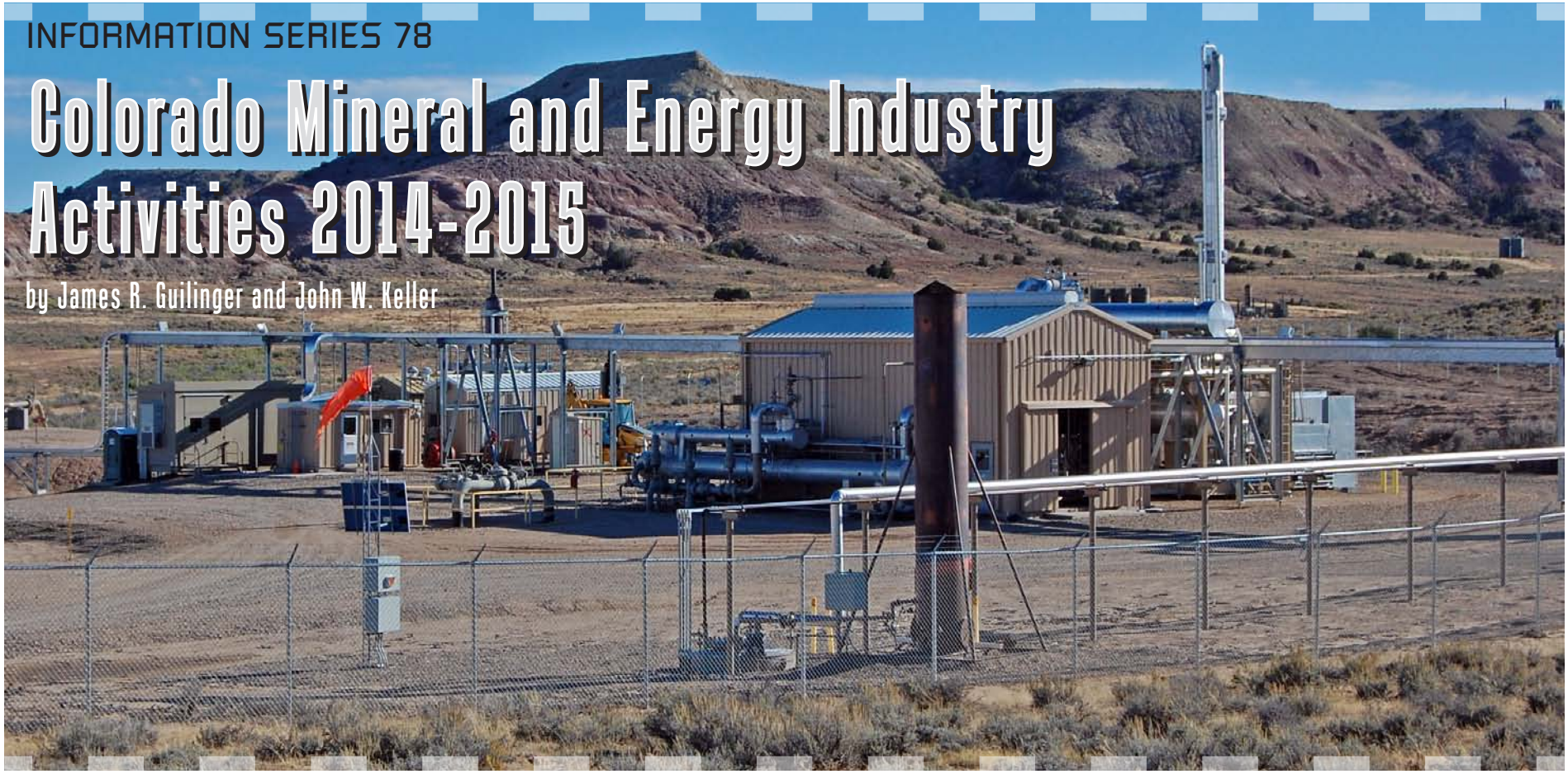
INFORMATION SERIES 78

Colorado Mineral and Energy Industry Activities 2014-2015

by James R. Guilinger and John W. Keller



INFORMATION SERIES 78

Colorado Mineral and Energy Industry Activities in 2014-2015

by James R. Guilinger[1] and John W. Keller[2]
[1] Consulting geologist [2] CGS contract geologist

Dr. Ramona M. Graves
DEAN,
COLLEGE OF EARTH
RESOURCE SCIENCES
& ENGINEERING

Karen A. Berry
STATE GEOLOGIST

Cover photos:

Powder Wash field gas plant in Moffat County by Larry Scott.
Wind farm in Kiowa County by Larry Scott.
Tanker truck on I-70 by Larry Scott.
West Elk Mine coal loadout in Gunnison County, CGS archive.

