national average. Nationally, all other industries had limited growth, or wages declined. For example, national median earnings for manufacturing and health care and social assistance each decreased by about 1 percent. Interestingly, for the region, *most* counties experienced a growth in wages in this period in manufacturing and health care and social assistance industries, exceeding the national average growth.

Second, nationally, all occupational categories, except heath care technicians and practitioners, experienced increases in median wages. Median wages in the computer and mathematics occupation were higher nationally than in the API region and saw larger percentage increases from 2005–2009 to 2009–2013. The wages for both health care support and extraction and construction increased by 20 percent nationally. While most counties saw median wages increase in these occupations, percentage growth in median wages was not as large as the national increases.

Third, national median wages over the period decreased for all education levels, yet most counties in the region experienced a growth in median wages by education level. The largest percentage decreases were for workers with high school diplomas (6.1 percent) and less than high school diplomas (5.9 percent). While workers with less than a high school diploma had the lowest median wages, regionally, those workers fared better: 14 counties had higher median wage growth than the national average, and ten counties' median wages increased for these workers. Similarly, for high school graduates, only two counties in the region saw median wages decrease by more than the national median.

Figure 4. Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers (ages 25 and above) in the API Region, 2009–2013

SOURCE: 2009–2013 ACS five-year estimates.
NOTES: Size of the colored bubbles corresponds to the size of the working-age population in each of the API region's 27 counties. Education-attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to the working-age population (ages 25–64).

Figure 5. Change in Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers in the API Region: 2005–2009 to 2009–2013

SOURCE: 2005–2009 and 2009–2013 ACS five-year estimates.
NOTES: Size of the colored bubbles corresponds to the size of the working-age population in each of the API region's 27 counties. Education attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to the working-age population (ages 25–64).

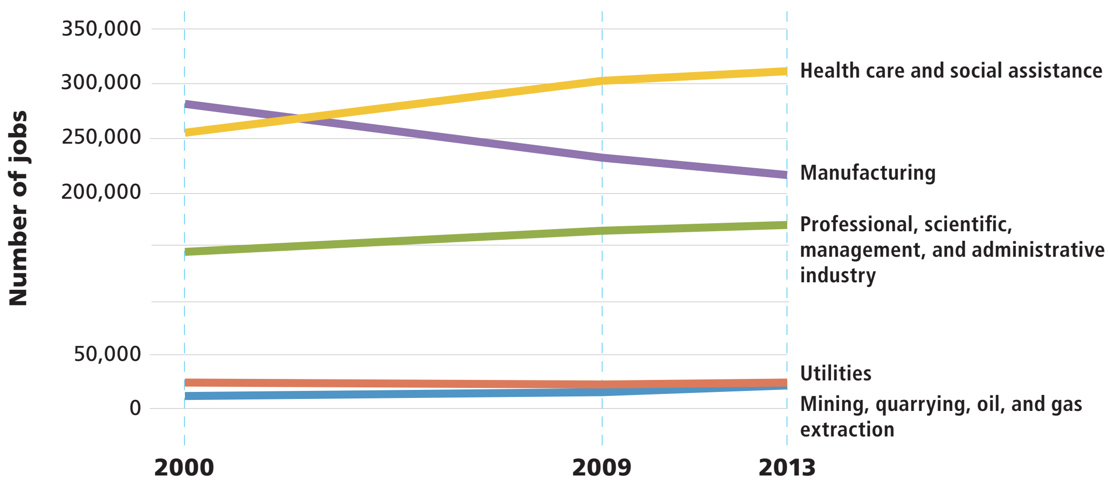
Trends in Employment for STEM Industries and Occupations

Despite a regional decline in working-age persons between 2000 and 2013 (as demonstrated in Figure 2), employment in STEM-related industries and the number of STEM jobs in the region grew over this same period. Overall, the share of STEM-related jobs in the region increased from 39.0 percent to 40.5 percent, while employment in other occupations and industries decreased. Such growth has been uneven, however, as illustrated in Figure 6.

