America's New Energy Future:
The Unconventional Oil and Gas Revolution and the US Economy

Volume 2 – State Economic Contributions

Appendix D. Methodology and Approach

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Appendix D. Methodology and Approach

Energy

IHS CERA's outlook for unconventional oil and gas in the lower 48 states includes production from 20 established unconventional oil and gas plays and from additional emerging unconventional oil and gas plays nationwide: 10 shale plays, 5 tight sands gas plays and 8 tight oil plays. These are listed below:

Unconventional Plays	Play Type	Geographic Extent of the Play*
Eagle Ford Shale Wet Gas	Shale Gas	Texas
Marcellus Shale	Shale Gas	Ohio, Pennsylvania, West Virginia
Haynesville Shale	Shale Gas	Texas, Louisiana
Fayetteville Shale	Shale Gas	Arkansas
Barnett Shale	Shale Gas	Texas
Eagle Ford Shale Dry Gas	Shale Gas	Texas
Utica Shale (Gas)	Shale Gas	Ohio, Pennsylvania, West Virginia
Niobrara	Shale Gas	Colorado, Wyoming
Woodford Shale	Shale Gas	Oklahoma
Emerging Gas Plays	Shale Gas	Texas, Oklahoma, Louisiana, New Mexico, Arkansas, Utah, Colorado, Wyoming, Ohio, Pennsylvania, West Virginia, Mississippi
Emerging Gas Plays	Tight Gas	Texas, Oklahoma, Louisiana, New Mexico, Arkansas, Utah, Colorado, Wyoming, Ohio, Pennsylvania, West Virginia, Mississippi
Cotton Valley	Tight Gas	Texas, Louisiana
Granite Wash-Colony Wash	Tight Gas	Texas, Oklahoma
Jonah-Pinedale	Tight Gas	Wyoming
Uinta-Piceance	Tight Gas	Utah, Colorado
Bakken	Tight Oil	North Dakota, Montana
Delaware Basin - Bone Spring	Tight Oil	Texas, New Mexico
Midland Basin - Spraberry-Wolfcamp	Tight Oil	Texas
Mississippian	Tight Oil	Oklahoma, Kansas
Cleveland-Tonkawa-Marmaton	Tight Oil	Texas, Oklahoma
Emerging Oil Plays	Tight Oil	Texas, Oklahoma, Louisiana, New Mexico, Arkansas, Utah, Colorado, Wyoming, Ohio, Mississippi, California
Eagle Ford Oil and Volatile Oil	Tight Oil	Texas
Utica (Oil)	Tight Oil	Ohio

*The list of unconventional plays provides the state location or locations of the play production considered for this study. States containing part of a play but no ongoing extraction takes place in those states at present are not included in this table. This study also assumes that no production is forthcoming from New York.

Source: IHS CERA

The assessments of geological potential take into consideration both oil and gas reserves and development activity. Projections of geological potential are based on trends in initial production rates, decline rates, and reserve amounts associated with new completions. Other petroleum and natural gas formations exist; however, they were not evaluated in this report. If other formations are identified and developed in the future, employment, value added and government revenue may be higher, especially in the later years of the forecast. Finally, this forecast also assumes current technology. Future advances in drilling/completion technologies and down-spacing could extend or increase production and investment in the latter part of the forecast, further increasing their economic contributions.

Estimates generated by IHS CERA on each state's capital expenditures and production provide the foundation for the economic contribution assessment developed by IHS Global Insight. We have aggregated the underlying capital expenditures and production data to the Census divisions for display in this report.

US Census Region and Division Definitions

Region	Division	States
Northeast	New England	Connecticut, Maine, Massachusetts, New Hampshire, Vermont, and Rhode Island
	Middle Atlantic	New Jersey, New York, and Pennsylvania
Midwest	East North Central	Illinois, Indiana, Michigan, Ohio, and Wisconsin
	West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota
South	South Atlantic	Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia
	East South Central	Alabama, Kentucky, Mississippi, and Tennessee
	West South Central	Arkansas, Louisiana, Oklahoma, and Texas
West	Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming
	Pacific	Alaska, California, Hawaii, Oregon, and Washington

US Census Division Annual Capital Expenditures: Unconventional Oil and Gas Activity