TABLE OF CONTENTS

ECONOMIC SUMMARY

The Colorado Geological Survey (CGS) is pleased to resume publication of the annual Colorado Mineral and Energy Industry Activities report after a hiatus of seven years. The report was last issued in 2008 and consisted of extensive discussions and graphics of all components of the mineral and energy industries. This report, based on 2014 production data, is a slightly condensed version of the earlier publications.

Due to higher prices and production, especially for oil, and a generally improving economy in 2014, several sectors of the Colorado minerals and energy resources industries enjoyed a year of growth. Since 2002, the value of mineral production in the state has more than quadrupled. The CGS estimates the total value of 2014 mineral and energy fuels production in Colorado to be $18.8 billion, a 21% increase over the 2013 value of $15.5 billion, and over four times higher than the 2002 value. The mineral production value for 2014 is broken out into the major mineral commodity classes in **Figure ES-1**. Mineral production values from 1995 through 2014 are shown in **Figure ES-2** show a large increase over that time.

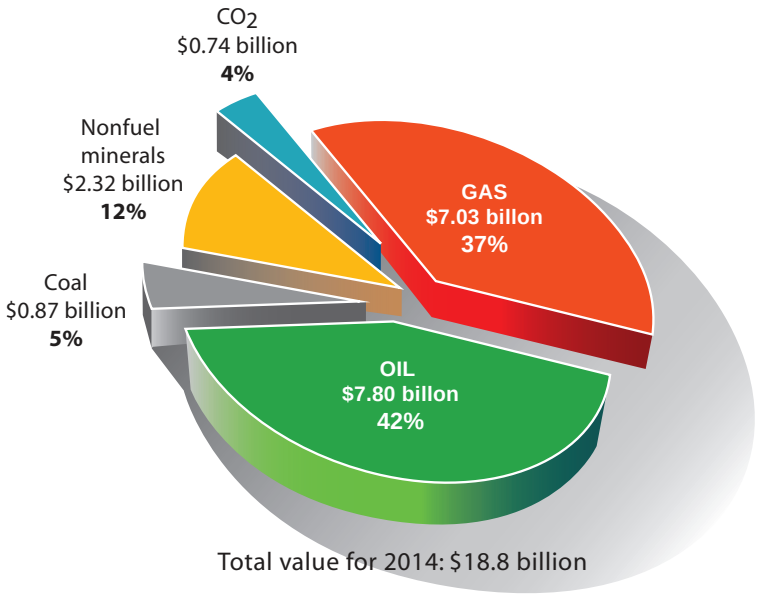


Figure ES-1. Mineral production value by commodity type in Colorado.