Across all STEM-related industries, the total number of jobs increased by 3.7 percent, while those in all other industries in the region *decreased* by 2.4 percent. Although there was STEM-job growth overall, there was substantial variation among jobs that compose the STEM workforce. For example, the number of jobs in manufacturing decreased by 22.9 percent, while those in utilities grew only 0.1 percent. Health care and social assistance jobs saw the greatest numeric increase, nearly 60,000, while mining, quarrying, and oil and gas extraction saw the greatest percentage increase, at 76.2 percent.

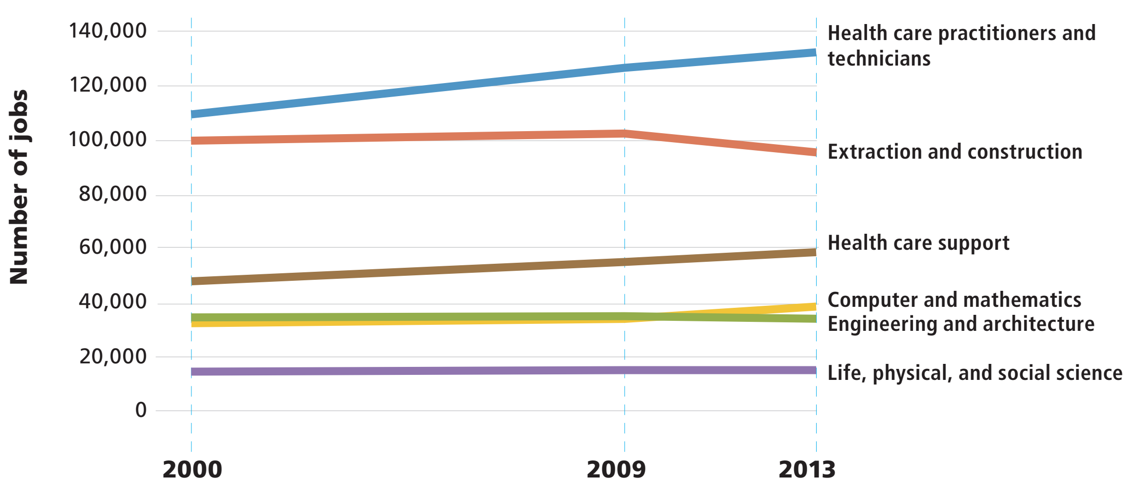
Figure 7 shows growth in STEM-related occupations from 2000 to 2013. Across all STEM-related occupations, the number of jobs in the region grew by 10.3 percent, while the

Figure 6. Trends in Number Employed in STEM-Related Industries in the API Region, 2000, 2009, 2013



SOURCES: 2000 U.S. Census, 2005–2009 ACS five-year estimates, and 2009–2013 ACS Survey five-year estimates.

Figure 7. Trends in Number Employed in STEM Occupations in the API Region, 2000, 2009, 2013



SOURCES: 2000 U.S. Census, 2005–2009 ACS five-year estimates, and 2009–2013 ACS five-year estimates.

number of jobs in other occupations decreased by 2.5 percent. Yet here, too, growth was uneven. In fact, the number of jobs decreased in extraction and construction, as well as in engineering and architecture. Growth was most rapid, both in absolute numbers and percentages, in health care. STEM-related occupations accounted for 18.4 percent of regional jobs in 2000 and 19.9 percent of jobs in 2013.

