

---

# HYDRAULIC FRACTURING BAN

## The Economic Impact of a Statewide Fracking Ban in Colorado

---

Conducted by:

Richard Wobbekind  
Brian Lewandowski

Editor: Cindy DiPersio  
Student Research Assistants:  
Jim Dalton, Rick Brubaker,  
Noah Seidenfeld, and Ryan Thorpe

**Business Research Division**  
Leeds School of Business  
University of Colorado Boulder  
420 UCB  
Boulder, CO 80309-0420  
Telephone: 303.492.3307  
[leeds.colorado.edu/brd](http://leeds.colorado.edu/brd)

March 2014



## **Business Research Division**

*The Business Research Division (BRD) of the Leeds School of Business at the University of Colorado Boulder has been serving Colorado since 1915. The BRD conducts economic impact studies and customized research projects that assist companies, associations, nonprofits, and government agencies with making informed business and policy decisions. Among the information offered to the public are the annual Colorado Business Economic Outlook Forum—now in its 49<sup>th</sup> year—which provides a forecast of the state’s economy by sector, and the quarterly Leeds Business Confidence Index, which gauges Colorado business leaders’ opinions about the national and state economies and how their industry will perform in the upcoming quarter. The Colorado Business Review is a quarterly publication that offers decision makers industry-focused analysis and information as it relates to the Colorado economy.*

*BRD researchers collaborate with faculty researchers on projects, and graduate and undergraduate student assistants, who provide research assistance and gain valuable hands-on experience.*

*Visit us at:*

[www.leeds.colorado.edu/brd](http://www.leeds.colorado.edu/brd)

## TABLE OF CONTENTS

Table of Contents .....	iii
Executive Summary.....	1
Introduction .....	3
Fracking.....	4
National Production.....	5
Public Information in Colorado.....	5
History of Oil and Gas in Colorado.....	7
State of the Industry .....	8
Legislation .....	11
Data and Assumptions.....	12
Economic Impacts .....	14
Conclusion.....	17
Bibliography .....	18
Appendix 1: Overview of REMI Policy Insight.....	22
Appendix 2: FrackingSENSE Speaker Series Discussion Summaries .....	25
Appendix 3: Recent Ballot Initiatives .....	28

## EXECUTIVE SUMMARY

In November 2012, voters in the City of Longmont passed a charter amendment effectively banning the use of hydraulic fracturing (fracking) and the storage of the resultant waste products by a 59.9% to 40.1% margin. The amendment does not ban drilling per se, but forbids the practice of fracking. This amendment set the stage for citizen initiatives elsewhere, including Boulder, Broomfield, Fort Collins, and Lafayette, that successfully passed moratoriums in November 2013. While legal contests to these bans and moratoriums are currently taking place, it is expected that another anti-fracking measure could be headed to the Colorado ballots this November. These measures fall into two general categories: local control and setbacks. Local Control Colorado has submitted language to the Colorado Legislative Services for a constitutional amendment that would allow Colorado voters a voice over whether hydraulic fracturing should be allowed within the bounds of their communities. Separately, the setback initiatives range between 1,500 feet and one-half mile. Colorado Governor John Hickenlooper describes the state's regulation as "the most comprehensive and stringent" in the country. This study focuses on the economic impacts of a statewide ban on fracking.

Reporting the industry size in terms of gross domestic product, oil and gas extraction and support activities was nearly equivalent to the construction industry or the accommodations and food services industry in 2011. More than 87% of oil and gas activity in Colorado is concentrated in 5 counties, and 31 counties represent the remaining 13% of activity. However, the employment and tax impacts are much more widespread. The five largest-producing counties represent 35% of upstream and midstream employment, the 31 smallest-producing counties represent 29%, and the 28 nonproducing counties account for 36%. Likewise, while industry taxes have the greatest impact on local government spending, the industry also pays taxes that flow to the Colorado general fund, which is then spent on everything from education to infrastructure in the state of Colorado.

This study was modeled beginning in 2015, assuming a 95% reduction in new activity and continued legacy production from existing wells. The study incorporates the steep depletion rates for oil and gas production observed in Colorado historical data going back to 1970. Given a fracking ban beginning in 2015, the economic consequence would be an average \$8 billion in lower gross domestic product (GDP) and 68,000 fewer jobs in the first five years compared to the baseline scenario, and an average of \$12 billion lower GDP and 93,000 fewer jobs between 2015 and 2040. The negative impact on disposable personal income places drag on the consumption-supported industries, such as retail and real estate, as well as on taxes. Extrapolating prior research on fiscal impacts of the industry, the depletion production would leave Colorado jurisdictions with an average direct revenue reduction of \$567 million over the first five years, declining \$985 million by 2040.

The economic impacts are presented as a change from baseline expectations. The fracking ban shifts Colorado's employment base downward, by an average of 68,000 jobs over the first five years, and by an average of 93,000 jobs between 2015 and 2040 (See Figure 1). The legacy production from existing wells and modest new production absent of fracking will continue to support direct and indirect upstream, midstream, and downstream employment. The direct industry impacts fall squarely on the Mining Sector, as well as some Construction (e.g., pipeline construction); Professional, Scientific, and Technical Services (engineering, R&D); and Government (regulation). The impacts of fewer jobs and wages result in reduced household spending impacts that affect everything from Construction to Retail Trade.

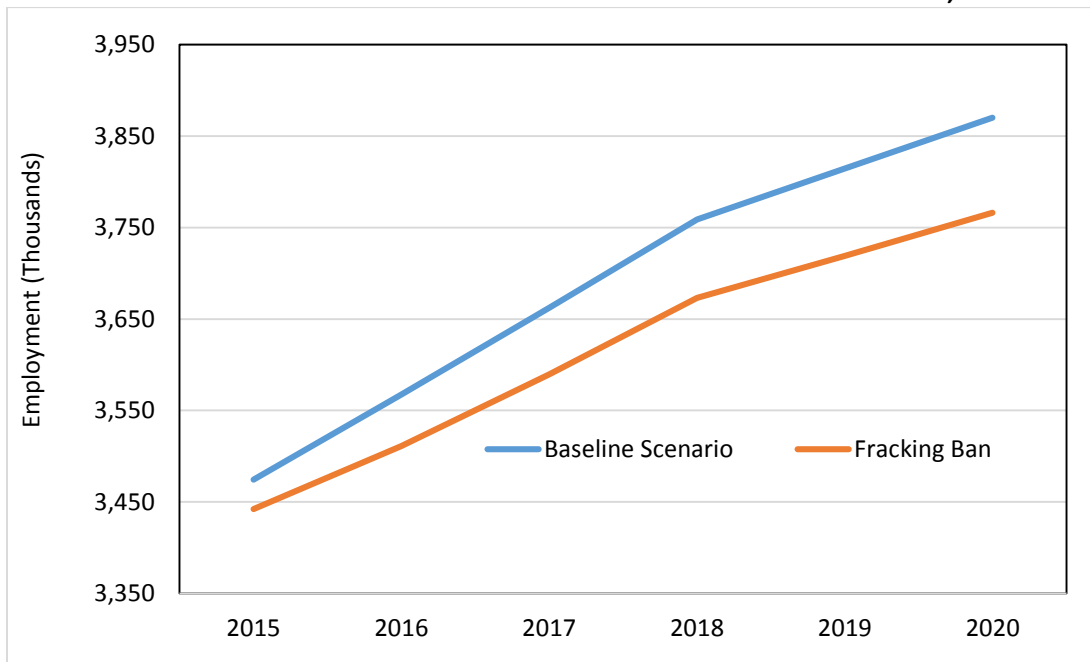
**TABLE 1: STATEWIDE FRACKING BAN, SUMMARY OF IMPACTS, 2015–2040**

Category	Units	Average Difference from Baseline Scenario					
		Year 1-5	Year 6-10	Year 11-15	Year 16-20	Year 21-25	Years 2015-2040 <sup>a</sup>
Total Employment	Jobs (Thousands)	-68	-113	-118	-95	-73	-93
	<i>Change from Baseline</i>	-1.9%	-2.8%	-2.8%	-2.2%	-1.6%	-2.2%
Private Non-Farm Employment	Jobs (Thousands)	-62	-102	-107	-86	-67	-84
	<i>Change from Baseline</i>	-1.9%	-2.9%	-2.9%	-2.2%	-1.6%	-2.3%
Output	Dollars (Billions) <sup>b</sup>	-13	-22	-24	-20	-16	-19
	<i>Change from Baseline</i>	-2.1%	-3.1%	-3.0%	-2.2%	-1.6%	-2.4%
Gross Domestic Product	Dollars (Billions) <sup>b</sup>	-8	-14	-15	-13	-10	-12
	<i>Change from Baseline</i>	-2.3%	-3.4%	-3.2%	-2.4%	-1.7%	-2.6%
Personal Income	Dollars (Billions) <sup>b</sup>	-5	-9	-10	-9	-8	-8
	<i>Change from Baseline</i>	-1.6%	-2.7%	-2.7%	-2.2%	-1.7%	-2.2%
Real Disposable Personal Income	Dollars (Billions) <sup>b</sup>	-4	-7	-8	-7	-7	-7
	<i>Change from Baseline</i>	-1.5%	-2.4%	-2.4%	-2.0%	-1.5%	-2.0%

<sup>a</sup>This average impact over the 25-year period (2015-2040) indicates Colorado total employment would be shifted lower by 93,000 jobs on average, and that GDP would be lower by an average of \$12 billion over the entire 25-year horizon. This shift is illustrated in Figure 1 (below).

<sup>b</sup>Dollars are fixed (2012) dollars.

**FIGURE 1: STATEWIDE FRACKING BAN IMPACT ON COLORADO EMPLOYMENT, 2015-2020**



This paper was prepared using the Regional Economic Models, Inc. (REMI) Tax-PI model built for Colorado and calibrated with Colorado revenues, expenditures, employment, and population. Researchers from the Business Research Division (BRD) researched the known, quantifiable industry metrics, ranging from production and prices to employment, wages, and taxes.

## INTRODUCTION

A partnership of public and private organizations announced in July 2013 the formation of a collaboration to provide Colorado lawmakers, policy makers, and business leaders with greater insight into the economic impact of public policy decisions that face the state and surrounding regions. The parties involved include the Common Sense Policy Roundtable, the Metro Denver Economic Development Corporation, and the Denver South Economic Development Partnership. The Business Research Division (BRD) of the Leeds School of Business at the University of Colorado Boulder was contracted by the consortium to provide third-party, nonbiased research that objectively analyzes the economic impacts of public policy. This consortium meets quarterly to discuss pressing economic issues impacting the state. The group identified the study of a statewide economic impact of hydraulic fracturing ban as both relevant and timely.

