

## Broken Promises: Impacts of Pennsylvania's Shale Gas Boom on Local Economies

This research note is based in part on the transatlantic workshop and study tour “Unpacking the Shale Gas Revolution,” undertaken by the Friedrich Ebert Foundation and Ecologic Institute US in collaboration with the Transatlantic Climate Bridge. A fact-finding team toured counties around Pittsburgh, Pennsylvania, to meet with local groups and study drilling infrastructure as well as locations affected by the U.S. shale gas boom.

One of the key arguments used in support of hydraulic fracturing (or “fracking”) for shale gas is the creation of new jobs and other benefits for local economies. However, the evidence from Pennsylvania suggests that these benefits have been grossly exaggerated. Job creation is negligible, and fracking has resulted in substantial damages and threats to infrastructure and human health. A comprehensive assessment of the local economic and environmental impacts can help communities make an educated choice between shale gas and other, more sustainable options.

### Pennsylvania's Economy

In 2013, Pennsylvania had the sixth highest gross state product in the United States, at \$645 billion.<sup>1</sup> Coal remains a prominent export, with over 50 million tons extracted annually, much of which is shipped to overseas markets.<sup>2</sup> The state's conventional oil and gas extraction date to the 19th century. Farming, meanwhile, employs more than 240,000 people, and many families have lived on their land for generations.<sup>3</sup> The once-dominant steel industry ceased to be an important employer in the mid-20th century, and statewide manufacturing has suffered in recent decades.

As a consequence, there is a lack of jobs for the rural workforce.<sup>4</sup> Although cities such as Pittsburgh feature eye-catching architecture and offices of Fortune 500 companies, many of the surrounding rural counties are comparatively poor, and young Pennsylvanians continue to leave the region because of a lack of opportunity.



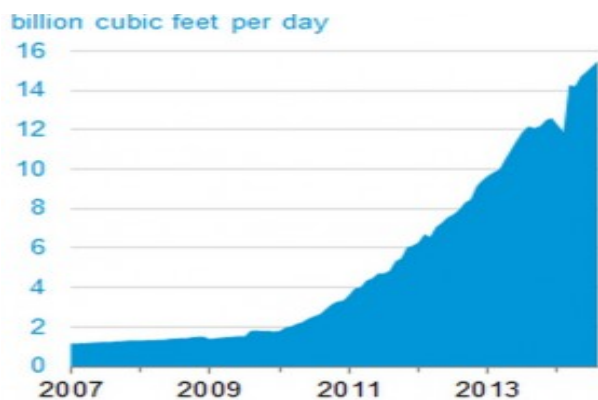
### Shale Gas Key Figures

Large swaths of Pennsylvania are part of the vast Marcellus Shale Gas formation that also underlies portions of Maryland, New York, Ohio, Virginia, and West Virginia. Exploitation of this resource has taken firm hold in the region. Although the U.S. natural gas price has fallen to around \$4 per 1,000 cubic feet (ft<sup>3</sup>), fracking is profitable at prices of \$1.50 per 1,000 ft<sup>3</sup>.<sup>5</sup> As a result, production from the Marcellus Shale has grown steadily.<sup>6</sup> (See Figure 1.) In 2013 alone, Pennsylvania wells delivered more than 9.2 billion ft<sup>3</sup> per day—or 3.1 trillion ft<sup>3</sup> annually—for a total value of \$12.4 billion.<sup>7</sup> Although this is less than 2 percent of the gross state product, production is projected to continue to grow in the coming decades.<sup>8</sup>

Today, some 200 companies are engaged in shale gas extraction in Pennsylvania.<sup>9</sup> Many of these focus on mining and selling so-called wet gas (which contains higher alkanes such as ethane, propane, and butane) because of the higher market

price. In addition to the more than 57,000 active wells in the state in 2013, a study suggests that a large number of oil and gas wells—between 280,000 and 970,000 (drilled during the current boom as well as before)—have been abandoned.<sup>10</sup>

**Figure 1. Marcellus Natural Gas Production, 2007–14**



Source: See Endnote 6.