EDUCATION PATHWAYS TO STEM CAREERS

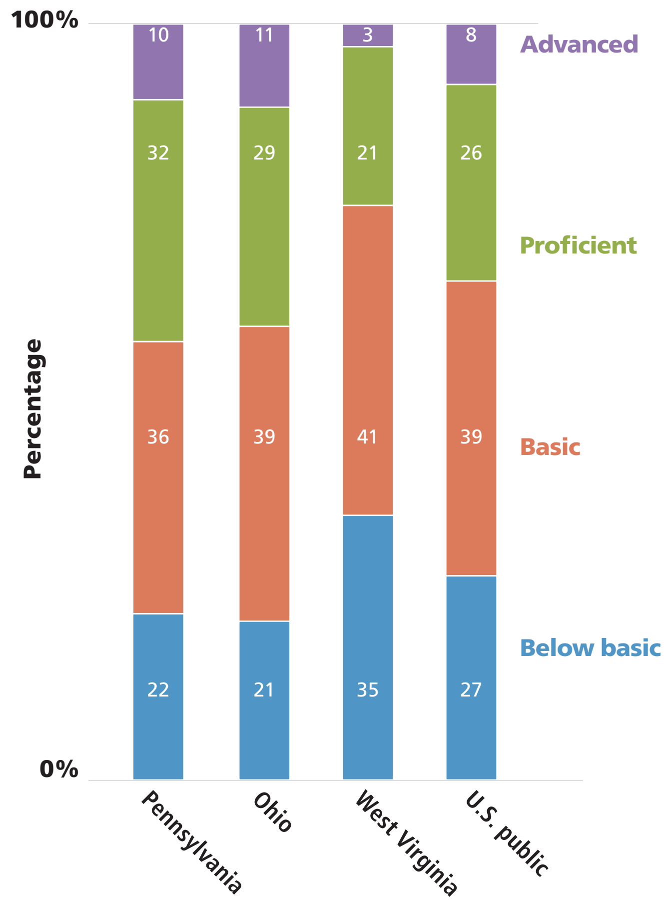
This section describes three indicators for gauging pathways to STEM-related careers in the API region: eighth-grade math and science assessments, high school graduation rates, and STEM degrees granted by regional colleges and universities. The indicators provide measures of the supply of talent that is entering, or in the pipeline to enter, the regional workforce. The eighth-grade assessments and high school graduation rates are based on state-average performance for Ohio, Pennsylvania, and West Virginia, benchmarked against the national-average performance as a point of comparison. For college STEM degrees, we present results for all colleges and universities within the API footprint, again with national-average rates as a point of comparison. The indicators reflect the most-recent available data (see the appendix for more information about the data used in this section).

Eighth-Grade Mathematics and Science Proficiency

Figure 8 shows eighth-grade mathematics proficiency, as assessed on the 2013 NAEP. This indicator provides a consistent measure of public school student performance across states and for the nation.[8] Pennsylvania and Ohio outperformed the national average, with 40 and 42 percent, respectively, of students at or above proficiency, compared with 34 percent nationally. Only about 21 and 22 percent, respectively, of students performed below basic, compared with 27 percent nationally. By contrast, West Virginia lagged significantly behind Pennsylvania, Ohio, and the national average, with 76 percent of students scoring basic or below basic, and only 24 percent scoring at or above proficiency.[9]

Figure 9 shows eighth graders' science proficiency on the 2011 NAEP. Here we see that 36 percent of U.S. eighth-grade students scored below basic and 33 percent at basic, with only

Figure 8. NAEP Eighth-Grade Math Proficiency, 2013



SOURCE: 2013 NAEP data from NCES, undated.

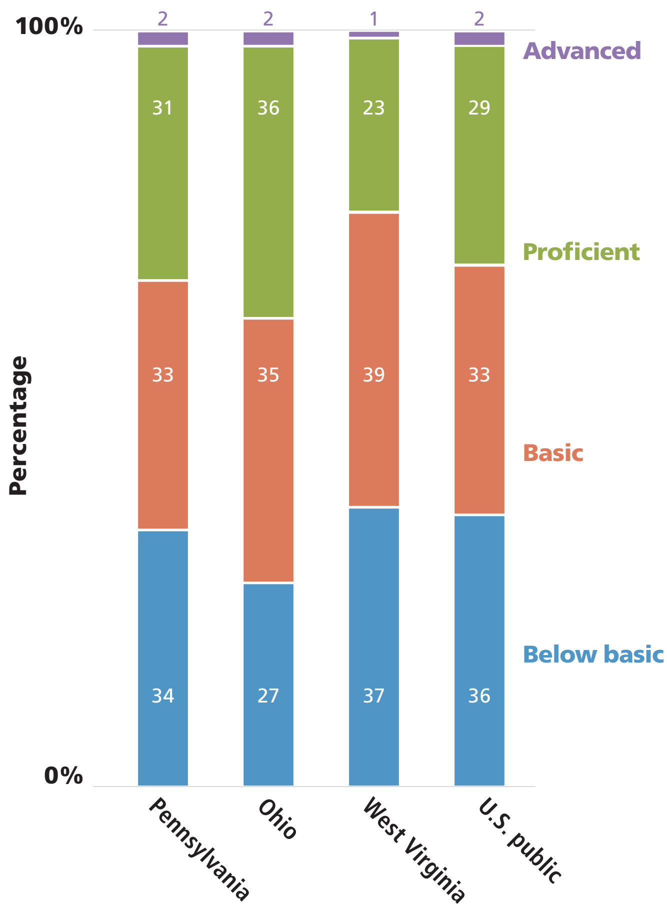
2 percent of students scoring advanced. Of the region's three states, Ohio had the highest percentage of students scoring at or above proficient (38 percent) on the tests and the lowest percentage of students scoring below basic (27 percent). West Virginia lagged in science proficiency, with 76 percent of students scoring basic or below basic.