The consortium licensed dynamic economic models from Regional Economic Models, Inc. (REMI) to study the economic impacts of policy. For this study, the BRD research team used the single-region, 70-sector, Tax-PI model built for Colorado and calibrated with Colorado revenues, expenditures, employment, and population.

Since embarking on the project, BRD researchers studied the oil and gas industry in Colorado, collecting data and talking with industry stakeholders in order to understand what is known and able to be modeled. No primary research, such as public surveys, was warranted for this study.

When modeling the impact of any policy change, a number of assumptions must be made. The model used for economic analysis illustrates scenarios of what could happen under the policy change, everything else held equal in the economy. Economies are inherently complex, and unanticipated changes caused by shifts (e.g., technology, energy discoveries, recessions) cause the economy to grow faster or slower than anticipated. The collective knowledge shared with the research team helped shape the assumptions that are transparently presented in this report.

This study started on the heels of fracking moratoriums passed by voters in four Colorado jurisdictions in 2013 and one in 2012. Expectations indicate that a statewide ban or moratorium may be presented to voters in 2014. Such language will likely be softened to allow for “local control,” whereby local jurisdictions could decide what is allowed and disallowed. Local jurisdictional bans would have a comparatively smaller economic consequence than a statewide fracking ban. This study focuses on the impacts of a statewide ban on fracking.

The purpose of this study is to provide objective, third-party insight into the economic impacts of a statewide fracking ban on the Colorado economy. This paper provides an overview of the political landscape surrounding the industry, quantifies the current production and economic activities as reported via public sources, and quantifies the economic impacts of a statewide ban on fracking activities.

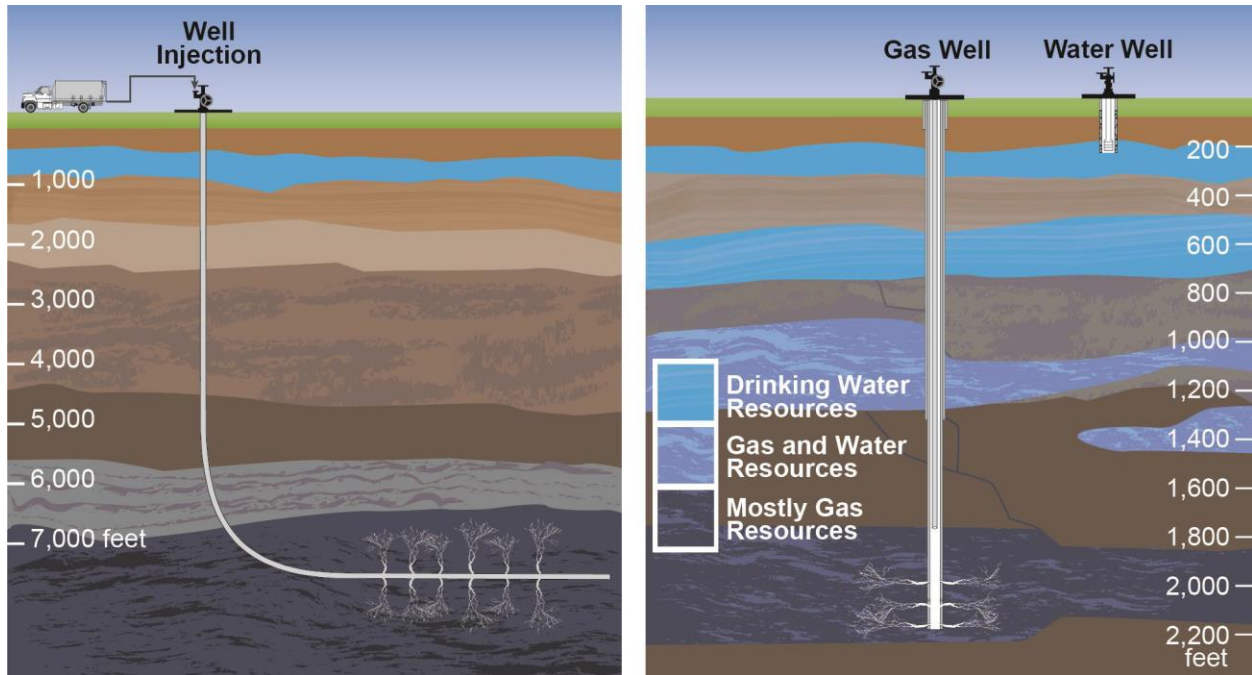
As the FrackingSENSE speaker series hosted by the Center of the American West partitions their discussions into what is known versus what is not known about hydraulic fracturing, this paper models what is currently known about production, prices, employment, wages, and taxes. This paper does not model events or impacts, if any, on water, air quality, health, or externalities on quality of life. Nor does the paper analyze the signal sent to the oil and gas industry and other industries in Colorado regarding uncertainty and political risk to doing business in the state. While this paper does not attempt to measure market reaction, it does quantify the economic implications of reducing a high-output, high-

wage industry to a fraction of current production. Universities and industry are currently researching many of the environmental and societal questions in multiyear, multimillion-dollar studies. The University of Colorado was awarded lead on a \$12 million National Science Foundation grant to study the effects of natural gas development, examining impacts on ecosystems and communities. Likewise, the U.S. Environmental Protection Agency (EPA) will publish a paper in 2014 on the study of the potential impacts of hydraulic fracturing on drinking water resources ([www.epa.gov/hfstudy](http://www.epa.gov/hfstudy)).

## FRACKING

Hydraulic fracturing (“fracking”) is the method of pumping water, chemicals, and sand deep into the ground in order to release oil and gas trapped in rock. The process increases oil and gas production, elevating project feasibility and profitability. In some cases, as production declines, wells are restimulated using fracking techniques, thus extending the life of existing wells. The practice of fracking dates back to the late 1940s and is applied to roughly 90% of wells. According to the Baker Hughes rig count, 80% of hydraulically fracked wells are oil, and 20% are gas. The Colorado Oil and Gas Conservation Commission (COGCC) of the Colorado Department of Natural Resources indicates that fracking in Colorado dates back to the 1970s.

**FIGURE 2: HYDRAULIC FRACTURING PROCESS**



Source: EPA, Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, presentation by Jeanne Briskin, Research Coordinator, accessed from NABE website February 25, 2014.

COGCC summarizes the fracking process in a staff report titled *Information on Hydraulic Fracturing*.

Hydraulic fracturing is the process of creating small cracks, or fractures, in deep, underground geological formations to liberate oil or natural gas and allow it to flow up the well for capture and use in heating our homes, fueling our cars and providing the electricity we all use for our televisions, computers and other devices.

To fracture the formation, fracturing fluids – mostly water and sand, with a small percentage of chemical additives – are injected down the well bore into the formation. The fluid, injected under pressure, causes the rock to fracture along weak areas.

The fluids that create the initial fractures are then mixed with thicker fluids that include sand and gelatin. These thicker fluids lengthen the openings in the rock. When the fractures are complete, and pressure is relieved, the fluids flow back up the well where they are captured and stored for later treatment or disposal.

As the fluids flow back up, sand remains in the fractures and props the rock open, maintaining an open pathway to the well. This allows the oil and gas to seep from the rock into the pathway, up the well and to the surface for collection. In Colorado, the targeted formations for hydraulic fracturing are often more than 7,000 feet underground, and some 5,000 feet below any drinking water aquifers.

## **NATIONAL PRODUCTION**

The International Energy Agency (IEA) and the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) provide annual energy outlooks.

The International Energy Agency's *World Energy Outlook 2013* states,

Whatever the policy landscape for the next quarter of a century, natural gas is set to grow in importance globally thanks to its widespread availability, competitive supply costs and environmental advantages over the other fossil fuels. (Page 100)

Nationally, roughly 30,000 wells were drilled in 2013. Revised expectations in recent forecasts speaks to the dynamic technological factors increasing reserves and production estimates. Natural gas and oil production estimates by the EIA were revised upward between the 2013 and 2014 AEO reports. According to the *Annual Energy Outlook 2014 Early Release* by the EIA, natural gas production in the lower 48 states will increase by 52% between 2013 and 2040, and production in the Rocky Mountain region will rise 48%. Crude oil production is also projected to increase 27% in the lower 48 states between 2013 and 2019 before peaking. The Rocky Mountain region is expected to peak later (2024) after a 29% increase. The Henry Hub price for gas is expected to climb 2.8% annually, to \$7.65 by 2040, while wellhead oil prices will increase at an annual rate of 1.3%, to \$137.63 per barrel (2012 dollars).

Public sentiment on unconventional gas will have a material impact on gas production in coming years. According to the International Energy Agency's *World Energy Outlook 2012*, such social and environmental concerns as land use, surface and groundwater contamination, and air pollution must be addressed successfully in order to realize unconventional gas production's potential. The report suggests that policy makers, regulators, operators, and others apply principles that emphasize full transparency, rigorous efforts to reduce environmental impacts, and engagement with local communities.

## **PUBLIC INFORMATION IN COLORADO**

Describing the regulatory environment in Colorado, Governor Hickenlooper wrote, "We were drawing attention to the fact that Colorado has created the most comprehensive and stringent set of regulations around oil and gas production in the country."



On a state level, Colorado is working with oil and gas producers to establish methane controls. Locally, the Arapahoe County Commissioners created a memorandum of understanding (MOU) that fast-tracks permitting in return for agreed upon regulation. Discussions and information about industry impacts are being shared through such organizations as the Center of the American West at the University of Colorado Boulder, which is hosting a series titled FrackingSENSE as a venue for discussing a wide range of industry issues, and the COGCC, which has an online library ranging from industry statistics on wells and production to regulations and public presentations.

While the debate ensues, some progress to find common ground has been made in Colorado. The industry faces a rigorous permitting process with state and local jurisdictions. Efforts by the state and industry to increase the flow of information and reduce the environment and community impacts of oil and gas development include facilitating: greater information about the chemical contents used in the fracking process, efforts to capture methane from wellheads, and the development of integrated pipelines to reduce the infrastructure and environmental impacts of over-the-road transportation of product.

As well, the industry is charged with timely reporting of spills made public through the Colorado Oil and Gas Information System (COGIS) database.

### **Methane Standards**

Colorado's largest oil and gas producers, including Anadarko Petroleum Corp., Noble Energy Inc., and Encana Corp., worked with environmentalists from the Environmental Defense Fund to form measures recently approved by the Colorado Air Quality Control Commission that would repair persistent methane leaks from their tanks and pipes. Emissions from methane leaks, a source of climate-changing greenhouse gas, have contributed to the worsening smog along the Rocky Mountains that exceeds the federal ozone guidelines. The mandates are the first attempt by a state to regulate methane emissions from fracking. Methane is 20 times more potent at trapping heat in the atmosphere than carbon dioxide according to the EPA.