### Job Creation Claims and Realities

Proponents of shale gas extraction tout its many benefits to communities, in particular the creation of local jobs. Representatives from U.S. and Pennsylvania Chambers of Commerce have stated an explicit goal of ensuring that legislators “don’t squander or obstruct this opportunity.”<sup>11</sup> One Chamber press release from 2012 claimed that shale gas production had created “over 300,000 new jobs in the last two years” in the state, although the release failed to elaborate on the criteria used for this estimate.<sup>12</sup>

In contrast, data from the Pennsylvania Department of Labor and Industry estimate only 18,000 jobs created in “core” Marcellus industries, plus 5,600 jobs created in “ancillary” industries, between late 2008 (when the boom really took off) and mid-2012.<sup>13</sup> According to the Department, this discrepancy is based on the Chamber’s use of a two-year-old study of job projections rather than actual data. The Chamber later revised its figure to 180,000 “supported” jobs, which remains far above the Labor Department’s figure and still is not backed up with sound data and methods.<sup>14</sup>

Job estimates need to take into account current data, as well as local conditions and employment histories. Dangers related to

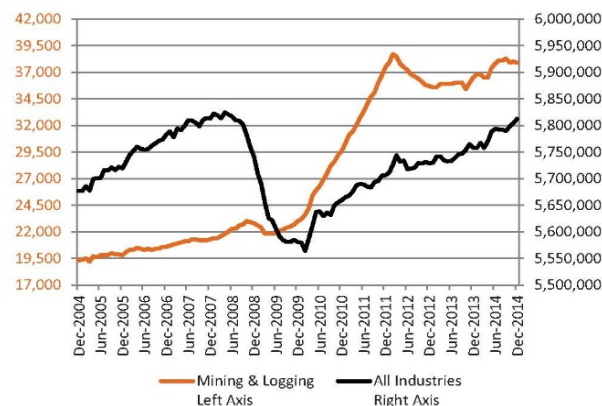
estimating or claiming employment effects include using “ancillary” jobs that have little or no causal relationship with the gas extraction. Although natural gas distribution might be a closely related sector, industrial machinery or trucking companies that benefit from the drilling may also benefit from projects in unrelated industries.

Another possible oversight is to attribute all current jobs—including jobs that existed before—to a given new activity. Oil and gas production, and a related core of jobs, existed in Pennsylvania well before the fracking boom began, and in some counties, the shift from coal to natural gas production may not have created any additional jobs. Finally, the rise or decline in employment in a given sector is usually strongly related to larger economic trends, such as crises and recoveries.

### Employment Growth in Pennsylvania

Total employment in Pennsylvania rose to over 5.8 million in mid-2008, then dropped below 5.6 million in the wake of the Great Recession, and more recently climbed to just over 5.8 million as of late 2014.<sup>15</sup> (See Figure 2.) It has only barely returned to the 2008 level, despite the increase in fracking. U.S. Bureau of Labor Statistics data confirm this trend, estimating Pennsylvania’s unemployment rate in November 2014 at 5.1 percent, still higher than before the crisis.<sup>16</sup> The overall trend is similar to the one in Illinois, a state without a significant shale gas industry.<sup>17</sup>

**Figure 2. Mining and Logging Employment Compared to Total Employment in Pennsylvania, 2004–14**



Source: See Endnote 15.

According to federal government data, logging and mining jobs in Pennsylvania (which include shale gas) grew from an estimated 18,000 in 2003 to some 23,000 in 2008, dipped briefly during the recession, then rose steeply to a peak of about 39,000 in 2011.<sup>18</sup> (See Figure 2.) Together, logging and mining employed just 0.6 percent of Pennsylvania’s total workforce of 6.37 million as of late 2014.<sup>19</sup> (See Table 1.) In contrast, trade, transportation, and utilities employed 17.7 percent, professional and business services 11.9 percent, and health and education 18.4 percent.<sup>20</sup>

**Table 1. Pennsylvania Labor Force Data, Selected Sectors, December 2014**

Sector	Labor Force (thousands)
<b>Total civilian labor force</b>	<b>6,367</b>
<b>Total employment</b>	<b>6,058</b>
Education and health services	1,171
Trade, transportation, and utilities	1,124
Professional and business services	759
Manufacturing	565
Mining and logging	38
Other (including farming)	2,401

Source: See Endnote 19.