It is important to remember that these averages are for the entire state and include results for students who did not live, or who might not consider employment opportunities, in the counties in the API footprint. Without NAEP scores for the 27 counties of interest, it is difficult to ascertain direct implications for the energy and advanced manufacturing sectors in API.

High School Graduation Rates

Table 3 compares the statewide high school graduation rates for the four-year cohort of the three API states,[10] as well as the U.S. national average. These indicators span three consecutive recent school years: 2010–2011, 2011–2012, and 2012–2013.

Figure 9. NAEP Eighth-Grade Science Proficiency, 2011



SOURCE: 2011 NAEP data from NCES, undated.

Graduation rates in the three API states, as well as nationally, rose by 2 to 3.5 percentage points over this three-year period. Ohio and West Virginia had high school graduation rates closely comparable to those of the national average, while Pennsylvania's graduation rates consistently exceeded the nationwide rate. This finding suggests that the proportion of recent high school graduates in the API states, who make up the potential entrants into the pipeline for energy or advanced manufacturing careers, was on par with the national average.

Degrees Granted in STEM-Related Fields

To gain a better understanding of the local talent pool available for employment in STEM careers, we explored the number of STEM degrees granted in two-year and four-year institutions of higher education located within the 27-county API region. Post-secondary education graduates could choose to move to a different county or region, and employers typically have a national pool of talent to choose from, so this analysis provides insight into the *potential* pool employers could select from locally.

Table 4 documents the percentage of degrees granted in STEM fields, as reported in the IPEDS for students who graduated between June 30, 2013, and July 1, 2014. Results are shown for five regions: (1) the United States as a whole; (2) the 27-county API region, which includes 150 post-secondary institutions; (3) the nine API counties in Ohio, which include 33 post-secondary institutions; (4) the 11 API counties in Pennsylvania; and (5) the seven API counties in West Virginia. We present the share of degrees granted in STEM fields for two categories: associate's degrees (along with one- and two-year certificates) and bachelor's degrees. See the appendix for the percentages by county.

In 2013–2014, institutions of higher education within the API region exceeded the nation in the percentage of students gaining certificates, associate's degrees, and bachelor's degrees in STEM fields. Ohio's 33 post-secondary institutions in the nine API counties produced more than double the national average in the percentage of certificates and associate's degrees in STEM fields (15.3 percent compared to 7.1 percent). West Virginia's seven API counties led the region in terms of the percentage of students earning bachelor's degrees in STEM-related fields (19.4 percent), which is almost entirely driven by West Virginia University, in Morgantown (see appendix). However, the institutions in the seven counties in West Virginia lagged behind their peer institutions in the United States, as well as in in Ohio and Pennsylvania, in producing certificates and associates' degrees in STEM-related fields.

Table 3. Four-Year Cohort Graduation Rates, 2010–2011 to 2012–2013

Region	2010–2011 (%)	2011–2012 (%)	2012–2013 (%)
U.S. average	79	80	81
Pennsylvania	83	84	86
Ohio	80	81	82
West Virginia	78	79	81

SOURCE: U.S. Department of Education, undated.

Table 4. STEM Degrees by Region and Type, 2013–2014

Region	Certificates and Associate's Degrees in STEM-Related Fields (%)	Bachelor's Degrees in STEM-Related Fields (%)
United States	7.1	16.2
API region (27 counties)	11.2	18.6
Ohio (9 counties)	15.3	15.7
Pennsylvania (11 counties)	10.2	18.9
West Virginia (7 counties)	6.0	19.4

SOURCE: 2014 IPEDS data from IPEDS, National Center for Education Statistics, home page, undated.