New rules provide guidance and technology for Colorado oil and gas businesses to find leaks and fix them in order to lower their emissions. The new regulations will require companies to install equipment to minimize leakage of methane and to control or capture 95% of emissions. Energy producers are subjected to routine inspections, as often as once a month, and when leaks are discovered, they must be repaired within 15 days. Chevron and members of the Colorado Oil & Gas Association and the Colorado Petroleum Association calculated that the cost to comply with the rules could be up to \$100 million for the industry, while the Air Pollution Control Division estimated costs at \$40 million. Noble Energy estimated that compliance with the new regulations could cost the company \$3 million a year and it will have to hire an additional 16 employees to tackle the new regulations.

### **Arapahoe County Memorandum of Understanding**

One example of an open process is the memorandum of understanding (MOU) developed by the Arapahoe County Commissioners. This brief MOU establishes a set of conditions, stricter than those imposed by the state, that, if followed, fast-tracks the permitting process for producers.

Arapahoe County approved the MOU for oil and gas companies in April 2013. Working with the COGCC, industry representatives, experts, and citizens, county commissioners, created a MOU that creates high standards for oil and gas companies beyond the already strict regulations in place at the state level. Unanimously approved, this MOU incentivizes companies to accept the new terms set by allowing the company to utilize a shorter and less costly administrative permitting process that can be completed

within 30 working days. If a company does not want to sign the MOU, then it is subject to COGCC's normal review process that typically requires three to five months.

The MOU is intended to supplement and add to the commission's rules and regulations. If any requirements of the MOU are in conflict with COGCC requirements, the stricter standards will take precedence. The standards addressed in the MOU include: operator pit practices, berms, water supply and quality, water quality testing, spill and release management, weed control, noise, emergency response planning, erosion control, private and public roads, floodplain encroachment, painting of oil and gas facilities, facility lighting, and county approvals and inspections. This MOU only applies to oil and gas facilities that have applied for permits as of the date the MOU was approved.

Arapahoe County's oil and gas MOU stands as an example of sustainable oil and gas development in Colorado. By working with oil companies, Arapahoe County commissioners have come to an agreement that meets both the environmental and economic needs of the community.

### **Other Data Sources**

Numerous sources in Colorado disseminate industry information to the public. Three objective sources of data include the Center of the American West at the University of Colorado Boulder, COGCC, and FracFocus. COGCC is a state-run receptacle for industry data (e.g., wells, production) as well as newsletters, research papers, and presentations. FracFocus is a searchable national registry of hydraulic fracturing chemicals. Data from other sources, such as the Colorado Department of Revenue, the EIA, and the Colorado Land Board, are presented later in this paper.

### **FrackingSENSE**

In 2013, CU-Boulder's Center of the American West began hosting an ongoing series of moderated discussions on the topic of fracking with the goal of learning "what we know, what we don't know, and what we hope to learn about natural gas development." As of February 2014, presenters have included industry experts, government officials, and social rights activists. Among those topics discussed so far are surface and subsurface boundaries, water pollution, air quality concerns, health risks, and government control. Appendix 2 includes a summary of speaker viewpoints.

## **HISTORY OF OIL AND GAS IN COLORADO**

Oil and gas activity in Colorado began near the Front Range in the Denver Basin, known as the Denver-Julesburg Basin (the DJ Basin). In 1901, the McKenzie Well #1 was drilled into the Pierre Shale formation within the Denver Basin, specifically in the Boulder Oil Field. Several years later, in 1947, a well in Grant County, Kansas, received hydraulic fracturing treatment in order to stimulate natural gas development. This well was the first hydraulically fractured well in the United States. In 1969, a device was detonated in a well drilled in the Piceance Basin near Rifle, Colorado, called Project Rulison. This attempt to fracture the rock and enable commercial extraction of the natural gas failed. In 1970, the Wattenberg Gas Field was discovered in the Denver Basin. Three years later, Amoco introduced massive hydraulic fracturing to the Wattenberg Gas Field in order to recover gas from a low-permeability sandstone formation. This was one of the first places massive hydraulic fracturing was performed both routinely and successfully. At this time, experts thought the field contained 1.1 trillion cubic feet of gas. Through 2008, the Wattenberg Field had produced 2.8 trillion cubic feet of gas, far surpassing the estimate in 1973. Since the late 1970s, the San Juan Basin has grown to become one of the largest coal-bed methane reservoirs in the world.

In 2007, the Wattenberg Gas Field accounted for 11 million barrels of oil and 170 billion cubic feet of gas from more than 14,000 wells. These production numbers made the Wattenberg Gas Field the ninth-largest source of natural gas in the United States according to a report by EIA. Also, in 2007, the Piceance Basin contained 5 of the top 50 gas fields in the nation in terms of proved reserves. Operators in the oil and gas industry discovered in 2009 that hydraulic fracturing, paired with horizontal drilling in the chalk of the Niobrara formation, yielded better quantities of gas and condensate.

In 2009, U.S. Congresswoman Diana DeGette and U.S. Congressman Maurice Hinchey introduced the FRAC Act, which would allow the EPA to evaluate hydraulic fracturing processes and make the practice enforceable under the Safe Drinking Water Act. The FRAC Act has not yet been passed through Congress. Currently, hydraulic fracturing is not enforceable under the Energy Policy Act of 2005 due to the “Halliburton Loophole,” which has kept the EPA from regulating fracturing operations.

A year later, the Raton Basin in Las Animas County was included in the 2010 EPA hydraulic fracturing study, which is expected to be released in 2014. Voters in three Colorado cities (Boulder, Fort Collins, and Loveland) approved ballot initiatives to impose or extend moratoria on hydraulic fracturing in November 2013.

Today, 75% of Colorado homes are fueled by natural gas produced in the state, and Colorado’s oil production accounts for 30% of the state’s needs for transportation fuel. Currently, nearly 95% of completed oil and gas wells in the United States are being hydraulically fractured.

## **STATE OF THE INDUSTRY**

With the proliferation of the services sectors, the goods-producing sectors of the Colorado economy (agriculture, mining, construction, and manufacturing) has fallen from 29% of state GDP in 1963 to 15.5% of nominal GDP in Colorado in 2012. While the production value of the mining industry has been impacted by price and production volatility over this period, the industry’s share of GDP in 2012 was nearly equal to the market share in 1963 (around 3.7%).

Colorado oil and gas applications for permits to drill (APDs) peaked in 2008 with 8,027 approved permits, coinciding with record high prices for many commodities and precluding the soft demand during and following the recession. Drilling permits preceded a general trajectory of decline, hitting a multiyear low in 2012 before increasing 6.7% in 2013.

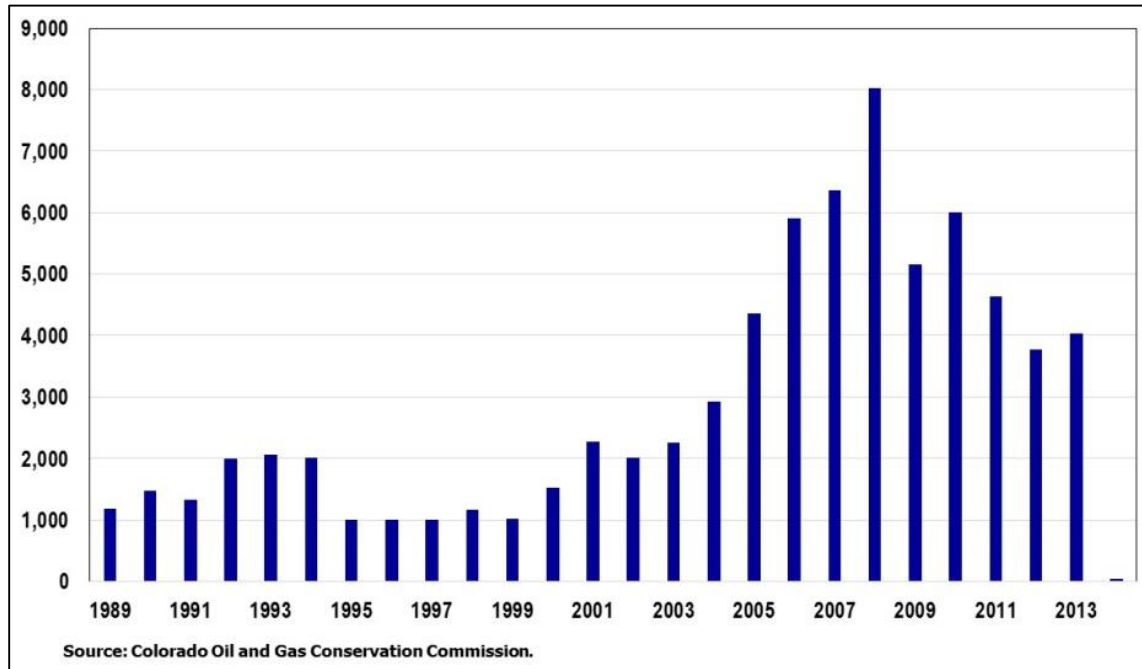
While APDs remain a market indicator, technological advancements, such as horizontal drilling and permitting changes, make APDs less of an indicator of the health of the industry. Horizontal wells allow for a greater amount of a reservoir to be drained than vertical wells because they can be manipulated to extract more from thin, shallow reservoirs.

According to the 2012 Colorado Business Economic Outlook, the Natural Resources and Mining committee explained that, “This decrease in total permits is due primarily to a new two-year permit scheme that became effective in late 2009.” A Denver Business Journal article dated December 2, 2009 reported the COGCC voted 8-1 to extend drilling permits, stating that, “Drilling permits for new gas and oil wells in Colorado will now be good for two years, doubling the amount of time energy companies will have to schedule investments and drilling rigs in the state.”

Likewise, an April 2011 memorandum from the COGCC explained, “Drilling permits are a less useful metric because they are now valid for two years in Colorado (this rule change became effective in late

2009) compared to one year in other states. Therefore, Colorado’s permit numbers for the first quarter reflect fewer expired and refilled permits than do the numbers for other states or for Colorado in prior years. In addition, an increasing number of Colorado’s permits are for horizontal wells. Horizontal wells typically take longer to drill, and a single productive horizontal well may be drilled in place of several vertical wells. Therefore, fewer permits may be necessary to reflect the same level of investment or reach the same level of production.”