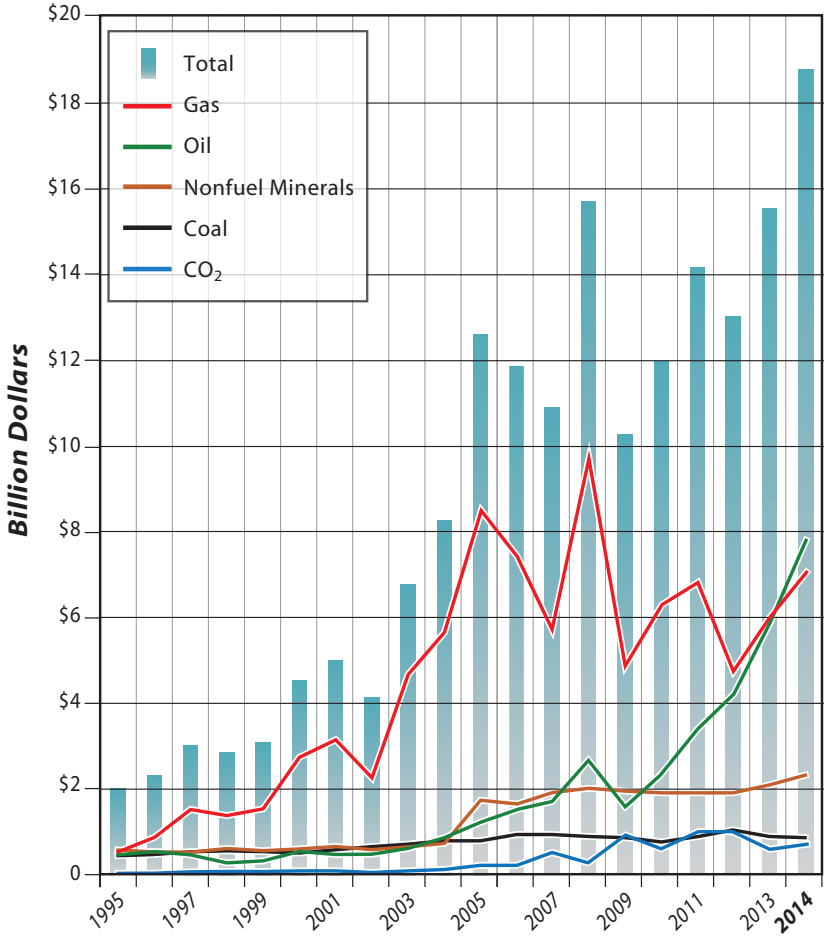


Figure ES-2. Mineral and energy fuel production value in Colorado, 1995–2014.

The vast majority of the increase in the value of Colorado's mineral production over the last decade has come from the oil and gas sector. This is largely due to technological advances and increased use of horizontal drilling and hydraulic fracturing. According to the U.S. Department of Energy, Energy Information Agency (EIA), Colorado has the 8th largest proven oil reserves in the U.S., and the 6th largest reserves of natural gas. The total estimated value of oil and natural gas production in 2014 is $14.8 billion. Despite a rapid drop

in prices in the last half of 2014, this is an increase of 24% compared to 2013 ($11.9 billion). Significant production increases from horizontal drilling and hydraulic fracturing for oil and natural gas in the Niobrara Formation, largely in Weld County, account for the higher values.

Colorado is the 11th largest coal producer in the U.S., with both underground and surface mines currently in operation on the Western Slope. Coal production decreased by around 5% from 24.27 million tons in 2013 to 22.98 million tons in 2014. The reduction in coal mine production is due primarily to the nation-wide trend away from coal-fired power plant energy, and increased use of natural gas and renewable energy. Nonetheless, coal is still the largest source of reliable, low-cost electricity in Colorado and nationally.

Nonfuel mineral production includes metals, industrial minerals, and construction materials. The United States Geological Survey (USGS) estimates that the total value of Colorado's production of nonfuel minerals in 2014 is $2.32 billion, a 10% increase over the 2013 estimated value of $2.11 billion. Increased production of molybdenum, sand and gravel, and crushed stone aggregate accounted for the increase. With 2014 production of 51 million pounds of molybdenum from two mines, Colorado is the largest molybdenum producer in the U.S. Although just one mine in the state reported gold production in 2014, Colorado is the third largest producer of the metal in the U.S.

Carbon dioxide produced in Colorado is used primarily for enhanced oil recovery in the Permian Basin oil fields of Texas. Both the production volume and price increased from 2013 to 2014. The production value of $738 million in 2014 is 17% higher than the production value of $629 million reported for 2013.

There was no uranium mining in Colorado in 2014. Continued low uranium prices primarily account for the lack of mining in the state. Despite the low prices however, company consolidations and project development was ongoing in 2014 and continued into 2015.

Renewable energy for electrical generation has grown rapidly in Colorado and much of the world in the past several years. In Colorado, wind is the largest renewable source of electrical generation. Both wind and solar energy are experiencing rapid growth rates. Technological advancements and improving economies of scale in manufacturing have led to rapid decreases in the costs to produce electricity from these sources. Hydroelectric power has a long history of use in Colorado and some new development is taking place near Lake Granby, Pueblo, and east of Montrose.

