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Introduction

The Marcellus Shale Energy and Environmental Laboratory (MSEEL) project in Morgantown, WV has provided a long-term field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development. The project also gives researchers access to a dedicated science well for subsurface geophysical observation while Northeast Natural Energy (NNE) deploys a range of next-generation well-completion technologies designed to increase operational efficiency and reduce environmental impact. MSEEL also has provided a venue for training and educating next-generation scientists and engineers.

This report summarizes the economic impacts of the MSEEL project for both the state of West Virginia and the Morgantown metropolitan area. It uses two types of data; the first is project data provided by NNE and processed using a Cost Estimation Tool developed by the authors, and second is worker survey data collected during the drilling phase.

Data

This report uses NNE data that were processed using the Cost Estimation Tool developed at the Regional Research Institute as a part of this project. The tool summarizes and transforms the MSEEL shale gas well expenditures data provided by NNE management into a data base that can be used to estimate a generalized production function that subsequently can be embedded within economic systems models. The Cost Estimation Tool results are based in purchaser prices, which include wholesale and retail trade margins and transport cost margins.

Because available input-output models for the study regions are denominated in producer costs, purchaser costs were converted to producer prices. Producer prices are prices paid to producers, which exclude trade and transport margins and other taxes or fees paid by the purchaser[1] The U.S. Bureau of Economic Analysis provides transportation, wholesale, and retail margins data in their "Margins after Redefinitions" table.[2] To convert purchaser prices to

[1] The Bureau of Economic Analysis provides a term glossary that can be consulted for definitions of many conventional terms used throughout this report. The glossary can be accessed at https://www.bea.gov/glossary/glossary_a.htm

[2]The relevant tables can be found on the BEA website at https://www.bea.gov/industry/more.htm.

producer prices requires the calculation of the percentages of purchaser prices that are allocated to producer prices, transportation margins, wholesale margins, and retail trade margins. Percentages for the four subcategories are then used to decompose the purchaser prices. The margins, extracted from all paid purchasers' prices, are summed over all goods and services purchased and are then assigned to the corresponding margins by sectors (Transportation, Wholesale Trade, and Retail Trade).[3]

The converted data were then used as drivers for the input-output analysis, which results in an impact assessment for the 69 industry categories listed in Table 1 that represent the entire regional economy.[4] The results reported include direct impacts, employment and employee compensation impacts, tax impacts, gross operating surplus impacts, and total value-added impacts[5]. The analysis was run twice, once for the state of West Virginia and once for the Morgantown Metropolitan Statistical Area (MSA), which includes Monongalia and Preston counties and is anchored by the city of Morgantown. The state of West Virginia data are included by default in the software used, which also supports the creation of user-defined regions. We used BEA data to create the impacts model for the Morgantown MSA region. The two regional models used the processed data to drive the impacts assessments analysis. However, because smaller regions import goods from the rest of the economy, the direct impacts are adjusted by industry-specific regional supply percentages and reflect each region's estimated ability to satisfy demand placed on its own industries.

The MSEEL science well allows the MSEEL research team to gather continually geological, environmental, and other data. This meant there were additional expenditures associated with scientific instrumentation, and that their installation and monitoring are not typical for production wells. For this reason, we conducted the impacts assessments with and without the additional science well expenditures to provide more generalizable impacts

[3]This means that if there were 10 affected industries, there would be 10 Wholesale Trade values, 10 Retail trade values, and 10 Transportation values. The sums of these values for the three margins sectors would become the direct impact values for those three sectors.

[4] The input-output software used is called IO-Snap (Input-Output – State and national analysis program). Details can be found at www.IO-Snap.com.

[5]According to the BEA website, the taxes referenced here consist of Federal excise taxes and customs duties, state and local sales taxes, property taxes (including residential real estate taxes), motor vehicle licenses, severance taxes, and special assessments. These are taxes that are borne by the producing industries and are estimated as proportions to industry output impacts. See the BEA glossary of terms and definitions for more information.