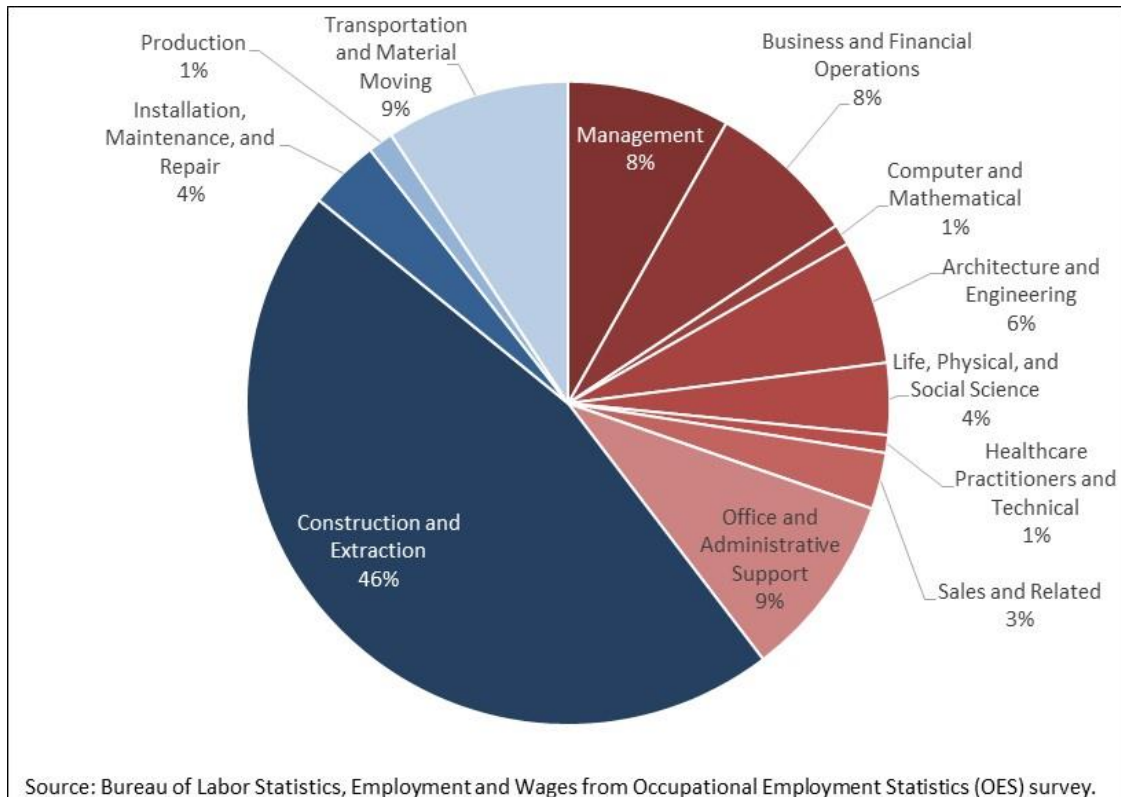
**FIGURE 3: COLORADO ANNUAL DRILLING PERMITS, ALL COUNTIES**



The Oil and Gas Sector is a component of the Mining industry. Mining in Colorado represented 3.7% of state GDP in 2012, or \$182,105 per person compared to \$85,639 for all industries in the state. The direct Mining industry represents 1.3% of total Colorado nonfarm wage and salary employment, but totals 2.7% of wages, illustrating high-salary industry jobs. In fact, average mining pay is \$108,000, more than twice the average wage for all industries in Colorado (\$50,559) in 2012, ranking it second only to the Management of Companies and Enterprises industry.

The occupational mix within the industry explains the above average wages. Occupational diversity falls in two general characterizations, demarked as field jobs or business support occupations. Figure 3 illustrates this split, with the blue occupations representing the field work (e.g., construction, extraction, production, maintenance, etc.) and the red occupations representing business support services (e.g., engineering, management, finance, etc.). Denver records no real production, but is among the highest oil and gas salary counties in the state, indicative of the valuable business support and regional headquarters jobs.

**FIGURE 4: STATE EXTRACTION OF OIL AND GAS AND SUPPORT ACTIVITIES FOR MINING OCCUPATIONS**



The production of oil and gas increased from 2011 to 2012, but the value of production decreased in 2012 on lower pricing and rebounded in 2013. Oil and gas production in the state totaled an estimated \$11.9 billion in 2013, with natural gas accounting for 50% of sales-based value; oil accounting for 46%; and carbon dioxide, 3% (Table 2). Oil and gas production is primarily sourced from private lands.

**TABLE 2: VALUE OF OIL AND GAS PRODUCTION BY RESOURCE, 2008-2012 (IN MILLIONS)**

Year	Crude Oil	Natural Gas	Carbon Dioxide	Subtotal
2008	\$2,619	\$10,993	\$429	\$14,041
2009	\$1,600	\$5,485	\$324	\$7,409
2010	\$2,323	\$6,970	\$208	\$9,501
2011	\$3,395	\$6,819	\$369	\$10,583
2012	\$3,698	\$4,754	\$353	\$8,805
2013 <sup>a</sup>	\$5,499	\$5,978	\$380	\$11,857

Sources: Colorado Geological Survey Mineral and Minerals Fuel Activity Reports, Colorado Oil and Gas Conservation Commission, Department of Minerals and Geology, and Colorado Business Economic Outlook Committee. <sup>a</sup>Estimated.

In an industry study, the BRD quantified more than 28,200 direct drilling, extraction, and support jobs with average annual wages in excess of \$104,700 in 2012. Considering the full upstream, midstream, and downstream supply chain of the industry, including transportation, refining, wholesalers, parts manufacturers, and gasoline stations, direct employment totaled nearly 47,800 jobs, with average wages over \$78,200. Collectively, this industry, from upstream to downstream activities, contributed nearly \$3.4 billion in employee income to Colorado households in 2012, or 2.8% of total Colorado salary and wages. In addition, \$567 million went to private land owners in 2012, assuming private land owners

capture royalty terms similar to those of the government. The upstream and midstream oil and gas industry contributed substantial public revenues in 2012—totaling more than \$1.1 billion, most of which was derived directly from severance taxes, public leases, public royalties, and property taxes.<sup>1</sup>

## LEGISLATION

As in most states, Colorado observes the property rights of both above ground land and property, as well as underground mineral rights. Especially in recent years, mineral rights are often owned separately from land. This may manifest from a long-time land owner, such as a farmer, who engages in a property sale. In order to maximize profits, the land owner sells tranches to interested parties. A housing developer is interested in purchasing above ground property, adding utility infrastructure, building housing units, and selling homes, with no interest paid to the underground natural resources. These resources are valueless to the developer. However, a mining firm is interested in securing reserves. These reserves may or may not be *proven* reserves, and current technology not make extraction feasible. The likelihood of reserves and feasibility of production impact the prices at which the mining firm secures the mineral rights. This sometimes presents conflict when mineral extraction intersects with housing developments.

In 2012, Longmont was the first jurisdiction in the state where voters approved a fracking ban (see Appendix 3). This ban set the stage for a legal fight, teeing up fracking initiatives elsewhere in Colorado. In 2013, voters in Boulder, Broomfield, Fort Collins, and Lafayette passed similar measures, calling for fracking “moratoriums” rather than “bans.” A moratorium temporarily halts the fracking practice compared to an outright ban. These actions are currently being contested in the courts.

Other anti-fracking measures could be headed to the Colorado ballot this November. These measures fall into two general categories: local control or setbacks. Local Control Colorado has submitted language to the Colorado Legislative Services for a constitutional amendment that would allow Colorado voters a voice over whether hydraulic fracturing should be allowed within the bounds of their communities. A similar proposal calling for a Community Rights Constitutional Amendment has been submitted by Colorado Community Rights Network (COCRN).

Prior to 2013, oil and gas drilling setbacks were 150 feet from homes and 350 feet from high-density areas. In 2013, the Colorado Oil and Gas Conservation Commission passed a 500-foot setback minimum between oil and gas drilling from homes and buildings, and the setbacks can be waived. The proposed setback initiatives in 2014 range between 1,500 feet to one-half mile from occupied structures. The initiative states that a structure, “means any building or structure that requires a certificate of occupancy, or building or structure intended for human occupancy, including but not limited to homes, schools, and hospitals.”

Once state officials approve the ballot language, organizers will be required to obtain 86,000 valid signatures from Colorado voters by the beginning of August to get the measure on the November ballot.

Local government officials are split on the issues. Some have reached out to Governor John Hickenlooper and other state legislators, advising them to take steps to clarify the rights of local governments to use zoning and land use powers to mitigate the potential negative impacts of oil and gas

---

<sup>1</sup>Based on research conducted by the Business Research Division in 2011, 2012, and 2013.

development. Others have asked the Governor and legislative leaders to clarify the state’s regulatory preemption of the field.

Coloradans for Responsible Energy Development released a statement in response to the proposed measures and stated that such measures could endanger tens of thousands of jobs supported by the oil and gas industry in Colorado. The spokesman suggests that, “The key to effective regulations and enforcement is to provide statewide predictability and consistency.” He also believes that by maintaining a consistent and sustainable oil and gas development model Colorado can become the standard for the rest of the nation.

## **DATA AND ASSUMPTIONS**

As of February 2014, hydraulic fracturing is still permissible in Colorado. According to the Colorado Oil & Gas Association, approximately 95% of well activity includes hydraulic fracturing. Five jurisdictions have voted to either ban or temporarily halt new activity. However, conjecture suggests that a statewide ballot issue is likely in November 2014. Research on this paper began with an expectation of a statewide fracking ban.<sup>2</sup> Proposed legislation is fluid, and the research team has strived to be responsive to legislative ideas—the most current being “local control.”

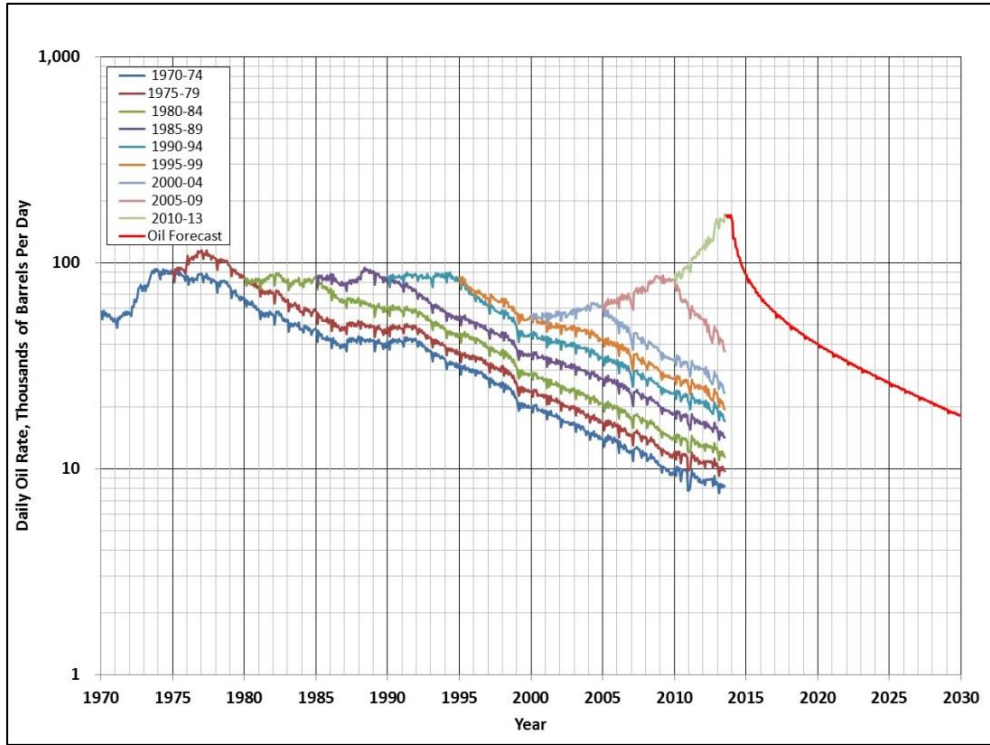
The implications for individual property owners of property rendered valueless are not quantified in this study.