SEVERANCE TAX REVENUE

Severance taxes are state taxes collected on the production of oil, gas, coal, molybdenum and other metallic minerals. A portion of the severance tax funds are distributed to counties, municipalities, and school districts. Severance tax funds are also used to support agencies like the CGS and programs in the Colorado Department of Natural Resources. These include the Colorado Oil and Gas Conservation Commission (COGCC), the Division of Reclamation, Mining, and Safety (DRMS), Colorado Water Conservation Board (CWCB), and Colorado Parks and Wildlife (CPW). In fiscal year 2014-2015, Colorado will have collected an estimated $369 million in severance taxes, a new record and up about 37% from the $268.7 million collected in 2013-2014 (Colorado Department of Revenue data). Continued low prices for natural gas and oil, combined with ad valorem tax credits, will result in a decline of $202.6 million in severance taxes in FY2015-16 (Office of State Planning and Budgeting, December, 2015). **Figure ES-3** shows the annual severance taxes collected since 1994. The map in **Figure ES-4** shows the distribution of fiscal year 2013-2014 severance taxes to each county.

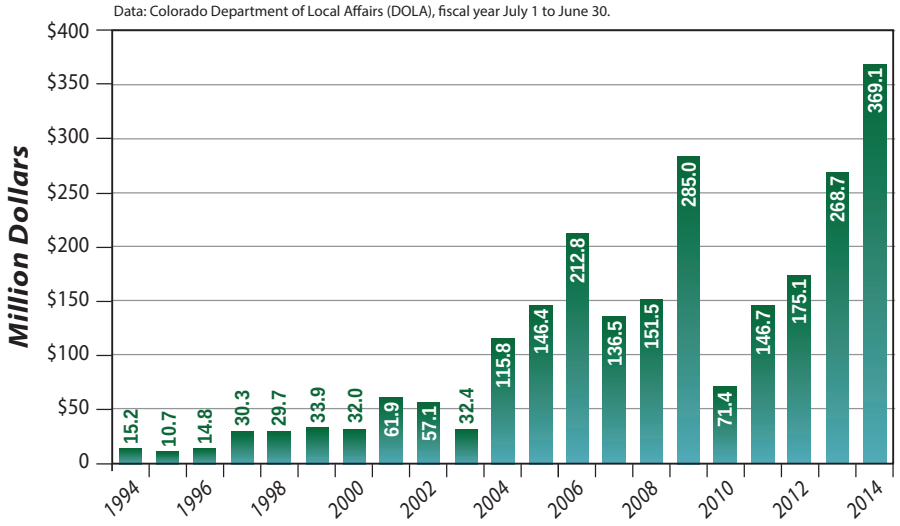


Figure ES-3. Colorado mineral severence tax revenues 1994–2014.