According to these data, employment growth in the state’s mining and logging sector has failed to mimic the near-steady rise in natural gas production. (See Figure 1.) Although the sector has grown rapidly, it started from a very low level compared to other sectors. If one subtracts the “background” jobs in the sector that already existed in 2004, then only about 20,000 new jobs have been created by the fracking boom.<sup>21</sup> This is in keeping with the Department of Labor figure of 18,000 jobs created, and is far below the Chamber of Commerce claim.<sup>22</sup>

### Local Benefits and Their Distribution

A study by Penn State University’s Center for Economic and Community Development makes it possible to assess the impact of Marcellus drilling on Pennsylvania’s economy as a whole, measured by tax returns.<sup>23</sup> Total tax revenues in 2012 were \$33 billion.<sup>24</sup> Between 2007 and 2011—a period that encompassed the Great Recession as well as the recovery—the average personal income tax return (aggregated at the county level) declined by

2.4 percent.<sup>25</sup> In counties with 90 or more shale gas wells, it similarly declined by 2.4 percent. Yet in counties with no wells, it decreased by only 1.3 percent.<sup>26</sup>

The average taxable income grew 4.3 percent, and the average gross compensation 1.4 percent, in counties with at least 90 wells, but it decreased in all others.<sup>27</sup> The average number of returns reporting compensation declined everywhere. This suggests that shale gas extraction failed to compensate for the overall effects of the downturn in the job market. Only the most heavily drilled counties have seen increases in average salary (but not employment).

One benefit has come from the rents and royalties that drilling companies pay to mineral rights owners. On average, income from these sources, as well as from patents and copyrights, increased by almost 300 percent in counties with more than 90 shale gas wells, compared to an average increase of 108 percent statewide.<sup>28</sup> The number of returns reporting such income rose by 40.3 percent in the counties with high well density, but by only 18.3 percent statewide.<sup>29</sup> However, documents on recent and past mining transactions are not aggregated, making it difficult to determine how many surface owners have sold their mineral rights or still own them, and how many of them live in the actual drilling counties.<sup>30</sup>

Under Pennsylvania’s split real estate principle, raw materials that lie beneath a home or farm can be owned by individuals or companies other than the surface estate’s owner. Sub-surface owners have the rights to access the underground property and to place drills and wells near homes without permission from the surface owner. Noise, emissions, and water pollution from the drilling can make these homes uninhabitable. Yet even sub-surface owners may not get their fair share of the benefits. Billions of dollars in royalties are reportedly kept out of paychecks, despite a mandatory minimum royalty of 12.5 percent of the mined gas value.<sup>31</sup>

Moreover, despite strong growth, the share of rents and royalties in total income has, according to the study, grown from 1.3 percent in 2004, before the shale boom, to only 5.5 percent today, in counties with 90 or more wells.<sup>32</sup> At the county-level average in the state, the share grew from 1.2

percent to only 1.6 percent.<sup>33</sup> Using the state's total annual tax income of \$33 billion as a basis, this additional 0.4 percent would equal \$132 million annually. In all counties, gross compensation remains the largest source of income by far, contributing around 80 percent.<sup>34</sup> Notably, the study reports a 460 percent increase in income from rents and royalties from 2007 to 2009—less than from 2007 to 2011—suggesting that the surge of this revenue has peaked already.<sup>35</sup>

Retail businesses appear to have benefited from the shale gas activity, gauged by sales tax collection figures. Counties that had 150 or more wells drilled between 2007 and 2013 saw a 14.2 percent increase in annual sales tax revenues, compared to a 13.1 percent decrease in counties with no activity.<sup>36</sup> Although it is hard to filter out additional contributing factors, the correlation between sales tax collection and drilling activity suggests associated benefits to the sector, such as additional business from drilling workers. From 2008 to 2012, total annual state taxes from sales and gross receipts rose from \$8.8 billion to nearly \$9.2 billion, a difference of some \$300 million.<sup>37</sup>

Pennsylvania's total annual tax collection grew by around \$800 million between 2008 and 2012; however, many states saw similarly high (or higher) growth during this period, including states without significant shale activity, such as Illinois.<sup>38</sup> This suggests that part of the tax revenue gain is related to more general recovery, rather than to specific shale gas activity, or can occur without it.

On a side note, in October 2014 electricity rates for commercial and industry customers in Pennsylvania (at 9.37 cents and 6.87 cents per kilowatt-hour, respectively) were similar to their national averages (10.87 cents and 6.95 cents per kilowatt-hour).<sup>39</sup> Average residential U.S. electricity rates have grown steadily since 2006.<sup>40</sup> This indicates that shale gas has not induced any drop in electricity cost that could benefit local economies, contrary to what one might expect.

In sum, local economies have seen only limited benefits from the increased shale gas activity, and primarily in heavily drilled counties. Many of these benefits have gone to mineral rights owners through rents and royalties, which may have peaked already. Tax incomes from compensation for workers and total hiring have not grown at all.