Fracking bans would be imposed on new activity, but legacy production would continue based on existing well activity. Examining well activity in five-year increments from 1970 forward, an implicit Colorado depletion curve is established. The data in Figure 5 and Figure 6 identify declining oil and gas production on a logarithmic scale. The parallel depletion provides some predictability for future depletion.

---

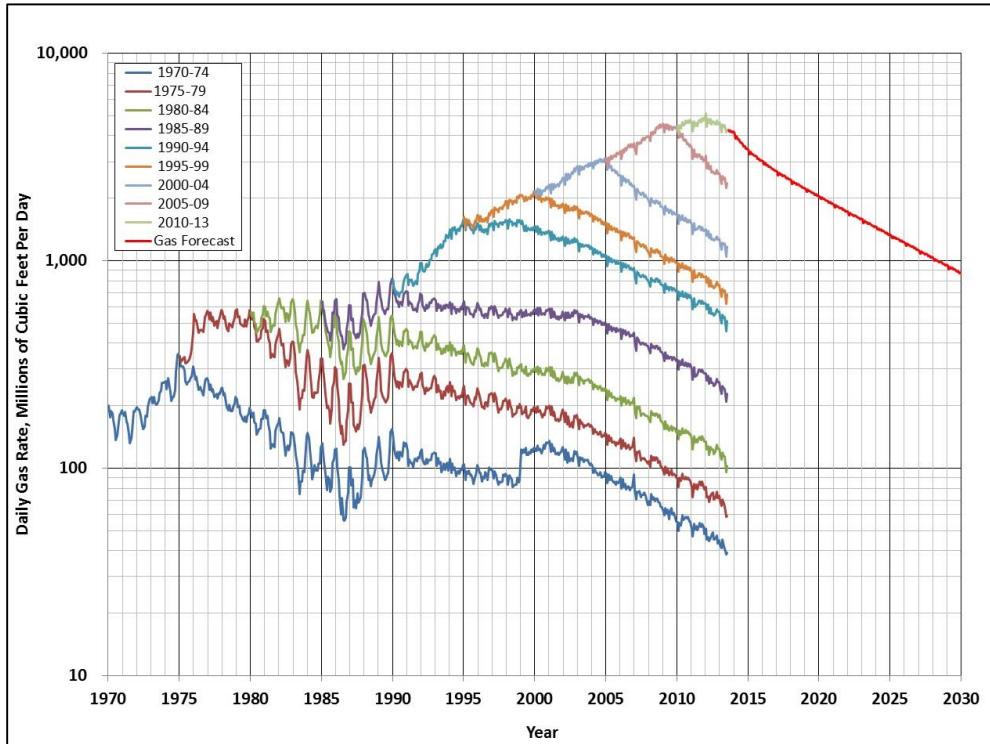
<sup>2</sup> The statewide fracking ban analysis examines a change in total production, including activity on federal and state lands.

**FIGURE 5: COLORADO OIL PRODUCTION**



Source: Rich McClure, EE3, Inc., based on IHS data.

**FIGURE 6: COLORADO GAS PRODUCTION**



Source: Rich McClure, EE3, Inc., based on IHS data.



The historical oil and gas depletion curves suggest steep declines in both oil and gas production absent of new activity. Oil production falls by more than 40% in year 1 and nearly 27% in year 2, with the rate of decline slowing (decreasing at a decreasing rate) 6.9% by year 16. Gas depletion rates are not as steep as oil depletion rates. The forecast for gas is 13.9% in year 1, falling 13.5% in year 2, and 8.2% by year 16. Given the general flattening of the curve, depletion after year 16 was modeled flat.

**TABLE 3: OIL AND GAS PRODUCTION FORECASTS**

Year	Oil Decline % / Year	Gas Decline % / Year
1	40.5%	13.9%
2	26.7%	13.5%
3	17.6%	10.9%
4	13.8%	9.7%
5	11.7%	9.0%
6	10.3%	8.6%
7	9.5%	8.3%
8	8.8%	8.2%
9	8.4%	8.2%
10	8.0%	8.2%
11	7.7%	8.2%
12	7.5%	8.2%
13	7.3%	8.2%
14	7.1%	8.2%
15	7.0%	8.2%
16	6.9%	8.2%

**ECONOMIC IMPACTS**

The economic impacts presented below are deviations from the baseline scenario. The fracking ban was modeled in REMI as a change in industry sales/exogenous production in the oil and gas industry beginning in 2015, assuming a 95% reduction in new activity and continued (but depleting production in existing wells). Blended depletion rates from 40 years of historical data on oil and gas well production in Colorado were applied based on the current split of industry activity between oil and gas.

Oil and gas on a per employee basis is a high-output, high-wage industry, resulting in an increase of the magnitude of the multiplier effect. While the resulting economic impact is notably positive during times of industry expansion, it is equally negative during times of industry contraction. Given a fracking ban beginning in 2015, the economic consequence would result in an average lower GDP of \$10 billion and 68,000 fewer jobs in the first five years, and an average of \$12 billion in lower GDP and 93,000 fewer jobs between 2015 and 2040. The negative impact on disposable personal income places drag on the consumption-supporting industries (e.g., retail, real estate), as well as on taxes. The unemployment rate stays somewhat unaffected as the decline in industry jobs marks a shift in the labor force. Extrapolating prior research on fiscal impacts of the industry, the drawdown on drilling and production would leave Colorado jurisdictions with an average direct (unmultiplied) revenue reduction of \$567 million over the first five years, declining \$985 billion by 2040.

**TABLE 4: STATEWIDE FRACKING BAN, SUMMARY OF IMPACTS, 2015–2040**

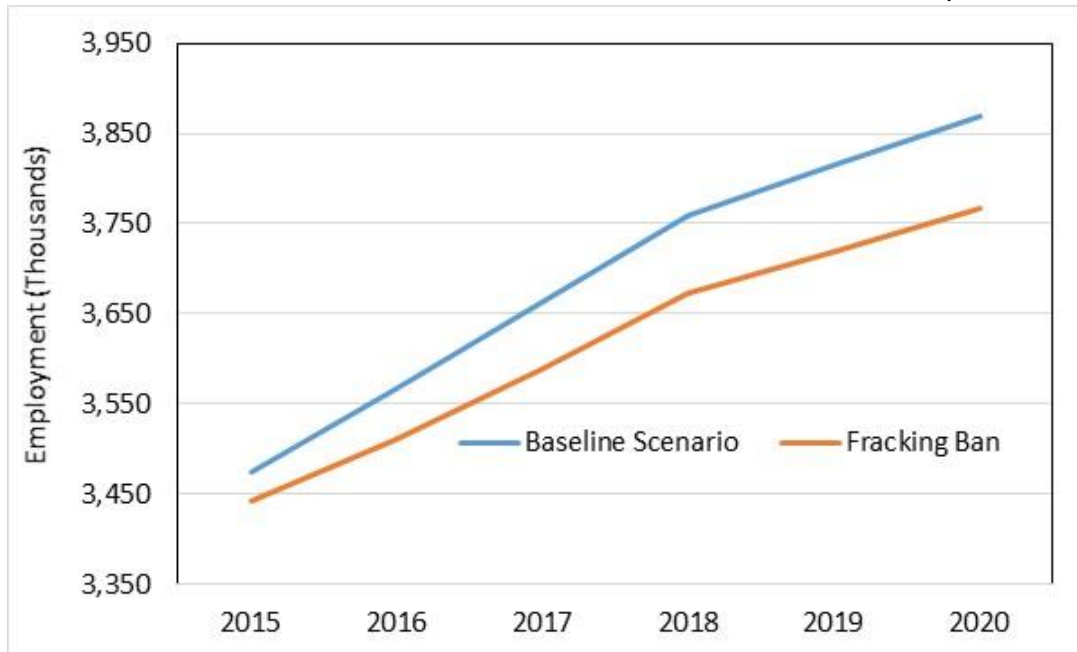
Category	Units	Average Difference from Baseline Scenario					
		Year 1-5	Year 6-10	Year 11-15	Year 16-20	Year 21-25	Years 2015-2040 <sup>a</sup>
Total Employment	Jobs (Thousands) <i>Change from Baseline</i>	-68 -1.9%	-113 -2.8%	-118 -2.8%	-95 -2.2%	-73 -1.6%	-93 -2.2%
Private Non-Farm Employment	Jobs (Thousands) <i>Change from Baseline</i>	-62 -1.9%	-102 -2.9%	-107 -2.9%	-86 -2.2%	-67 -1.6%	-84 -2.3%
Output	Dollars (Billions) <sup>b</sup> <i>Change from Baseline</i>	-13 -2.1%	-22 -3.1%	-24 -3.0%	-20 -2.2%	-16 -1.6%	-19 -2.4%
Gross Domestic Product	Dollars (Billions) <sup>b</sup> <i>Change from Baseline</i>	-8 -2.3%	-14 -3.4%	-15 -3.2%	-13 -2.4%	-10 -1.7%	-12 -2.6%
Personal Income	Dollars (Billions) <sup>b</sup> <i>Change from Baseline</i>	-5 -1.6%	-9 -2.7%	-10 -2.7%	-9 -2.2%	-8 -1.7%	-8 -2.2%
Real Disposable Personal Income	Dollars (Billions) <sup>b</sup> <i>Change from Baseline</i>	-4 -1.5%	-7 -2.4%	-8 -2.4%	-7 -2.0%	-7 -1.5%	-7 -2.0%

<sup>a</sup>This average impact over the 25-year period (2015-2040) indicates Colorado total employment would be shifted lower by 93,000 jobs on average, and that GDP would be lower by an average of \$12 billion over the entire 25-year horizon. This shift is illustrated in Figure 7 (below).