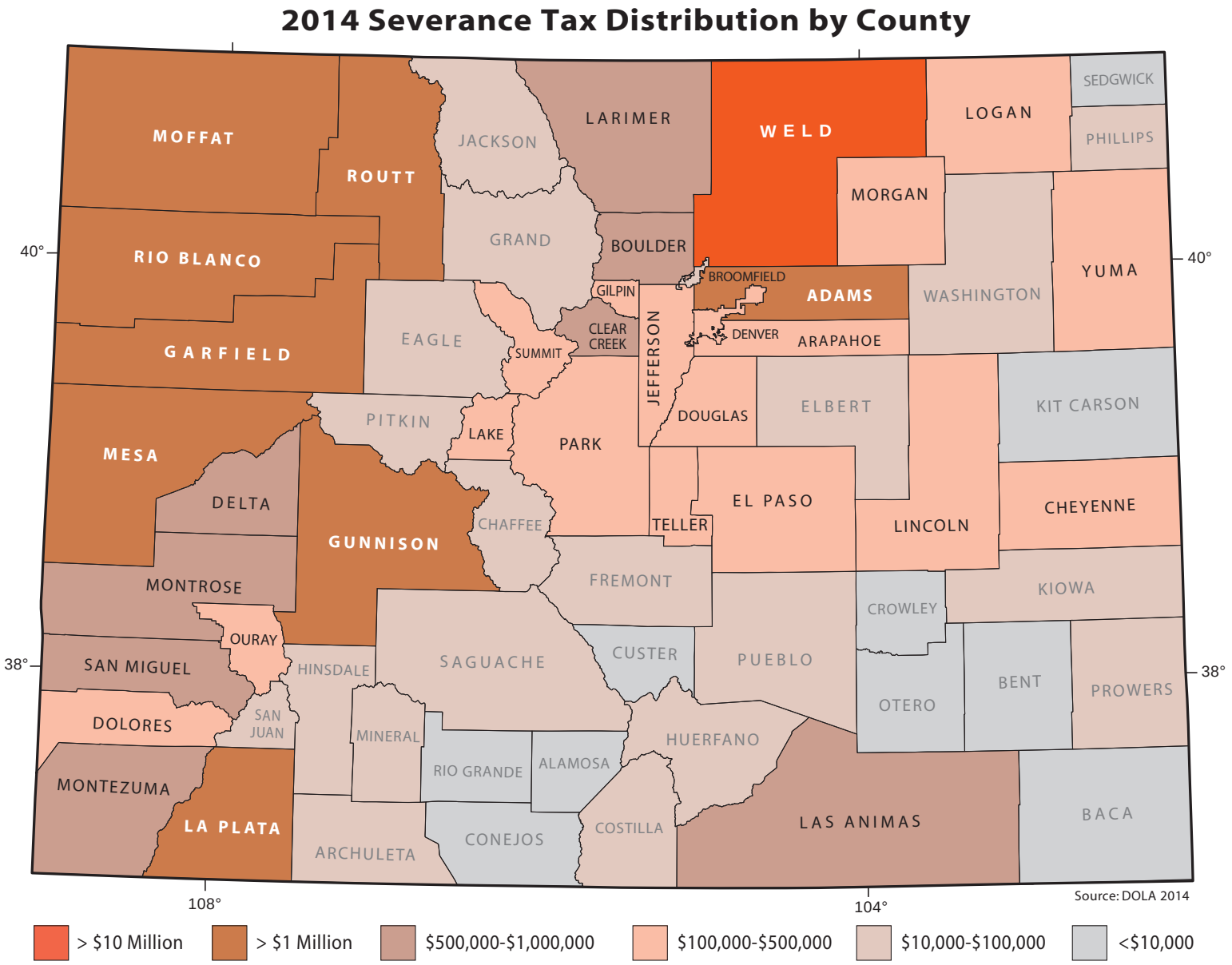


Figure ES-4. Colorado mineral severence tax distribution by county, fiscal year 2013–2014.

STATE LAND BOARD MINERAL REVENUE

The State of Colorado owns over 4 million acres of mineral land managed by the Colorado State Land Board. Leasing and royalty revenue from mineral activities on these lands are deposited into the state's Public School Permanent Fund which was created to help finance public primary education. Funds collected are distributed through the School Finance Act to school districts on a per student basis. In the fiscal year (FY) ending on June 30, 2014, the Colorado State Land Board received a record high $155.9 million from mineral royalties, bonuses, and rentals on state owned land. This is an increase of approximately 45% over the $107.2 million collected in FY 2013, and nearly three times more than was collected in 2010. **Figure ES-5** shows the State Land Board revenues from 1997 through the fiscal year ending in June 2014.

FEDERAL MINERAL LEASE AND ROYALTY REVENUE

The state of Colorado also receives 50% of the revenue from mineral and energy leases on federal land. In FY 2013-2014 revenues totaled approximately $182 million, a 42% increase over FY 2012-2013 total of $128 million. **Figure ES-6** shows Colorado's share of federal mineral lease revenues from 2009 to 2014.