Taken together, Figures 8 and 9 and Tables 3 and 4 suggest that the API region is producing a supply of talent entering, or in the pipeline to enter, the regional workforce that is on par with, and on some indicators exceeding, the national average. We also find that institutions of higher education in the 27-county API footprint are producing more STEM graduates than the U.S. average. Yet West Virginia lags behind Ohio and Pennsylvania and national averages in percentages of students graduating from high school and scoring "proficient" on the NAEP tests. While these findings suggest that the 27 counties, as a whole, are fairing well compared with national averages, this descriptive portrait alone cannot determine whether the supply of graduates in STEM-related fields is meeting local labor market demands or has the necessary skills to meet the needs of those jobs.

The API region is producing a supply of talent entering, or in the pipeline to enter, the regional workforce that is on par with, and on some indicators exceeding, the national average.

CONCLUSION

Typically, sudden shifts in markets or rapid economic growth can cause mismatches of labor supply and demand: Job opportunities in new industries or sectors increase in one area and disappear in other areas; in growing areas, additions of population through migration can propel employment growth, thereby drawing still more economic migrants to fill new jobs, whereas, in declining areas, the reverse might occur (Morrison, 1973). As the API region transitions to an economy that is becoming more reliant on the extraction of natural gas and advanced manufacturing, balancing employer demands in the API region's STEM labor market and the local workforce's skills is imperative to ensuring a successful and sustainable economic transformation.

This report provides a descriptive portrait of the state of the local labor market and education of the local talent within the 27-county API region. The indicators examined for this report illustrate the strengths and weaknesses of the API region's STEM economy and the education of the local talent pool, which can be tracked through time.

Two questions guided the descriptive analysis presented in this report.

Is there evidence that local labor markets are adjusting to increases in demand for workers to fill STEM positions?

Working-age population. At a time when the working-age population in the United States grew by 13.6 percent, Monongalia County, West Virginia, stands out in stark contrast, having experienced a 29.2-percent increase. Other counties had modest growth: Butler County, Pennsylvania, grew by 8.6 percent; Washington County, Pennsylvania, grew by 5.4 percent; and five other counties experienced a modest growth of less than 5 percent in their working-age popula-

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tions (Marion County, West Virginia; Allegheny County, Pennsylvania; Stark County, Ohio; Belmont County, Ohio; and Tuscarawas County, Ohio). Twenty counties in the region experienced a decrease in their working-age populations.

An important question to consider is why the working-age population is shrinking in the region. Is this decline because of retirees or because there are smaller cohorts aging into the working-age cohorts? The answer to this question could not be explored in the analyses presented in this report but could be explored in future reports.

Wages. Across the United States, national median wages decreased across all occupations and industries. However, in the API region, five of the six STEM-related occupational categories experienced increases in median wages.

- Nationally, the mining, quarrying, and oil and gas extraction industry experienced the greatest percentage increase in median wages, at 5.7 percent. About half of the counties in the region were on pace with the national average, experiencing a growth in median wages in this industry, and 12 counties experienced increases in median wages above the national average.
- The occupations of engineering and architecture enjoyed the highest median wages of STEM-related occupations, yet there is a wide range of median wages in the 27-county region, even within the same industry or type of occupation. Median wages were relatively high in some suburban Pittsburgh areas but highest in portions of Monongalia County, West Virginia, which experienced the highest growth in its working-age population. Note, however, that there was less regional variation in wages for employees with less than a bachelor's degree. This suggests that an employer's location could have had an impact on salaries for a more educated workforce, but the impact was much less for a workforce with less than a bachelor's degree. These workers could therefore move across county lines and expect to receive similar wages.

Employment in STEM industries and occupations. Within the API region, the number of people employed in STEM-related industries and occupations increased, even as the number of people employed in other industries shrank and despite an average regional decline in working-age persons between 2000 and 2013. Overall, the share of STEM-related jobs in the region increased slightly, while employment in other occupations and industries decreased.