<sup>b</sup>Dollars are fixed (2012) dollars.

The impact of the fracking ban is a shift in employment downward from a baseline scenario. That average change over the first five years is 68,000 jobs compared to the baseline expectation for Colorado employment.

**FIGURE 7: STATEWIDE FRACKING BAN IMPACT ON COLORADO EMPLOYMENT, 2015-2020**



The negative implication for industry employment are most absorbed by five sectors: Mining; Construction; Retail Trade; Professional, Scientific, and Technical Services; and Government. The legacy production from existing wells and modest new production absent of fracking will continue to support direct and indirect upstream, midstream, and downstream employment. The direct industry impacts fall squarely on the Mining Sector, as well as some Construction (e.g., pipeline construction); Professional, Scientific, and Technical Services (engineering, R&D); and Government (regulation). The impacts of

fewer jobs and wages result in reduced household spending impacts that affect everything from Construction to Retail Trade.

**TABLE 5: STATEWIDE FRACKING BAN, EMPLOYMENT IMPACTS, 2015–2040, IN THOUSANDS**

Industry	Average (Thousands)					
	Year 1-5	Year 6-10	Year 11-15	Year 16-20	Year 21-25	Years 2015-2040
Forestry, Fishing, and Related Activities	0	0	0	0	0	0
Mining	-14	-22	-22	-16	-12	-17
Utilities	0	0	0	0	0	0
Construction	-15	-26	-24	-15	-7	-17
Manufacturing	-1	-2	-2	-1	-1	-1
Wholesale Trade	-2	-3	-3	-2	-2	-2
Retail Trade	-6	-10	-11	-10	-8	-9
Transportation and Warehousing	0	-1	-1	-1	0	0
Information	0	-1	-1	-1	-1	-1
Finance and Insurance	-1	-1	-1	0	0	-1
Real Estate and Rental and Leasing	-3	-5	-5	-5	-3	-4
Professional, Scientific, and Technical Services	-4	-8	-10	-9	-8	-8
Management of Companies and Enterprises	0	0	0	0	0	0
Administrative and Waste Management Services	-3	-5	-5	-5	-4	-4
Educational Services	-1	-1	-2	-2	-2	-1
Health Care and Social Assistance	-4	-7	-8	-8	-7	-7
Arts, Entertainment, and Recreation	-1	-2	-2	-2	-2	-2
Accommodation and Food Services	-3	-6	-7	-7	-6	-5
Other Services, except Public Administration	-3	-4	-4	-3	-3	-3
Government	-7	-11	-11	-9	-7	-9

All occupations are negatively impacted by the fracking ban. The impacts mostly affect five occupations: Sales, Construction and Extraction, Management, are most absorbed by five sectors:

- Sales and related, office and administrative support
- Construction and extraction
- Management, business, and financial
- Computer, mathematical, architecture, and engineering
- Food preparation and serving related

**TABLE 6: STATEWIDE FRACKING BAN, OCCUPATION IMPACTS, 2015–2040, IN THOUSANDS**

Occupations	Average (Thousands)					
	Year	Year	Year	Year	Year	Years
	1-5	6-10	11-15	16-20	21-25	2015-2040
Management, business, and financial	-7	-12	-12	-10	-8	-10
Computer, mathematical, architecture, and engineering	-5	-8	-9	-7	-6	-7
Life, physical, and social science	-1	-2	-2	-2	-2	-2
Community and social service	0	-1	-1	-1	-1	-1
Legal	-1	-1	-1	-1	-1	-1
Education, training, and library	-3	-5	-5	-4	-3	-4
Arts, design, entertainment, sports, and media	-1	-1	-1	-1	-1	-1
Healthcare	-3	-6	-6	-6	-6	-5
Protective service	-1	-2	-2	-2	-1	-2
Food preparation and serving related	-3	-6	-7	-7	-6	-6
Building and grounds cleaning and maintenance	-3	-5	-5	-5	-4	-4
Sales and related, office and administrative support	-16	-26	-28	-23	-18	-22
Farming, fishing, and forestry	0	0	0	0	0	0
Construction and extraction	-13	-22	-21	-14	-8	-15
Installation, maintenance, and repair	-4	-6	-6	-5	-3	-5
Production	-3	-4	-4	-3	-2	-3
Transportation and material moving	-4	-6	-7	-5	-4	-5

**CONCLUSION**

This report shows the estimated economic impacts associated with a statewide fracking ban. It is based on currently known economic factors of the industry related to production, prices, employment, and taxes. A statewide fracking ban would prove damaging to the Colorado economy, setting the state back an average of 68,000 jobs in the first five years and \$8 billion in GDP. Over the long term (2015-2040), the impact of a ban would result in average 93,000 fewer jobs and \$12 billion in lower GDP when compared to a baseline scenario.

## BIBLIOGRAPHY

- Aguilar, John. "Another anti-fracking measure could be headed to November ballot," *The Denver Post*, [http://www.denverpost.com/localpolitics/ci\\_25222991/another-anti-fracking-measure-could-be-headed-november](http://www.denverpost.com/localpolitics/ci_25222991/another-anti-fracking-measure-could-be-headed-november), accessed February 25, 2014.
- American Petroleum Institute, Exploring for America's Energy Future. [http://www.api.org/~media/Files/Policy/Exploration/Energy-Resources/StrategicEnergyResources\\_Wattenberg.pdf](http://www.api.org/~media/Files/Policy/Exploration/Energy-Resources/StrategicEnergyResources_Wattenberg.pdf). Accessed February 24, 2014.
- Baker Hughes. Baker Hughes Rig Counts, <http://www.bakerhughes.com/rig-count>. Accessed February 24, 2014.
- Ballotpedia, City of Fort Collins Five Year Fracking Suspension Initiative, Question 2A (November 2013), [http://ballotpedia.org/City\\_of\\_Fort\\_Collins\\_Five\\_Year\\_Fracking\\_Suspension\\_Initiative,\\_Question\\_2A\\_\(November\\_2013\)](http://ballotpedia.org/City_of_Fort_Collins_Five_Year_Fracking_Suspension_Initiative,_Question_2A_(November_2013)). Accessed February 25, 2014.
- Ballotpedia, City of Lafayette "Community Rights Act" Fracking Ban Amendment, Question 300 (November 2013), [http://ballotpedia.org/City\\_of\\_Lafayette\\_%22Community\\_Rights\\_Act%22\\_Fracking\\_Ban\\_Amendment,\\_Question\\_300\\_\(November\\_2013\)](http://ballotpedia.org/City_of_Lafayette_%22Community_Rights_Act%22_Fracking_Ban_Amendment,_Question_300_(November_2013)). Accessed February 25, 2014.
- Broomfield Five Year Fracking Suspension, Question 300 (November 2013), [http://ballotpedia.org/Broomfield\\_Five\\_Year\\_Fracking\\_Suspension,\\_Question\\_300\\_\(November\\_2013\)](http://ballotpedia.org/Broomfield_Five_Year_Fracking_Suspension,_Question_300_(November_2013)). Accessed February 25, 2014.
- CBS Denver. Judge To Decide Validity Of Broomfield Election On Fracking, February 25, 2014, <http://denver.cbslocal.com/2014/02/25/judge-to-decide-validity-of-broomfield-election/>. Accessed February 25, 2014.
- City of Fort Collins, Special Election held in conjunction with the Larimer County General Election November 5, 2013, <http://www.fcgov.com/cityclerk/elections2013nov.php>. Accessed February 25, 2014.
- Colorado Public Radio. *Ballot initiative aims to give communities control of fracking*. <http://www.cpr.org/news/story/ballot-initiative-aims-give-communities-control-fracking>. Accessed February 25, 2014.
- Community Environmental Legal Defense Fund. January 21, 2014. *Colorado Community Rights Network Files Constitutional Amendment*.

[http://www.celdf.org/downloads/PR\\_CELDF\\_COCRN\\_Constitutional\\_Amendment\\_012014.pdf](http://www.celdf.org/downloads/PR_CELDF_COCRN_Constitutional_Amendment_012014.pdf), Accessed March 2, 2014.

Bloomberg. Colorado First State to Clamp Down on Fracking Methane Pollution. February 23, 2014. <http://www.bloomberg.com/news/2014-02-24/colorado-first-state-to-clamp-down-on-fracking-methane-pollution.html>, Accessed February 25, 2014.

Boulder County Clerk and Recorder's Office, November 2012. [http://www.bouldercounty.org/doc/clerk/2012g\\_finalmap\\_longmont300.pdf](http://www.bouldercounty.org/doc/clerk/2012g_finalmap_longmont300.pdf). Accessed February 25, 2014.

Boulder County Clerk, Final Official 2013 Coordinated Election Results for Boulder County Election Day - November 5, 2013, <http://webpubapps.bouldercounty.org/clerk/voterresults2013/IssueResults.aspx?issue=all>. Accessed February 25, 2014.

Briskin, Jeanne. November 2011. Final Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources. Accessed from NABE website, February 25, 2014.

Bureau of Labor Statistics, Quarterly Census of Employment and Wages. [www.bls.gov](http://www.bls.gov) (accessed January 24, 2014).

Bureau of Labor Statistics, Current Employment Statistics. [www.bls.gov](http://www.bls.gov) (accessed January 24, 2014).

Bureau of Economic Analysis, Gross Domestic Product by State. [www.bea.gov](http://www.bea.gov) (accessed January 24, 2014).

Business Research Division, Leeds School of Business, University of Colorado Boulder. December 2011. 2012 Colorado Business Economic Outlook, page 24. <http://leeds.colorado.edu/asset/publication/2012beof.pdf>. Accessed February 27, 2014.

City of Boulder, Ballot 2013, <https://bouldercolorado.gov/elections/2013-ballot>. Accessed February 25, 2014.

Center of the American West. FrackingSENSE: What We Know, What We Don't Know, and What We Hope to Learn about Natural Gas Development. Lecture series, <http://centerwest.org/events/airwateregas-4>.

Coloradans for Responsible Energy Development. "Coloradans for Responsible Energy Development Opposes Statewide Ballot Proposal to Ban Fracking," <http://www.cred.org/multimedia-posts/press-release-224/#sthash.A3jb7LI7.dpuf>. Accessed February 25, 2014.

Colorado Oil and Gas Conservation Commission. Coalbed Methane Development in the Northern San Juan Basin of Colorado. [http://oil-gas.state.co.us/Library/sanjuanbasin/blm\\_sjb.htm](http://oil-gas.state.co.us/Library/sanjuanbasin/blm_sjb.htm). Accessed February 24, 2014.