This indicates that many of those hired are non-resident workers, who may spend some of their income in local retail shops and restaurants but are taking the bulk of it out of the county.<sup>41</sup> It remains to be seen how long-lasting these benefits will be for the retail sector.



### Volatility of Shale Mining Employment

In some counties, some of the limited fracking jobs that were created may have been lost already as operations have shifted from the dry gas regions in northern Pennsylvania to more profitable wet gas areas to the south.<sup>42</sup> And some activity has left Pennsylvania for more-profitable oil shale fields in other states. Shale-related employment across the six-state Marcellus/Utica region actually decreased between the first quarter of 2012 and the first quarter of 2013.<sup>43</sup>

A 2014 survey by the gas industry trade group shows the industry's job growth slowing, from 4,000 new hires in 2013 to only half that in 2014.<sup>44</sup> The share of new jobs created in the state grew from 57 percent in 2012 to 60 percent in 2013, confirming that a large portion (40 percent) of the jobs are going to specialized, out-of-state workers.<sup>45</sup> Many of these workers live in trailers lined up near the rigs, and move from site to site.

Even most locally created jobs apparently have only a short time span. According to a 2011 workforce estimate for Pennsylvania, out of the between 9,800 and 15,900 jobs created by end of 2014 over 2010 levels, most are needed only for the pre-drilling and drilling phases.<sup>46</sup> For wells drilled between 2011 and 2014, only between 1,879 and 2,822 workers are needed for the actual gas production.<sup>47</sup> Transportation jobs are not included, according to the definitions of this assess-



ment; however, the state's transportation, trade and utility sector, too, has barely recovered from the recession.<sup>48</sup> Most of the truck trips are needed during the construction and drilling phases, not thereafter. All of this means that only a small share of the jobs are for locals in the first place, and these are not available for long.

### Direct Taxes and Fees

Pennsylvania levies no direct taxes on shale gas drilling or related revenues; however, support for a tax is growing, given the state's \$1.5 billion deficit.<sup>49</sup> Since 2012, gas producers have been required to pay a local impact fee into an "Unconventional Gas Well Fund." In 2013, some \$225 million was collected, up from \$202 million in 2012.<sup>50</sup> Yet this represents only a tiny fraction of the industry's annual revenue of several billion dollars.<sup>51</sup> Although the state legislature voted in 2014 to raise the fuel tax, the cost will fall on all vehicular travel, not just shale-related traffic.

### Damage to Infrastructure

Studies indicate that, rather than reaping substantial benefits from shale gas, many communities are experiencing mounting negative effects.<sup>52</sup> Impacts include the costs of repairing roads damaged by heavy truck traffic, which can reach \$5,000–\$10,000 per well, or an estimated \$265 million in Pennsylvania in 2010.<sup>53</sup> Using the estimate of 57,000 active wells currently, this sum rises to \$570 million.<sup>54</sup>

What this estimate fails to account for is the damage to homes from the vibrations and exhaust fumes, as well as the loss in property values from nearby drilling activity, even without any physical damage. Additionally, sealing abandoned wells to prevent further leaking costs up to an estimated \$1,000 per well; given the estimated number of abandoned wells, the cost would run to hundreds of millions of dollars.<sup>55</sup> These figures would offset a large part of the accumulated annual benefits from taxes and fees discussed earlier.

### Damage to Tourism and Fishing

Intense fracking inflicts damages on existing industries as well. In one reported incident, the effects

of a nearby shale gas operation accidentally shifted a dam that was holding back a recreational fishing pond. The dam, which became unstable and threatened to flood nearby communities, had to be emptied on short notice, killing thousands of fish. A settlement was reached without the company accepting responsibility, and a new dam will not be installed before 2017.<sup>56</sup>

### Wastewater and Groundwater Hazards

Harder to quantify, but mounting, are adverse effects on both worker and public health and on the environment. Fracking wastewater is a leading environmental concern and the subject of intense study in Pennsylvania.<sup>57</sup> The fracking fluid used for each well contains up to 500,000 gallons (1.9 million liters) of various chemicals, and wells are typically "re-fracked" up to 10 times during their productive lifetime.<sup>58</sup> The additives can include halogen compounds, alcohols, salts, and even diesel or kerosene, used to modify the properties of the rock and the cracks. Although drilling companies are required to disclose the chemicals that they use, several hundred substances often are listed simply as volatile organic compounds (VOCs).

Once pumped underground, the chemicals undergo secondary reactions with the soil, minerals, and the mined gas itself. The byproducts can include trihalomethanes, which are highly regulated for potentially causing cancer.<sup>59</sup> Moreover, the well casing is typically applied only to the well's vertical section, and is hard to monitor. These vertical portions may cross aquifers, and faults and cracks can allow fluid to leave the well and contaminate the groundwater.