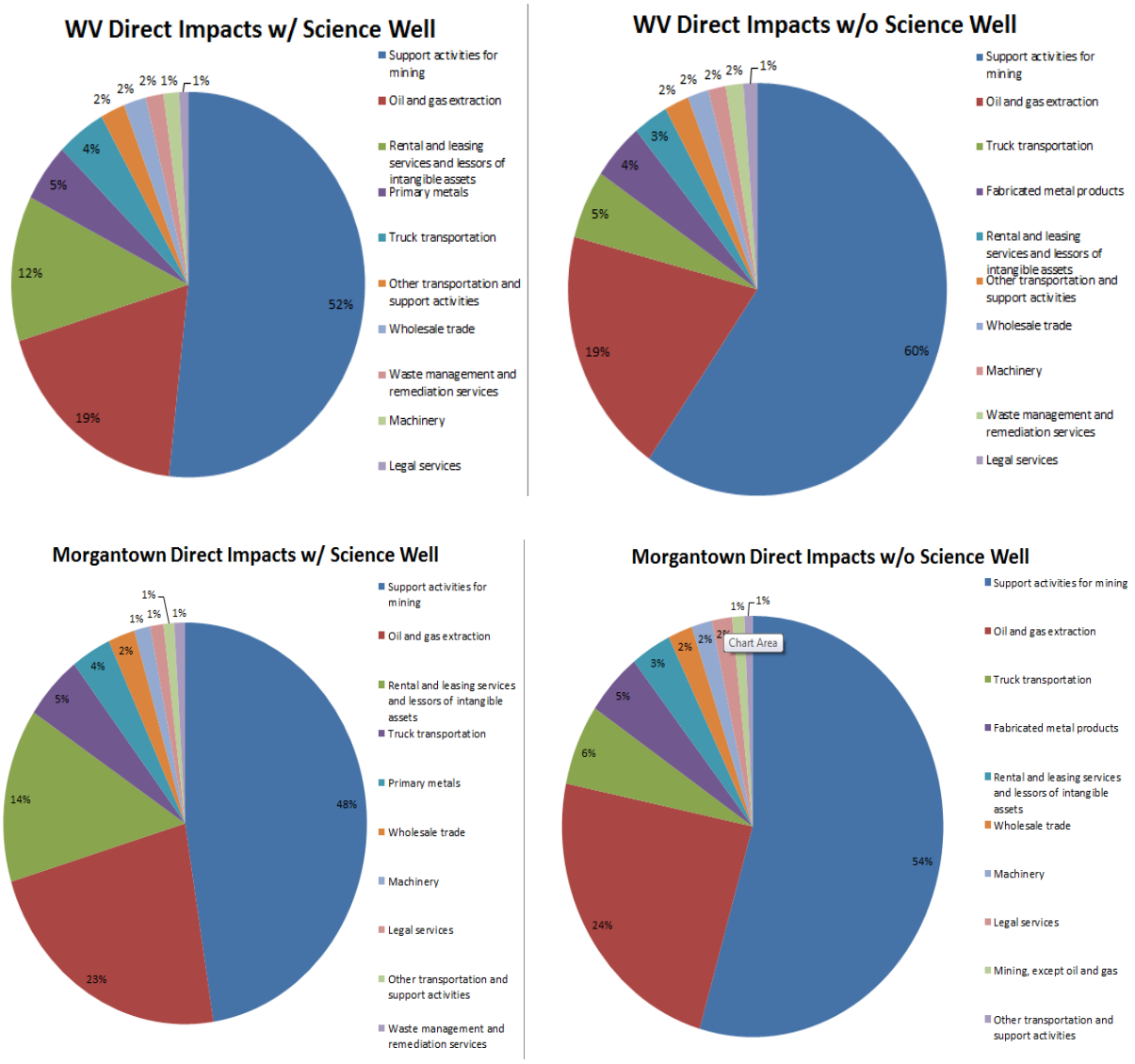
assessments. Figure 1 below shows the distribution of the compiled direct impacts for the state of West Virginia and Morgantown with the science well expenditures included and excluded.[6] The two largest direct impacts are on the *Support Activities for Mining* industry sector (52% and 60%) and the *Oil and Gas Extraction* (19%) sector. *Truck Transportation*, *Primary Metals*, and *Legal Services* sectors accounted for most of the remaining changes for both the state and the MSA.