(Current $M)

	2012	2015	2020	2025	2030	2035
New England	11	25	46	75	133	217
Middle Atlantic	4,115	7,205	11,010	16,394	25,426	38,263
East North Central	4,908	9,677	16,411	24,269	35,376	48,879
West North Central	8,630	13,880	18,400	23,843	26,396	27,982
South Atlantic	975	1,779	2,852	4,362	6,925	10,519
East South Central	65	103	160	497	1,280	2,556
West South Central	54,312	74,405	102,126	131,339	148,994	168,144
Mountain	11,314	15,209	16,902	20,876	31,586	45,940
Pacific	2,971	4,006	4,634	6,012	8,037	10,577
US Total	**87,301**	**126,288**	**172,542**	**227,667**	**284,154**	**353,076**

Source: IHS Global Insight

US Census Division Annual Production: Unconventional Oil

(mbd)

	2012	2015	2020	2025	2030	2035
New England	0.00	0.00	0.00	0.00	0.00	0.00
Middle Atlantic	0.00	0.01	0.02	0.03	0.04	0.07
East North Central	0.01	0.10	0.25	0.35	0.45	0.54
West North Central	0.62	1.04	1.23	1.23	1.03	0.80
South Atlantic	0.00	0.00	0.01	0.01	0.02	0.03
East South Central	0.00	0.00	0.00	0.01	0.03	0.05
West South Central	1.06	1.84	2.33	2.23	2.06	1.93
Mountain	0.37	0.51	0.60	0.67	0.83	1.02
Pacific	0.00	0.00	0.00	0.01	0.04	0.06
US Total	**2.07**	**3.50**	**4.43**	**4.53**	**4.49**	**4.50**

NOTE: Numbers may not sum due to rounding.

Source: IHS Global Insight

US Census Division Annual Production: Unconventional Gas

(bcf per day)

	2012	2015	2020	2025	2030	2035
New England	0.00	0.00	0.00	0.00	0.00	0.00
Middle Atlantic	3.82	5.95	9.01	11.76	14.87	18.70
East North Central	0.08	0.52	1.97	3.38	5.13	6.81
West North Central	0.46	0.92	1.28	1.40	1.34	1.20
South Atlantic	1.05	1.65	2.58	3.43	4.42	5.64
East South Central	0.00	0.00	0.00	0.01	0.08	0.28
West South Central	25.20	29.56	38.94	45.69	43.46	41.68
Mountain	5.51	5.66	5.76	3.93	3.70	5.69
Pacific	0.00	0.00	0.00	0.01	0.04	0.08
US Total	**36.12**	**44.27**	**59.53**	**69.61**	**73.06**	**80.05**

Source: IHS Global Insight

Economic Contribution Assessment

Data Requirements and Assumption

This economic contribution assessment is based on state-level data of unconventional oil and gas activity. Both the value of production and capital expenditures were input, by state, into the model to conduct the economic analysis.

The following activities were determined to be major direct contributors:

- Unconventional oil and natural gas drilling
- Unconventional oil and natural gas extraction
- Support activities and services required for unconventional oil and natural gas drilling and extraction
- Construction of facilities, related materials and machinery for hydraulic fracturing, completions, and facilities for the upstream activity

The primary analytical tool for this multi-state study is the same IMPLAN Input-Output model used, with the IHS US Macroeconomic Model, in the overall US analysis. However, the architecture of the existing IMPLAN model could not efficiently handle the computational complexity of a multi-state analysis in which each state is, within IMPLAN, effectively an independent geographic region. To adjust for this limitation, IHS Global Insight ran multiple, alternative versions of the IMPLAN multi-regional model and integrated the output with in-house proprietary databases to assess the indirect and induced economic contribution by industry and state. This fine-tuned methodology ensures that inputs that are not locally produced – or do not have a competitive advantage locally – are sourced from other states creating economic "leakages" from one state to another. In the broader context, an economic "leakage" is explained as inter-regional activity in which the production requirements of a commodity (or a service) use inputs produced in other states thus causing the economic impact to "leak" to other states and introduce a regional ripple effect.