Between 1 million and 4 million gallons (3.8 million and 15 million liters) of water are pumped out of each well as "flowback," along with 60 gallons (227 liters) of various dissolved solids.<sup>60</sup> Because the chemistry and composition is complex and poorly understood, there are no reliable methods to clean the sludge. Some companies simply collect the flowback in ponds lined with off-the-shelf plastic sheeting. This can slip or tear easily, exposing the soil to wastewater seepage.

Investigations of possible threats to fresh water and associated costs are ongoing. Continuous

monitoring would be necessary, but is rarely being done. In addition, the large number of companies and subcontractors involved in the extraction process makes it difficult to identify the specific entity responsible for a given damage.

### Air Pollution from Transport and Drilling

An immediate hazard is air pollution from the drilling itself. Several hundred truckloads per well need to be transported to and from the site, to deliver the pad material and drilling equipment, haul away the cuttings, supply fresh water, and ferry off the waste water.<sup>61</sup> The diesel engines of trucks and equipment, and the occasional flarings of wells, release known air pollutants, including nitrogen oxides (NO<sub>x</sub>) and VOCs, endangering human health. During the flowback phase, workers are exposed to benzene, which can cause cancer.<sup>62</sup>

Mining activity is projected to contribute 12 percent of the Marcellus region's NO<sub>x</sub> and VOC emissions.<sup>63</sup> NO<sub>x</sub> emissions, through reactions in the air, can raise local ozone levels significantly, as is likely also happening in drilling areas in Texas.<sup>64</sup> Ground-level ozone harms health directly, as does mineral dust from the drilling, and noise pollution from the trucks and drilling sites.<sup>65</sup> Even though comprehensive data on the annual healthcare costs associated with fracking are lacking, existing indications are sufficient to warrant concern.

Furthermore, a scientific study estimates that methane leaks from gas wells are 100 to 1,000 times larger than the amounts estimated by the U.S. Environmental Protection Agency.<sup>66</sup> Because methane has a far higher global warming potential than carbon dioxide, this puts into question the claim that switching from (now exported) coal to natural gas will reduce greenhouse gas emissions.

### Net Effects of Shale Drilling

Given the limited benefits and numerous costs of shale gas drilling, indications are mounting that the net effects are not merely small, but in fact negative. A recent study in Ohio lists the advantages and disadvantages of shale gas and recommends increasing taxation to pay for the negative effects, as well as improving the monitoring of health and environmental issues.<sup>67</sup> The state of New York banned fracking in 2014

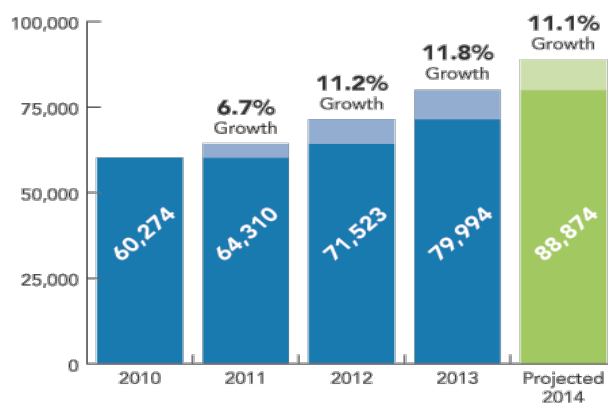
because of the risks to the state's air and water resources and to public health.<sup>68</sup> Pennsylvania's experience helped influence New York's decision, which in turn has increased the pressure on Pennsylvania to improve health impact monitoring.<sup>69</sup>

### Alternatives to the Resource Economy

Pennsylvania has good potential to embrace other industries, such as tourism, and to harness renewable energy sources, particularly wind, biogas, and second-generation biofuels from the farming sector.<sup>70</sup> Non-governmental groups allege that the state government does not pursue these avenues sufficiently but focuses instead on making business easy for the oil and gas industry.<sup>71</sup>

Across the United States, the development of alternative economies is proving to be beneficial, particularly for the job market. In Massachusetts, clean energy jobs enjoy steady growth of more than 10 percent annually and were projected to approach 89,000 in 2014.<sup>72</sup> (See Figure 3.) This is more than twice the figure for shale gas job creation in Pennsylvania. Pennsylvania itself gained more than 167,000 jobs in "green goods and services" in 2011, more than four times the total jobs in mining and logging combined.<sup>73</sup>

Figure 3. Clean Energy Jobs in Massachusetts, 2010–14



Source: See Endnote 72.