Table 1: Input-output Model Industries

Farms	Transit and ground passenger transportation
Forestry, fishing, and related activities	Pipeline transportation
Oil and gas extraction	Other transportation and support activities
Mining, except oil and gas	Warehousing and storage
Support activities for mining	Publishing industries, except internet (includes softw
Utilities	Motion picture and sound recording industries
Construction	Broadcasting and telecommunications
Wood products	Data processing, internet publishing, and other infor
Nonmetallic mineral products	Federal Reserve banks, credit intermediation, and re
Primary metals	Securities, commodity contracts, and investments
Fabricated metal products	Insurance carriers and related activities
Machinery	Funds, trusts, and other financial vehicles
Computer and electronic products	Real estate
Electrical equipment, appliances, and components	Rental and leasing services and lessors of intangible
Motor vehicles, bodies and trailers, and parts	Legal services
Other transportation equipment	Computer systems design and related services
Furniture and related products	Miscellaneous professional, scientific, and technical
Miscellaneous manufacturing	Management of companies and enterprises
Food and beverage and tobacco products	Administrative and support services
Textile mills and textile product mills	Waste management and remediation services
Apparel and leather and allied products	Educational services
Paper products	Ambulatory health care services
Printing and related support activities	Hospitals
Petroleum and coal products	Nursing and residential care facilities
Chemical products	Social assistance
Plastics and rubber products	Performing arts, spectator sports, museums, and rel
Wholesale trade	Amusements, gambling, and recreation industries
Motor vehicle and parts dealers	Accommodation
Food and beverage stores	Food services and drinking places
General merchandise stores	Other services, except government
Other retail	Federal government enterprises
Air transportation	Federal general government
Rail transportation	State and local government enterprises
Water transportation	State and local general government
Truck transportation	

[6]The same graph for the Morgantown MSA is in the Appendix.

Figure 1: Direct Impacts



These direct changes can then be used in the model to drive the impact analyses.[7] Even though every industry does not have a corresponding direct change, all industries can be affected directly and indirectly through interindustry linkages.

[7] For the sake of confidentiality, precise direct impacts values for each individual sector are not shown.

Results

This section highlights the results of the impact analysis of MSEEL drilling operations in both the state and in Morgantown. Table 2 below shows the combined direct, indirect, and income-induced impacts of MSEEL drilling operations on the state of West Virginia and in Morgantown.[8] MSEEL drilling operations (with the science well related expenditures included) supported 121 full-time equivalent employees (FTEs) in the state and 110 FTEs in the Morgantown metropolitan area.[9] There was a $6.12M and $5.45M employment compensation impact in the state and in Morgantown MSA respectively.[10] The parallel analysis that excludes the science well reduced the number of FTEs by roughly 15 and 11 for the state and MSA analyses, and compensation impacts for West Virginia and Morgantown were reduced accordingly to $5.44M and $4.94M respectively.

An FTE represents the equivalent of a full-time job; this can correspond to three workers working four months each, six workers working two months each, etc., so these estimates should not be confused with numbers of workers. Further, because many of the materials used at the well site are acquired through vendor workers, there are on-site labor costs embedded in the materials costs. Consequently, the number of employees (FTEs) who participated directly in on-site activities cannot be precisely estimated with the available data; this also makes it difficult to estimate direct compensation impacts. Nevertheless, the total FTEs represent best estimates of employment and compensation impacts derived from published data on FTEs and compensation per industry dollar output.