Taken together, these findings suggest that market processes are gradually adjusting so that more talent is being employed in STEM occupations and industries. It is important to continue to monitor whether this progress continues and where variations in wages and employment concentrate.

Is the local talent pool graduating from high schools and colleges with skills and in fields that could be utilized in the STEM labor market?

Science and mathematics eighth-grade test scores. West Virginia lagged behind Pennsylvania, Ohio, and the national average in mathematics and science assessment scores, with 76 percent of eighth graders scoring at basic or below, only 3 percent scoring advanced in mathematics, and more than three in four students scoring basic or below basic in science.

High school graduation rates. Ohio and West Virginia had high school graduation rates comparable to the nation, while Pennsylvania outperformed the national average. Graduation rates in the three API states, as well as nationally, improved by 2 to 3.5 percentage points between 2010–2011 and 2012–2013.

STEM-degrees in higher education granted. Ohio and Pennsylvania exceed the nation in percentages of students gaining associate's degrees in STEM-related fields, while West Virginia trailed these states. All three states, and the nation, had roughly comparable percentages of students gaining bachelor's degrees in STEM-related fields.

These educational indicators highlight an important strength of the region: Relative to the national average, a higher percentage of degrees granted from post-secondary institutions in the API region were in STEM fields, particularly associate's degrees and one- and two-year certificate programs. This is an encouraging indicator that, to date, there is a healthy supply of STEM-focused students who are entering the workforce. However, we cannot say, given the analyses presented in this report, whether the supply is sufficient for the demand.

The educational indicators also highlight areas that are in need of improvement: The pipeline of potential talent might not be keeping pace with potential demand. Scores on the NAEP eighth-grade assessments suggest that students in West Virginia are lagging in math and science proficiency, compared with national averages and with students in Ohio and Pennsylvania. For those interested in investing in the regions' educational and economic health, this might be an area in need of additional support.

Relative to the national average, a higher percentage of degrees granted from post-secondary institutions in the API region were in STEM fields, particularly associate's degrees and one- and two-year certificate programs.

APPENDIX

The indicators presented in this report relied on the following data sources.

Data Sources for Wages and Employment Indicators

We downloaded wage and employment data from the U.S. Census Bureau's *American FactFinder* website (undated). The three sources of data from the U.S. Census Bureau, downloaded in May 2015, were (1) the 2000 Decennial Census, (2) the Population Estimates Program (PEP) 2013, and (3) the ACS five-year estimates (2009–2013 and 2005–2009). Data from the ACSs were found in Tables B01001, B20004, B24011, C24010, C24013, S1903, S2402, and S2403. The 2005–2009 five-year estimates reflect data collected between January 2005 and December 2009; the 2009–2013 five-year estimates reflect data collected between January 2009 and December 2013. Accordingly, our comparisons using ACS data are for two periods that are four years apart.

Figure 2, about working-age (18–64) population growth, compares county population totals from the ACS five-year estimates (2009–2013) and the 2000 Decennial Census. Because the number and geography of census tracts varied over time, our analyses were not able to map population growth at the census tract level from 2000 to 2013.

Figures 3 and 4 and Table 1, about median wages, were created using data from ACS five-year estimates for 2009–2013, downloaded in June 2015. Figures 4 and 5, about changes in employment for STEM-related industries and occupations, compare data from the ACS 2013 five-year estimates (2009–2013) with the ACS 2009 five-year estimates (2005–2009), which is the earliest set of five-year estimates published, and to the 2000 Decennial Census.

These data sources were selected because they provide the most accurate, geographically detailed portrait of the 27-county API region. The ACS produces estimates for one-year, three-year, and five-year periods. While we would have preferred to report annual trends, the ACS does not publish one-year estimates for counties with populations under 65,000. This would have excluded ten of the 27 counties in the API region. The three-year ACS estimates are not published for counties with populations under 20,000, which would have excluded three counties. We therefore selected the five-year estimates from 2005–2009 and 2009–2013. Together, they afford a four-year window of comparison, including comparisons based on a statistically more stable five-year national sample with which to examine trends for the 27 API counties.