To tap more of this potential, a bill is pending in the Pennsylvania legislature to increase the mandated share of renewable energy in the state's power generation from 8 percent by 2020 to 15 percent by 2023.<sup>74</sup> New York has a more ambitious target of 29 percent by 2015.<sup>75</sup>

## Conclusions and Recommendations

Given Pennsylvania's extensive shale assets, and the state's stance so far, it appears that fracking will continue either until the gas pockets run empty or profits decline. But as the gas industry and mineral rights owners reap huge revenues, the industry's promises of broadly distributed, substantial, and long-lasting benefits have not materialized. Job creation is negligible, and communities face mounting damage to infrastructure, health, and the environment.

Prepared by Christoph v. Friedeburg.

## Endnotes

<sup>1</sup> U.S. Department of Commerce, Bureau of Economic Analysis, "GDP by State," [www.bea.gov/regional/index.htm](http://www.bea.gov/regional/index.htm), viewed 7 November 2014.

<sup>2</sup> U.S. Energy Information Administration (EIA), coal data by state, [www.eia.gov/coal/annual/xls/table1.xls](http://www.eia.gov/coal/annual/xls/table1.xls), viewed 9 February 2015.

<sup>3</sup> U.S. Department of Labor, Bureau of Labor Statistics (BLS), "Economy at a Glance – Pennsylvania," [www.bls.gov/eag/eag.pa.htm](http://www.bls.gov/eag/eag.pa.htm), viewed 2 March 2015. "Total Nonfarm" jobs subtracted from "Employment" to yield figure.

<sup>4</sup> Center for Coalfield Justice and FracTracker Alliance, personal communications with Christoph von Friedeburg, Worldwatch Institute.

<sup>5</sup> EIA, "Natural Gas Prices," [www.eia.gov/dnav/ng/ng\\_pri\\_sum\\_dcu\\_nus\\_m.htm](http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm), viewed 7 November 2014.

<sup>6</sup> Figure 1 from Ibid.

<sup>7</sup> EIA, "Shale Gas Provides Largest Share of U.S. Natural Gas Production in 2013," *Today in Energy*, 25 November 2014; Laura Legere and Katie Colaneri, "Pennsylvania Shale Production Continued to Grow in 2013," NPR StatelImpact, 19 February 2014; EIA, "Marcellus Region Production Continues Growth," *Today in Energy*, 5 August 2014.

<sup>8</sup> ICF International, "Marcellus and Utica Shale Gas Production Continues to Grow According to New ICF International Detailed Production Report," press release (Fairfax, VA: 26 June 2014).

<sup>9</sup> John Stolz, Duquesne University, personal communications with Christoph von Friedeburg, Worldwatch Institute 2014.

<sup>10</sup> Mary Kang, *CO<sub>2</sub>, Methane, and Brine Leakage Through Subsurface Pathways: Exploring Modeling, Measurement, and Policy Options* (Princeton, NJ: Princeton University, 2014); EIA, "Natural Gas, Number of Producing Gas Wells," [www.eia.gov/dnav/ng/ng\\_prod\\_wells\\_s1\\_a.htm](http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm), viewed 10 November 2014.

<sup>11</sup> Donald Gilliland, "US Chamber of Commerce Launches Pro-gas Campaign with Inaccurate Jobs Numbers," *Harrisburg Patriot-News*, 19 July 2012; Frank Mauro et al., *Exaggerating Shale Drilling's Employment Impacts: How & Why* (Harrisburg, PA: Multi-State Shale Research Collaborative, November 2013).

Pennsylvania's enormous alternative energy potentials, if developed ambitiously, could create economic benefits on a much larger scale, and for a longer term, than the shale gas industry has been able to provide—and without damages to public health and infrastructure. Greater education on this tradeoff is needed to help individuals, communities, and governments make smart decisions that go beyond the industry's short-term, unwarranted promises.

<sup>12</sup> Ibid.

<sup>13</sup> Ibid.

<sup>14</sup> Ibid.

<sup>15</sup> Pennsylvania Department of Labor and Industry (DLI), "Marcellus Shale Fast Facts" (Harrisburg, PA: January 2014 and November 2014 editions); BLS, op. cit. note 3.

<sup>16</sup> Ibid.