Total Value-Added as reported in Table 2 is the sum of Employment Compensation, Tax, and Gross Operating Surplus.[11] With the science well included, the total valued-added is $8.65M

[8]Impacts were generated using 2012 IO-Snap data, which is the data year that most closely corresponds with the timing of the expenditures. This means that the respective model structures are based on the 2012 structures of the two regional economies.
[9]Impacts are Type-2 Commodity Driven, which include direct, indirect, and income-induced impacts.
[10]Due to the way in which some materials are delivered, there are some on-site labor costs embedded in the materials. This results in some unavoidable but unmeasurable inaccuracies, likely underestimating actual labor and compensation impacts. As such, the impacts reported here are likely to be conservative estimates.
[11]Value-added is alternatively defined as the difference between gross output and intermediate inputs and includes the value of labor and capital used in producing gross output, and indirect taxes and fees.

for West Virginia and $7.49M for the Morgantown MSA. If the science well is excluded, total value-added falls to $7.14M and $6.31M for the state and the MSA respectively.

Table 2: Overall Impacts of MSEEL drilling in West Virginia and Morgantown

Impacts	West Virginia	Morgantown	West Virginia (Science Well Excluded)	Morgantown (Science Well Excluded)
Employment Compensation	6.12	5.45	5.44	4.94
Tax	0.33	0.27	0.23	0.19
Gross Operating Surplus	2.2	1.77	1.47	1.18
Total Value-Added	8.65	7.49	7.14	6.31
Employment (Full Time Equivalent)	121.28	109.62	106.3	98.51

Impacts in millions of 2012 dollars unless otherwise noted.

Figure 2 (below) highlights the top eight sectors by employment impacts for the state of West Virginia. The majority of employment impacts (approximately 16) were in the *Support Activities for Mining* sector, irrespective of whether the science well expenditures were included. *Oil and Natural Gas Extraction*, *Wholesale Trade*, and *Miscellaneous Professional, Scientific, and Technical Services* were also in the top eight sectors. Figure 3 (below) highlights the top eight sectors by employment impact for the Morgantown MSA. The *Support Activities for Mining* sector again had the majority of employment impacts. The *Ambulatory Health Care Services* sector replaces the *Administrative and Support Services* sector in the top eight sectors for Morgantown.

Figure 2: Top 8 Sectors by Employment Impacts in West Virginia (Science Well Included v. Science Well Excluded)