The ACS has well-documented limitations (U.S. Census Bureau, 2009). First, the ACS reports employment levels by occupation and industry, using major occupational and industrial groups but not more-granular categories. For example, the ACS reports management, business, science, and arts occupations together instead of reporting each of the subcategories. We reported industry employment separately from occupation employment because these two categories are not mutually exclusive. Second, while the ACS permits the reporting of median wages by education level, it does not permit the reporting of wages by industry, occupation, or education level within age groups. Such information, if available, could help us better understand differences in age-cohort wages or employment. Third, the ACS does not report wages by occupation and education concurrently.

Data Sources for STEM-Education Indicators

The NAEP is a nationally representative assessment that allows comparisons across states. The NAEP is administered to a national sample of students in fourth, eighth, and 12th grades. Mathematics assessments are administered every two years; science assessments are administered every four years. In this report, we used the most-recent data available: the 2011 science assessments and 2013 mathematics assessments. More information about the NAEP is available at its website (National Center for Education Statistics [NCES], 2015). NAEP data were downloaded from NCES (undated). For ease of interpretation, we presented data in terms of NAEP achievement levels—below basic, basic, proficient, and advanced—rather than scale scores. For more information on the expectations for eighth-grade students to perform proficiently in the mathematics and science NAEP tests, refer to NCES, 2006, and NCES, 2012.

We used high school graduation rates from data compiled by the U.S. Department of Education and available at the department's ED*Facts* web site (undated). ED*Facts* centralizes data provided by state education agencies, local education agencies, and schools. The four-year adjusted cohort graduation rate is calculated based on the number of first-time ninth graders in a given year who graduate within four academic years, after accounting for those who transferred into or out of the cohort.

The IPEDS is a compilation of surveys conducted by the U.S. Department of Education's NCES. IPEDS gathers information from every college, university, and technical and vocational institution that participates in federal financial aid programs for students. Results presented in the body of the report give the average share of degrees granted that are in STEM fields, as defined by Classification of Instructional Programs (CIP) codes. More than 200 areas of study are under the STEM umbrella, with categories including computer and information sciences, engineering and engineering technologies, biological and biomedical sciences, mathematics and statistics, physical sciences, and sciences technologies, among others. The complete list of STEM CIP codes are available from the U.S. Department of Education (NCES, 2011). Graduates include those who completed a degree or certificate between July 1, 2013, and June 30, 2014, from an institution within the 27-county API region. The share of STEM degrees is simply the total number of graduates from STEM fields divided by the grand total number of graduates from the relevant institutions.

Detailed county-level results are shown in Table 5. Results show the share of graduates in STEM fields by county, for those who completed an associate's degree or a one- or two-year certificate program and those who completed a bachelor's degree program. Across counties, the number of educational institutions ranged from zero to 48, with the share of graduates in STEM fields ranging from 0 to 30 percent. Note that the county-level results are often based on a small sample size of graduates from only a few institutions. As a result, one should be cautious when interpreting the differences between counties with small sample sizes.

Table 5. STEM Degrees by County and Type, 2013–2014

State	County	Number of Institutions	Associates Degrees and Certificates			Bachelors Degrees		
			Total Grads	STEM Grads	STEM (%)	Total Grads	STEM Grads	STEM (%)
West Virginia	Hancock	1	13	0	0	0	0	
West Virginia	Brooke	1	0	0		128	23	18
West Virginia	Ohio	5	425	21	5	690	47	7
West Virginia	Marshall	1	18	0	0	0	0	
West Virginia	Wetzel	0	0	0		0	0	
West Virginia	Marion	3	567	43	8	612	90	15
West Virginia	Monongalia	7	262	13	5	4,268	945	22
Ohio	Mahoning	7	914	98	11	1,569	329	21
Ohio	Columbiana	6	638	6	1	41	0	0
Ohio	Stark	13	2,740	556	20	1,334	156	12
Ohio	Carroll	0	0	0		0	0	
Ohio	Tuscarawas	2	342	49	14	10	6	60
Ohio	Harrison	0	0	0		0	0	
Ohio	Jefferson	3	403	42	10	464	46	10
Ohio	Belmont	2	333	68	20	0	0	
Ohio	Monroe	0	0	0		0	0	
Pennsylvania	Mercer	6	200	15	8	811	207	26
Pennsylvania	Lawrence	6	623	3	0	329	65	20
Pennsylvania	Beaver	6	573	38	7	504	90	18
Pennsylvania	Butler	4	567	70	12	1,701	221	13
Pennsylvania	Armstrong	2	76	0	0	0	0	
Pennsylvania	Allegheny	48	8,983	1,137	13	10,083	2,285	23
Pennsylvania	Indiana	4	1,544	4	0	2,412	229	9
Pennsylvania	Washington	6	255	10	4	1,810	263	15
Pennsylvania	Westmoreland	11	1,446	153	11	1,114	227	20
Pennsylvania	Greene	2	28	0	0	372	46	12
Pennsylvania	Fayette	4	356	62	17	112	0	0