---

\_\_\_\_\_. Colorado Oil and Gas Information System (COGIS). <http://cogcc.state.co.us/cogis/>. Accessed February 24, 2014.

- \_\_\_\_\_. *Information on Hydraulic Fracturing*,  
<http://cogcc.state.co.us/General/HydraulicFracturingInfoSheet.pdf>. Accessed January 7, 2014.
- \_\_\_\_\_. Memorandum from Director David Nelsin.  
[https://cogcc.state.co.us/announcements/CommissionLtr4\\_25\\_11.pdf](https://cogcc.state.co.us/announcements/CommissionLtr4_25_11.pdf), Accessed February 28, 2014.
- Dunn, Sharon. "Colorado's Wattenberg growing in importance in oil, gas industry," *The Denver Post*,  
[http://www.denverpost.com/breakingnews/ci\\_21300801/colorados-wattenberg-growing-importance-oil-gas-industry](http://www.denverpost.com/breakingnews/ci_21300801/colorados-wattenberg-growing-importance-oil-gas-industry). Accessed February 21, 2014.
- Enercom. February 14, 2013. "Colorado Gov Hickenlooper Says to Enviros: 'Have a Drink on Me!'"  
<http://www.oilandgas360.com/colorado-guv-hickenlooper-says-to-enviros-have-a-drink-on-me/>. Accessed February 28, 2014.
- Everley, Steve. *Energy in Depth. You Missed a Spot: A Timeline of Hydraulic Fracturing*.  
<http://energyindepth.org/national/you-missed-a-spot-a-timeline-of-hydraulic-fracturing/>.  
Accessed February 21, 2014.
- FracFocus. National hydraulic fracturing chemical registry, <http://fracfocus.org/>. Accessed February 15, 2014.
- Hood, Grace. "Ballot initiative aims to give communities control of fracking," Colorado Public Radio,  
<http://www.cpr.org/news/story/ballot-initiative-aims-give-communities-control-fracking>. Accessed February 25, 2014.
- League of Women Voters of Boulder County,  
[http://lwvbc.org/files/2012\\_BallotLongmontQuestion300.pdf](http://lwvbc.org/files/2012_BallotLongmontQuestion300.pdf). Accessed February 25, 2014.
- Lewandowski, Brian and Richard Wobbekind. July 2013. *Assessment of Oil and Gas Industry 2012 Industry Economic and Fiscal Impacts in Colorado*. Business Research Division, Leeds School of Business, University of Colorado Boulder.
- McClure, Rich. EE3, Inc. E-mail correspondence with BRD researchers.
- Middle East Well Evaluation Review. 1995. *Horizontal Highlights*.  
[http://www.slb.com/~media/Files/resources/mearr/wer16/rel\\_pub\\_mewer16\\_1.pdf](http://www.slb.com/~media/Files/resources/mearr/wer16/rel_pub_mewer16_1.pdf). Accessed February 27, 2014.
- Proctor, Cathy. December 2, 2009. *Colorado extends gas, oil drilling permits to 2 years*. Denver Business Journal. <http://www.bizjournals.com/denver/stories/2009/11/30/daily37.html?page=all>.  
Accessed February 27, 2014.
- Oldham, Jennifer. Colorado First State to Clamp Down on Fracking Methane Pollution, Bloomberg Sustainability, <http://www.bloomberg.com/news/2014-02-24/colorado-first-state-to-clamp-down-on-fracking-methane-pollution.html>. Accessed February 25, 2014.

United States Environmental Protection Agency. EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources, [www.epa.gov/hfstudy](http://www.epa.gov/hfstudy). Accessed February 24, 2014.

U.S. Department of Energy. Project Rulison, <https://www.osti.gov/opennet/forms.jsp?formurl=films/data/0800036.html>. Accessed February 17, 2014.

U.S. Energy Information Agency. Top 100 Oil and Gas Fields of 2009, [http://www.eia.gov/pub/oil\\_gas/natural\\_gas/data\\_publications/crude\\_oil\\_natural\\_gas\\_reserves/current/pdf/top100fields.pdf](http://www.eia.gov/pub/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/current/pdf/top100fields.pdf). Accessed February 24, 2014.

U.S. Energy Information Administration. June 2012. Annual Energy Outlook 2012 with Projections to 2035. [http://www.eia.gov/forecasts/aeo/chapter\\_market\\_trends.cfm](http://www.eia.gov/forecasts/aeo/chapter_market_trends.cfm) (accessed June 28, 2013).

\_\_\_\_\_. April 2013. Annual Energy Outlook 2013 with Projections to 2035. <http://www.eia.gov/forecasts/aeo/> (accessed July 6, 2013).

\_\_\_\_\_. December 16, 2013. AEO2014 Early Release Overview. <http://www.eia.gov/forecasts/aeo/er/index.cfm> (accessed February 3, 2014).

Wobbekind, Richard and Brian Lewandowski. December 2011. *Assessment of Oil and Gas Industry Economic and Fiscal Impacts in Colorado in 2010*. Business Research Division, Leeds School of Business, University of Colorado Boulder.

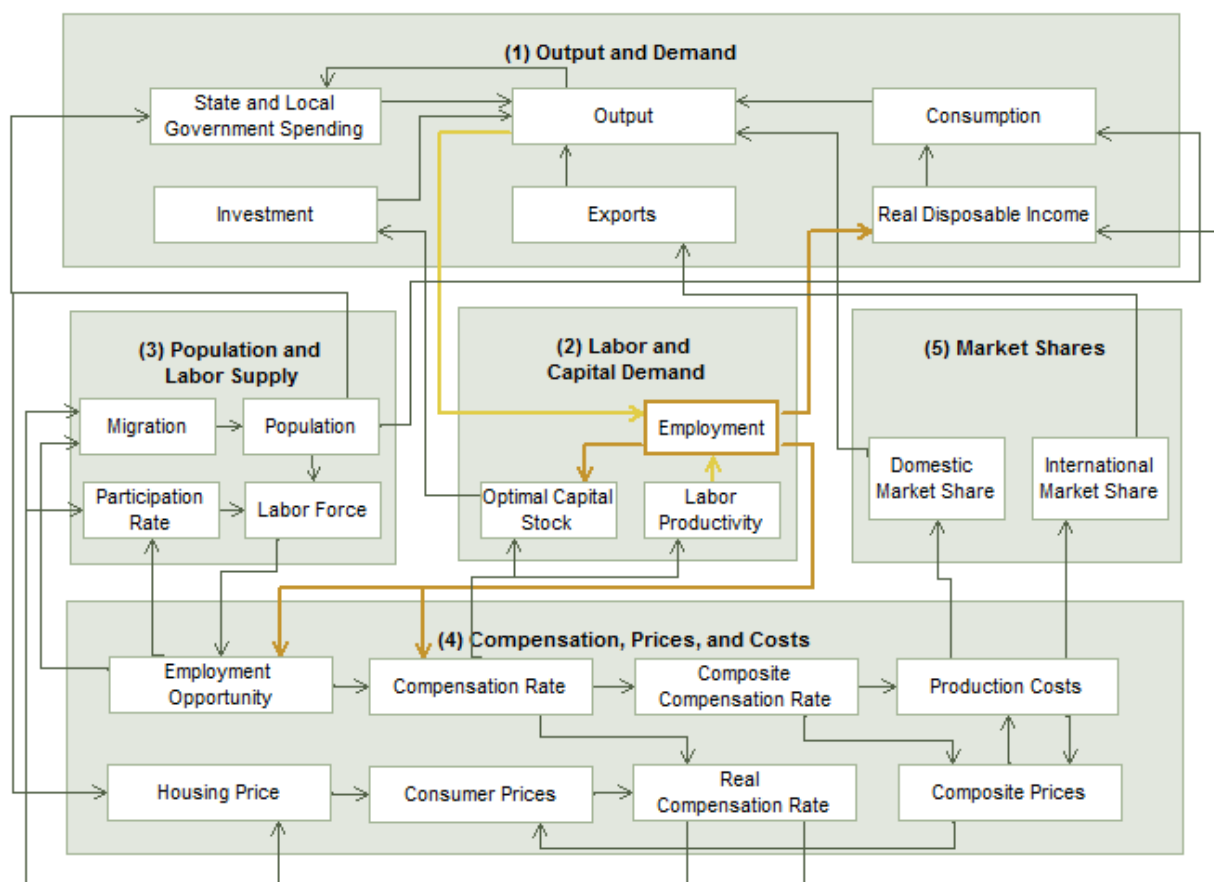


## APPENDIX 1: OVERVIEW OF REMI POLICY INSIGHT

This summary was provided by REMI, Inc.

Policy Insight is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric, and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to wage, price, and other economic factors.

The REMI model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the model. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Wages, Prices and Costs, and (5) Market Shares.



### Block 1. Output and Demand

This block includes output, demand, consumption, investment, government spending, import, product access, and export concepts. For each industry, demand is determined by the amount of output, consumption, investment and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities and population. Input productivity depends on access to inputs because the larger the choice set of inputs, the more likely that the input with the specific characteristics required for the job will be formed. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for

residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

### **Block 2. Labor and Capital Demand**

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

### **Block 3. Population and Labor Supply**

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age and gender, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after tax compensation rate. Migration includes retirement, military, international and economic migration. Economic migration is determined by the relative real after tax compensation rate, relative employment opportunity and consumer access to variety.

### **Block 4. Wages, Prices, and Costs**

This block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the wage equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods and services.

These prices measure the price of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs of distance are significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of output in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by cost of labor, capital, fuel and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing price changes from their initial level depend on changes in income and population density.

Compensation changes are due to changes in labor demand and supply conditions and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

**Block 5. Market Shares**

The Market Shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

The Labor and Capital Demand block includes labor intensity and productivity as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Wages, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the wage equations. The proportion of local, inter-regional and export markets captured by each region is included in the Market Shares block.

## APPENDIX 2: FRACKINGSENSE SPEAKER SERIES DISCUSSION SUMMARIES

### *Property Rights*

Susan Tierney, former Assistant Secretary for Policy at the U.S. Department of Energy, addressed the difficulties arising from the boundary between the surface and the subsurface. Tierney referenced property rights as the surface and mineral rights as the subsurface. In contrast to other countries, the oil and gas industry in the United States is privately controlled; this affects how decisions are made. The United States has the rights broken up between surface land rights and subsurface mineral rights. For privately owned oil and gas companies, their decisions tend to be separated from attitudes on energy security, safety, and environmental concerns. Furthermore, companies' investments tend to be in infrastructure systems that last for decades. Moreover, there is disconnect in opinions among land-owners and mineral rights owners. Matthew Sura, an attorney specializing in the representation of land owners, mineral owners, and local governments, maintained that oil and gas companies have the rights to drill wherever they believe is necessary as long as they have the mineral rights. Sura also believes that the fracturing itself does not create the greatest damage to the land's surface, but rather the pipeline corridors and physical scarring of the land by the large machinery required to hydraulically fracture. Howard Boigon, a lawyer who focuses on transactional, regulatory, and business matters in energy and natural resources law and policy, stated that the oil and gas industry has a "traditional" attitude as companies believe in the rule of capture, which states that the first person to capture a resource owns that resource.