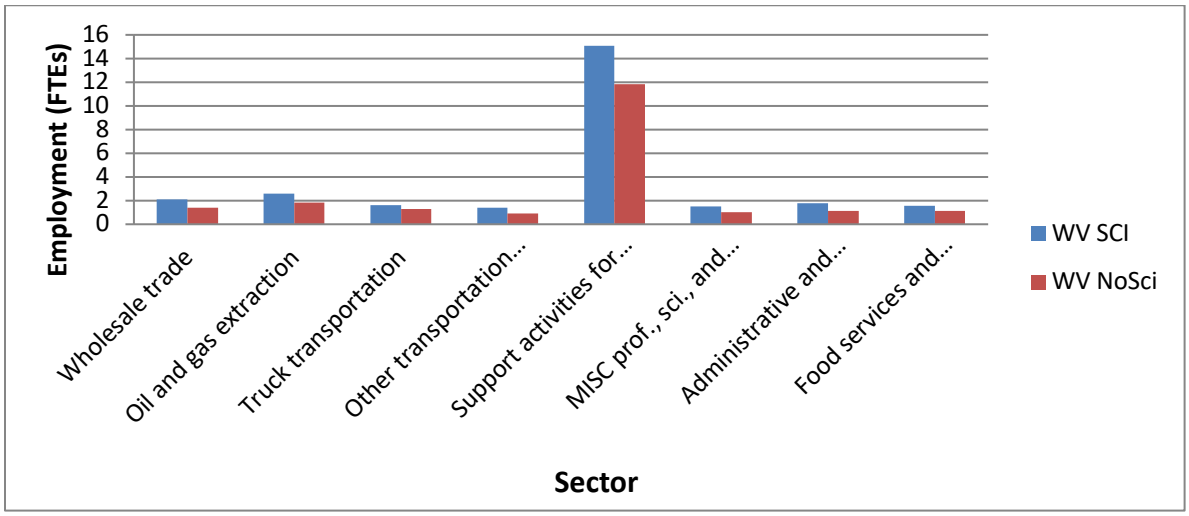
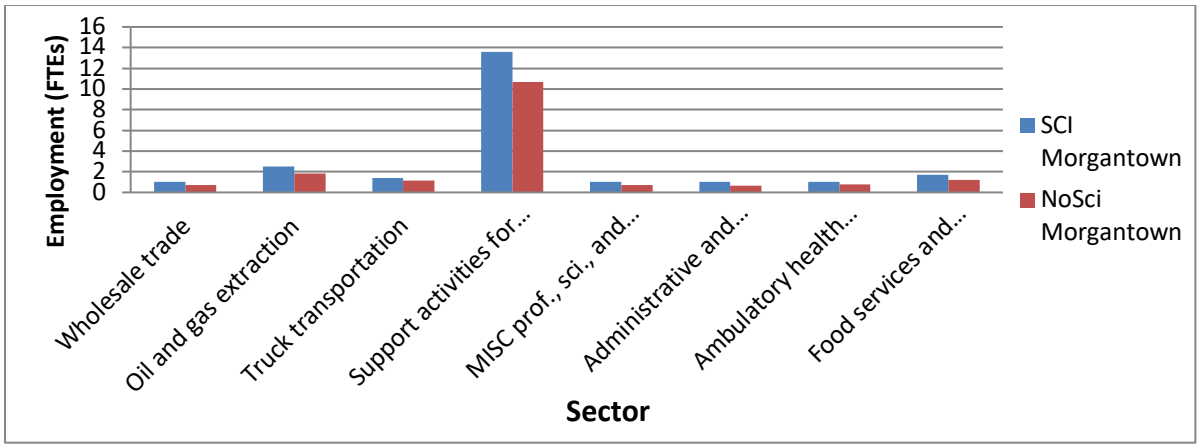


Figure 3: Top 8 Sectors by Employment Impacts in Morgantown (Science Well Included v. Science Well Excluded)



Worker Expenditure Results

Many contractors reside outside of the study regions. These workers will impact the local economy primarily through their needs for accommodations, food and beverage providers, and local retail. Almost 70 workers were surveyed, although not all of the survey questionnaires were completed. Questions on the survey included workers backgrounds and experiences, local interactions, personal information, and economic information. Best efforts were used to glean

useful information from the survey. Missing or omitted data for some returned questionnaires were imputed using averages for reported data from similar respondents. The economic information from the survey of the workers was used to generate the results regarding lodging, transportation, and food. The total addition to final demand from workers' expenditures was approximately $80K. This change would have been sufficient to support two FTEs, adding and an additional $90k to total value-added. In practice, employment impacts this limited in proportion to the host economy can often be absorbed by existing workers. Many of the jobs that were supported by the drilling activity were filled by non-residents. Of those who responded to a question on typical hotel expenditures, roughly three out of four reported using a hotel for one or more nights. As expected, the top industries in employment impacts were *Accommodation* and *Food Services and Drinking Places*.

Summary & Discussion

This document reports the results of impact analyses based on the Marcellus Shale Energy and Environmental Laboratory (MSEEL) and using models that correspond to two different study regions: the state (West Virginia) and the Morgantown MSA. The estimates indicate that the MSEEL project supported between 99 and 121 FTEs directly and indirectly. The impacts are presented in FTE, and because the majority of labor required is known to have been on-site for periods of less than one year, the actual number of individual workers involved will have been greater than the numbers of FTEs. The majority of the direct impacts occurred in the *Support Activities for Mining* sector. Other sectors like *Truck Transportation*, *Oil and Gas Extraction*, and *Rental and Leasing Services and Lessors of Intangible Assets* were also positively affected.

It is customary in impacts assessments like these to report multiplier values calculated as ratios of total impacts to direct impacts. For purposes of future generalization, the output multiplier values for the MSA and WV were 1.57 and 1.75.