The model framework used here was set up as a system of linked state economies. As a result, the sourcing of inputs for the development of unconventional gas activity will impact those states that do not have an unconventional gas play within their borders. For example, the development of unconventional gas wells in Arkansas relies on bank, insurance and securities services in New York and professional services primarily located in Texas. Capturing these connections highlights the indirect economic contribution even in states that lack unconventional gas plays. The leakages also impact US GDP and employment multipliers, making them more accurate for states that do have unconventional oil or gas plays.

The IMPLAN model also produces "own-state" multipliers – that is, the indirect and induced impact that flow from direct activity as a result of that state's unconventional oil and gas development excluding any impact from the supplier states providing services or products.

In a given year, the volume of oil and natural gas produced in each state is impacted by both the wells drilled during the course of the year and by wells drilled in previous years that remained in operation. The monetary value of oil and gas production volumes was calculated using WTI and the Henry Hub price. These values served as inputs to the oil and gas extraction industry in the corresponding states in the IMPLAN model.

Capital Expenditures

While the value of oil and gas production is attributed only to states with unconventional oil and/or gas plays, the allocation of capital expenditures among the producing and non-producing states is more involved. Capital expenditures act as direct impacts at both the state and industry levels. The complexity lies in the fact that a portion of that spending may be allocated to states that do not have unconventional oil or gas plays. This spending will trigger indirect and induced impacts in these states as they provide goods and services. To ensure that these effects are included in the economic analysis, IHS Global Insight used industry input, IHS Global Insight's in-house expertise and proprietary databases, and extensive additional research to arrive at the best possible methodology for allocating capital expenditures among different states.

The first step, as in the national study, was to map the capital expenditure breakdown for the categories specified by the IMPLAN model. Capital expenditure and support services for oil and natural gas drilling correspond to industry sectors within the IMPLAN model. However, the breakdowns for drilling, completion, facilities, gathering and processing were mapped to many other categories of the model.

The research, expertise and input from industry sources were integrated with an interstate trade-flow and IHS Global Insight's Business Market Insight databases to determine the sources of various products and services by state. For example, it is evident that unconventional gas extraction requires special sand for hydraulic fracturing that is produced primarily in Wisconsin, Minnesota, Ohio, and Arkansas. Since not all states with unconventional oil or gas plays produce these unusual sands, they must import them from other states and are assumed to do so in the model. IHS's trade-flow database was one of many sources used to determine the origin and destination of the various materials and equipment on a state level basis.

This process was undertaken for all the products in the 16 states with current and future drilling in unconventional oil and gas plays. The final set of capital expenditures, by various products and services, and, if applicable the value of production, was input into 43 IMPLAN state models to assess the contribution on each individual state's economy.

Modeling the State Economic Contribution

The multi-regional capability of the IMPLAN model estimated the economic contributions of unconventional oil versus gas production and capital spending at the state level. The methodology assessed not only the contribution to states with unconventional oil and gas production but also non-producing states affected directly (via capital expenditures) or indirectly (via cross-state trade flows) by the producing states' activity. The IMPLAN model calculated the contribution to states with unconventional oil and gas production and/or allocated direct capital spending. However, indirect and induced impacts were determined using various analytical tools: the IMPLAN model, IHS Global Insight's trade-flow databases for product groupings, and IHS Business Market Insight for services categories. The process was repeated for each state with unconventional oil and/or gas production and for those states affected by direct capital spending (a subset of non-producing states). Finally, all of the state-by-industry direct, indirect and induced contributions to employment, value added to GDP, labor income, and government revenue were calibrated with the national results.

Starting with the IMPLAN Multi Regional Analysis (MRA) capability, each of the state models were simulated using value of production and/or capital expenditures depending on whether the state is a producing state or not. The MRA results were obtained for each state with direct production and/or capital expenditures as well as for all states that experience cross border

impacts (leakages). The cross border contributions for the other states include both supply chain (indirect) and income (induced) effects. To ensure these impacts were traced to the best possible source, IHS used its point-to-point commodity trade database (Transearch) and establishment location database (Business Market Insight) to determine the distribution of cross border contributions by state and industry. Finally, all of the state-by-state level results were calibrated with the national results to report a consistent and cohesive set of contributions by state and industry.

State-Level Enhanced Economic Contribution Methodology Schematic