NOTES

[1] In hydraulic fracturing, high-pressure water, mixed with sand and other compounds, is pumped into a borehole to crack layers of a shale rock formation, releasing trapped oil and gas.

[2] STEM jobs are a large and growing portion of the U.S. economy, composing 20 percent of all U.S. jobs (National Research Council, 2013; Rothwell, 2013), and are expected to increase by 17 percent through 2018 as employers seek to fill 2.4 million STEM job vacancies (Carnevale, Smith, and Melton, 2011).

[3] As the Monitoring and Evaluation lead, RAND does not make investment decisions; rather, RAND evaluates the extent to which API's portfolio of program investments meets Chevron's goals in the region. For more, see Dougherty (2014).

[4] For information on the population, employment, and labor force in the 420-county, 12-state Appalachian region, see Pollard and Jacobson (2015) and Center for Regional Economic Competitiveness and West Virginia University (2015).

[5] The ACS five-year data used here (unlike the decennial census) refer to a five-year period, during which data were collected continuously. Accordingly, our comparisons using ACS data are for two periods that are four years apart. See the appendix for more information.

[6] A county's median wage is defined as the wage below which half of the workers in the county earned. An average median wage takes the average of the 27 counties' median wages: the summation of the 27 county median wages divided by 27.

[7] Capturing the diversity of such jobs and their responsibilities, as well as the levels of education and skills they demand, across geographies would require an examination of individuals' wages.

[8] As explained in the appendix, NAEP does not test all students in a state. It therefore does not report results at the district level (or county level).

[9] For more information on how proficiency in a NAEP subject is defined, see National Center for Education Statistics, 2016.

[10] The four-year cohort graduation rate is calculated based on the number of first-time ninth graders in 2008–2009 who graduated within four academic years (by 2012–2013), after accounting for those who transferred into or out of the cohort.

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About This Report

The research was conducted within RAND Education, a unit of the RAND Corporation. The authors would like to thank RAND colleagues Robert Bozick and Catherine Augustine, who reviewed early drafts of this report and provided important commentary. We would also like to thank our two objective peer reviewers, Peter Morrison and Italo Lopez Garcia, for their insights and suggested changes, which greatly improved the report. However, any errors within are the responsibility of the authors alone.

This research was sponsored by the Appalachia Partnership Initiative (API). As the Monitoring and Evaluation lead of API, RAND was asked to produce annual descriptive portraits of employment and wages in energy and advanced manufacturing–related industries and STEM education indicators in the API region. This is the first of five annual reports. These reports should be of interest to regional education, business, and community leaders interested in STEM education and the career readiness of workers in the energy and advanced manufacturing sectors.

The Appalachia Partnership Initiative

Appalachia Partnership Initiative
MAKING OUR NEW ENERGY ECONOMY WORK

Chevron North America (CNAEP) Appalachian/Michigan Business Unit's Social Investment Team was established to strengthen science, technology, engineering, and mathematics (STEM) education in middle and high schools and improve pathways for high school graduates and adult learners interested in careers in oil and gas industries and in advanced manufacturing in the Pennsylvania, West Virginia, and Ohio region. As part of these efforts, in 2014, Chevron's Social Investment Team launched API, a partnership of businesses, nonprofit organizations, and education institutions in the region. As of 2015, API consisted of representatives from Chevron, the Claude Worthington Benedum Foundation, Allegheny Conference for Community Development, and the RAND Corporation.

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RR-1357-CHC