<sup>17</sup> BLS, "Economy at a Glance – Illinois," [www.bls.gov/eag/eag.il.htm](http://www.bls.gov/eag/eag.il.htm), viewed 2 March 2015.

<sup>18</sup> Figure 2 from Pennsylvania DLI, op. cit. note 15.

<sup>19</sup> Table 1 from BLS, op. cit. note 3.

<sup>20</sup> BLS, op. cit. note 3.

<sup>21</sup> Worldwatch calculations based on data from BLS and DLI.

<sup>22</sup> DLI, op. cit. note 15; BLS, op. cit. note 3.

<sup>23</sup> Emily O'Coonahern, Kirsten Hardy, and Timothy W. Kelsey, *Marcellus Shale and Local Economic Activity: What the 2013 Pennsylvania State Tax Data Say* (State College, PA: Penn State Center for Economic and Community Development, 13 November 2013).

<sup>24</sup> "State Tax Revenues: Charts and Data," [www.governing.com](http://www.governing.com), viewed 12 January 2015.

<sup>25</sup> O'Coonahern, Hardy, and Kelsey, op. cit. note 23.

<sup>26</sup> Ibid.

<sup>27</sup> Ibid.

<sup>28</sup> Ibid.

<sup>29</sup> Ibid.

<sup>30</sup> Ibid.

<sup>31</sup> Abraham Lustgarten, "Unfair Share: How Oil and Gas Drillers Avoid Paying Royalties," ProPublica.org, 13 August 2013; "How the Kings of Fracking Crossed Their Way to Riches," TheDailyBeast.com, 13 March 2014.

<sup>32</sup> O'Coonahern, Hardy, and Kelsey, op. cit. note 23.

<sup>33</sup> Ibid.

<sup>34</sup> Ibid.

<sup>35</sup> Ibid.

<sup>36</sup> Ibid.

<sup>37</sup> "State Tax Revenues: Charts and Data," op. cit. note 24.

<sup>38</sup> Ibid.

---

<sup>39</sup> EIA, "Table 5.6.A. Average Retail Price of Electricity to Ultimate Customers by End-Use Sector," [www.eia.gov/electricity/data.cfm](http://www.eia.gov/electricity/data.cfm), October 2014.

<sup>40</sup> EIA, "European Residential Electricity Prices Increasing Faster Than Prices in United States," *Today in Energy*, 18 November 2014.

<sup>41</sup> O'Coonahern, Hardy, and Kelsey, op. cit. note 23.

<sup>42</sup> Marie Cusick, "Gas Industry Survey Shows Job Growth Slowing," NPR Statelmpact, 29 July 2014.

<sup>43</sup> Mauro et al., op. cit. note 11.

<sup>44</sup> Cusick, op. cit. note 42.

<sup>45</sup> Ibid.

<sup>46</sup> Marcellus Shale Education & Training Center, *Marcellus Shale Workforce Needs Assessment* (Williamsport, PA: June 2010), p. 22.

<sup>47</sup> Ibid.

<sup>48</sup> BLS, op. cit. note 3.

<sup>49</sup> Jordan Krom, "Bipartisan Coalition Proposes Marcellus Shale Tax," PoliticsPA.com, 9 April 2014; Reid Wilson, "At a Time of Surpluses Elsewhere, Pennsylvania Faces Deficit," *Washington Post* blog, 7 February 2014.

<sup>50</sup> Barbara Miller, "Natural Gas Impact Fee Revenue Totals \$225 Million for 2013, Gov. Corbett Says," [www.pennlive.com](http://www.pennlive.com), 3 June 2014.

<sup>51</sup> Ibid.

<sup>52</sup> Mike Lee, "Drilling Boom Costs Pa. Thousands per Well in Road Damage," *E&E Publishing*, 27 March 2014; Elizabeth Ridlington and John Rumpler, *Fracking by the Numbers: Key Impacts of Dirty Drilling at the State and National Level* (Washington, DC: Environment America, October 2013); Tony Dutzik, Elizabeth Ridlington, and John Rumpler, *The Costs of Fracking: The Price Tag of Dirty Drilling's Environmental Damage* (Washington, DC: Environment America Research and Policy Center, Fall 2012).

<sup>53</sup> Ibid.

<sup>54</sup> Worldwatch calculations.

<sup>55</sup> See, for example, Minnesota Department of Health, "Sealing Unused Wells," brochure (Faribault, MN: undated).

<sup>56</sup> Center for Coalfield Justice and FracTracker Alliance, op. cit. note 4.