### *Water*

Two water issues have come to the forefront when considering fracking—water pollution and water usage. When considering water pollution, Robert Martin, former National Ombudsman for the EPA, believes that several questions must be posed when discussing groundwater issues. He believes that researchers should confirm there is a contaminant and a pathway to exposure. If there is both a contaminant and a pathway, then researchers should determine what that means. Joe Ryan, a professor of environmental engineering in the Department of Civil, Environmental, and Architectural Engineering at the University of Colorado Boulder, believes the potential flow paths of how chemicals are moving from sources to receptors must be researched. Also, when discussing groundwater pollution, Sura referenced a *Denver Post* article that stated there was an average of more than one spill per day. According to this *Denver Post* article, the average daily spill totaled 5,300 gallons. However, Sura believes the biggest impact to water quality is the sediment loading in the rivers and streams. George King, a registered professional engineer in multiple states who has 42 years of industry experience supports the idea that initial fracturing (from pressure) cannot fracture into the groundwater as wells are far too low in comparison to the water table. King stated that natural seepage into groundwater is approximately 0.00005% of the total contamination and that the majority of problems occurring above ground activities include both transportation and human error. King also suggested that because one horizontal well can cover the same area as 5-10 vertical wells, hydraulic fracturing can eliminate a large portion of the human error present in the oil and gas industry. Governor John Hickenlooper stated, "We can't find an example where the actual fracturing of the rock has pushed the fracking fluids up into the formation in the past 30 years."

The second water issue involves the water usage in order to fracture the intended rock layer beneath the ground. Reagon Waskom, director of the Colorado Water Institute and director of the Colorado State University Water Center, stated that horizontal wells require anywhere from 2–5 million gallons of water for drilling depending on the length of the lateral portion of the well and the number of fracture

stages. Furthermore, Waskom stated that the annual water demand in Colorado from hydraulic fracturing is supposed to be 17,800 acre-feet per year, equivalent to nearly 6 billion gallons per year. However, Governor John Hickenlooper stated that fracking uses less than one-tenth of 1% of the total water usage in the state every year in fracking, which he considered “a drop in the bucket.” As the Ogallala aquifer continues to dry up due to seasonally warm temperatures, water will continue to be an important issue in the fracking discussion. Waskom described the composition of fracturing fluid: water – 90%; sand proppant (including inhibitors, reducers, surfactants, and breakers) – 9.5%; and other – 0.5%.

### *Air Quality*

Atmosphere and air quality have both been considered when considering fracking in Colorado. Matthew Sura stated that ground-level ozone is created from volatile organic compounds (VOCs) in storage tanks and wells, nitrogen oxide from transportation, and heat from the sun. He said that Colorado has had readings that are over the EPA’s mandate regarding ground-level ozone readings, which he believes are the result of drilling in Weld County. Dan Grossman, regional director for Environmental Defense Fund’s Rocky Mountain Regional Office in Boulder, stated that according to a National Oceanic and Atmospheric Administration (NOAA) study, actual methane leakage from the oil and gas sector in Colorado accounts for 2.3%–7.7% of the total leakage. Grossman also quoted a NOAA/CU study that stated that oil and natural gas development accounted for 55% of wintertime VOCs in 2011. Jana Milford, a researcher who addresses technical, legal, and policy aspects of air pollution, and Gabrielle Pétron, a NOAA Earth Systems Research Laboratory Associate Scientist, conducted research that shows that something unknown is causing increased benzene levels in the air, which they believe to be partly due to natural gas. Susan Tierney, among other speakers, believes the main causes of air emissions are methane leaks, ozone precursors, and flaring emission.

### *Health*

Bernard D. Goldstein, MD, an emeritus professor and dean of the Graduate School of Public Health at the University of Pittsburgh, stated 264 possible health issues could arise from fracking. Matthew Sura stated that people living within a half-mile from oil and gas operations are at an increased risk for health impacts and that one’s risk of cancer doubles if they live within one mile of a condensate tank. Sura believes that these health risks are associated with the natural gas itself, rather than the fracking process. A consensus among several speakers was that potential health risks increase with small oil and gas companies and older wells. According to the American Lung Association, there are increased risks of asthma attacks in areas near hydraulic fracturing.

### *Government Regulation*

The controversy regarding the governing behind the oil and gas industry and fracking specifically rests between the state and local governments. Sura believes that the argument for state control is that COGCC has the expertise and experience in a highly technical field and that there is a need for uniformity. Alternatively, the argument for local government control is that local land use conflicts are best solved by the local government and that the local government should have a say in the monitoring of the industry. Charles Davis, a professor of political science at Colorado State University, stated that uniform state regulations allow companies within the industry to grow. He suggests that in general, regulation falls under a legislative mandate that encourages the development of oil and gas resources. Congresswoman Diana DeGette spoke about the Energy Policy Act of 2005 in which the “Halliburton Amendment” allowed oil and gas companies an exemption on the safe drinking water act. However, DeGette is currently championing a FRAC Act that would repeal the Halliburton loophole and require oil and gas companies to abide by the federally mandated clean water act. Furthermore, DeGette states

that economic benefits of natural gas cannot come at the expense of local communities and the environment.

Howard Boigon stated that banning fracking would essentially ban all oil and gas drilling within the state, which he believes would have a devastating effect on our economy. He believes that hydraulic fracturing is necessary for the drilling of virtually every well in the state. However, Goldstein believes that a statewide moratorium would allow researchers to examine the potential harmful effects it could have on the state.

### **APPENDIX 3: RECENT BALLOT INITIATIVES**

The following paragraphs include the ballot language related to oil and gas fracking bans/moratoriums in five Colorado cities between 2012 and 2013, and the respective poll results.

*City of Longmont Ballot Question No. 300, November 2012*

[Charter Amendment to Ban Hydraulic Fracturing]

*Shall the City of Longmont Home Rule Charter be amended by adding a new article XVI to prohibit within the City of Longmont the use of Hydraulic Fracturing to extract oil, gas, or other hydrocarbons, and prohibit within the City of Longmont the storage in open pits or disposal of solid or liquid wastes created in connection with the hydraulic fracturing process, including but not limited to flowback or produced wastewater and brine?*

Results:           Yes – 59.94%  
                      No – 40.06%  
                      2,773 Total Votes

The city charter amendment prohibits in Longmont both the use of hydraulic fracturing (fracking) and the storage of the resultant waste products. It does not ban drilling per se but forbids fracking.

*City of Boulder Ballot Question 2H (Ordinance No. 7915) - Oil and Gas Exploration Moratorium Extension, November 2013*

*Shall Ordinance No. 7907 be amended to extend the current moratorium on new oil and gas exploration until June 3, 2018 and to set legal standards and the council voting requirements for lifting the moratorium amended pursuant to Ordinance No. 7915?*

Results:           Yes – 78.07%  
                      No – 21.93%  
                      30,819 Total Votes

This measure extended the current moratorium on new oil and gas exploration and the new use of *fracking* for oil and gas. It converted the current one-year moratorium on fracking to a five-year ban.

City of Lafayette, November 2013

*Shall Chapter II of the Lafayette Home Rule Charter be amended to add a new section 2.3 entitled Community Bill of Rights and Obligations to (i) prohibit corporations, or persons using corporations, from extracting gas and oil within the city limits, except through currently active wells; (ii) prohibit corporations, or persons using corporations, from depositing, storing or transporting within city limits any water, brine, chemical or by-products used in or that result from the extraction of gas or oil; (iii) prohibit corporations, or persons using corporations, from engaging in the creation of fossil fuel and nuclear energy production or to create delivery infrastructure that facilitates activities related to the extraction of gas and oil; (iv) prohibit corporations, or persons using corporations, from extracting water from sources in the city for use in the extraction of gas and oil; (v) impose liability on corporations, or persons using corporations, that engage in the extraction of gas or oil extraction outside of the city limits for harm caused within the city; (vi) interpret the definition of “persons” who are entitled to certain rights and privileges of the United States and Colorado Constitutions; (vii) limit the rights of corporations, or persons using corporations, that engage in gas and oil extraction to enforce state or federal law, or to challenge municipal or charter provisions; and (viii) invalidate permits, licenses, privileges or charters issued by state or federal agencies, boards or commissions that would violate the charter prohibitions?*

Results:           Yes – 60.16%  
                      No – 39.84%  
                      8,723 Total Votes

This measure amended the Lafayette City Charter to add a “Community Bill of Rights and Obligations” section that imposes a ban on oil and gas extraction and all related activities, especially *fracking*, within the city limits. The proposed amendment also established certain rights for city residents and ecosystems as part of the city charter such as clean water, air and freedom from certain chemicals and oil and gas industry by products.

City and County of Broomfield, November 2013

*Shall Broomfield's Home Rule Charter be amended for five years so as to prohibit the use of hydraulic fracturing to extract oil, gas, or other hydrocarbons within the City and County of Broomfield and to prohibit the disposal or open pit storage of solid or liquid wastes created in connection with the hydraulic fracturing process?*

Results:           Yes – 50.04%  
                      No – 49.96%  
                      20,702 Total Votes

This measure adds clause in the charter of Broomfield establishing a five-year prohibition on hydraulic fracturing. A lawsuit was filed by a pro-fracking group and went on trial February 20, 2014. Unofficial results indicated the five-year ban failed by 13 votes, but a recount showed it passed by 20 votes out of more than 20,000 votes cast. The results were upheld by District court judge Chris Melonakis on February 27, 2014.



City of Fort Collins, November 2013

*An ordinance placing a moratorium on hydraulic fracturing and the storage of its waste products within the City of Fort Collins or on lands under its jurisdiction for a period of five years, without exemption or exception, in order to fully study the impacts of this process on property values and human health, which moratorium can be lifted upon a ballot measure approved by the people of the City of Fort Collins and which shall apply retroactively as of the date this measure was found to have qualified for placement on the ballot.*

Results:           Yes – 55.36%  
                      No – 44.64%  
                      36,371 Total Votes

The measure established an ordinance prohibiting for five years the use of hydraulic fracturing and prohibiting for the same time the storage of any waste products associated with fracking in the city limits. This measure was on the ballot through *citizen initiative petition*. The ordinance approved by Question 2A also called for studies and research on whether there are in fact harmful effects that might come from fracking.