<sup>57</sup> See, for example, Duquesne University, "Research on Shale Gas Extraction Symposium," Pittsburgh, PA, 25–26 November 2013.

<sup>58</sup> Stolz, op. cit. note 9.

<sup>59</sup> Ibid.; U.S. Environmental Protection Agency (EPA), "Disinfection Byproducts: A Reference Resource," [www.epa.gov/envirofw/html/icr/gloss\\_dbp.html](http://www.epa.gov/envirofw/html/icr/gloss_dbp.html), and "Health Risk of the Trihalomethanes Found in Drinking Water Carcinogenic Activity and Interactions," <http://cfpub.epa.gov/ncer/abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/22>, both viewed 10 November 2014.

<sup>60</sup> Stolz, op. cit. note 9; Center for Coalfield Justice and FracTracker Alliance, op. cit. note 4.

---

<sup>61</sup> See, for example, Marcellus Share US, "Our Look at Gas Drilling Truck Traffic," [www.marcellus-shale.us/truck-traffic.htm](http://www.marcellus-shale.us/truck-traffic.htm), viewed 9 February 2015.

<sup>62</sup> Eric. J. Esswein et al., "Evaluation of Some Potential Chemical Exposure Risks During Flowback Operations in Unconventional Oil and Gas Extraction: Preliminary Results," *Journal of Occupational and Environmental Hygiene*, 1 August 2014.

<sup>63</sup> A.A. Roy et al., "Air Pollutant Emissions from the Development, Production, and Processing of Marcellus Shale Natural Gas," *Journal of the Air & Waste Management Association*, January 2014, pp. 19–37.

<sup>64</sup> Lisa Song, "What's Behind Surging Ozone Pollution in Texas? Study to Weigh Role of Fracking in Health Hazard," [insideclimatenews.com](http://insideclimatenews.com), 23 October 2013.

<sup>65</sup> EPA, "Ground-level Ozone Makes It Harder to Breathe," [www.epa.gov/groundlevelozone/](http://www.epa.gov/groundlevelozone/), viewed 10 November 2014.

<sup>66</sup> Dana R. Caulton et al., "Toward a Better Understanding and Quantification of Methane Emissions from Shale Gas Development," *Proceedings of the National Academy of Sciences*, 29 April 2014, pp. 6237–42.

<sup>67</sup> Douglas J. Guth, "Ohio Study Finds More Costs Than Benefits in Shale Gas Drilling," *Midwest Energy News*, 9 July 2014; Amanda Woodrum, *Fracking in Carroll County, Ohio: An Impact Assessment* (Cleveland, OH; Policy Matters Ohio. April 2014).

<sup>68</sup> Denver Nicks, "New York Bans Fracking," *Time*, 17 December 2014; Aisha Abdelhamid, "Why New York Banned Fracking," [InspiredEconomist.com](http://InspiredEconomist.com), 12 January 2015.

<sup>69</sup> See, for example, Sharon Kelly, "As New York Bans Fracking, Calls for Moratorium in Pennsylvania Grow Stronger," [DeSmogBlog.com](http://DeSmogBlog.com), 21 December 2014; Katie Colaneri, "After New York Ban, Pennsylvania Renews Focus on Fracking Health Impacts," NPR Statelmpact, 30 December 2014.

<sup>70</sup> Natural Resources Defense Council, "Renewable Energy for America - Pennsylvania," [www.nrdc.org/energy/renewables/penn.asp](http://www.nrdc.org/energy/renewables/penn.asp), viewed 9 February 2015.

<sup>71</sup> Center for Coalfield Justice and FracTracker Alliance, op. cit. note 4.

<sup>72</sup> Stephen Lacey, "MA Has Double the Jobs in Clean Energy That PA Has in Natural Gas," [GreenTechMedia.com](http://GreenTechMedia.com), 19 September 2013; Figure 3 from Massachusetts Clean Energy Center, *2013 Clean Energy Industry Report* (Boston: 2014).

<sup>73</sup> American Council On Renewable Energy, "Renewable Energy in Pennsylvania," in *Renewable Energy in the 50 States: Northeastern Region* (Washington, DC: June 2014), pp. 25–25.

<sup>74</sup> Matt Kasper, "Pennsylvania Looks to Double Its Renewable Energy Standard, For Real This Time," *Think Progress*, 12 November 2013.

<sup>75</sup> Database of State Incentives for Renewable Energy (DSIRE), "New York: Renewable Portfolio Standard," [www.dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=NY03](http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY03), viewed February 2015.