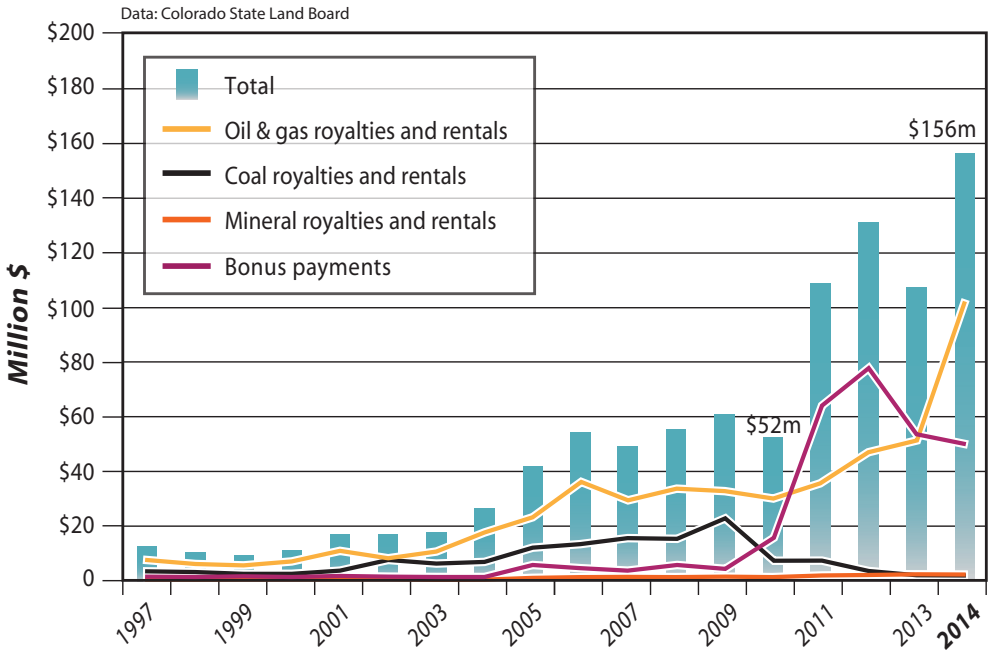


Figure ES-5. Colorado State Land Board mineral revenues, 1997–2014.

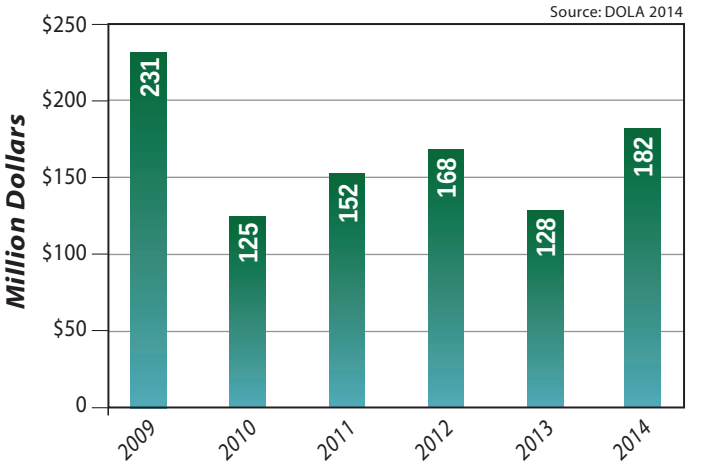


Figure ES-6. Colorado revenue from federal mineral leases 2009–2014.

SUMMARY

The total value of Colorado's oil and natural gas production in 2014 is estimated at $14.8 billion, a 24% increase over the 2013 value of $11.9 billion. Most of the production occurs in seven sedimentary basins across the state.

The map in **Figure 2-1** shows the major basins and the locations of recent oil and gas well drilling permits. Colorado's oil and natural gas production generally declined for many years until 2001. Since then, with higher oil prices and the advent of improved horizontal drilling and hydraulic fracturing technologies, the Niobrara Formation in northeastern Colorado has become a prolific producer of "tight" shale oil and natural gas. Other areas of the state also had an increase in exploration and production during this time. The latest resource estimates indicate that the Niobrara Formation may contain as many as 2 billion barrels of oil (EIA)

"Conventionally" produced oil and natural gas production (e.g., vertical wells, permeable sandstone or carbonate reservoirs and wells that do not require hydraulic-fracture stimulation) continued its downward decline in 2014 . Some conventional fields, such as Rangely, benefited from horizontal drilling and multi-stage hydraulic fracturing of the Niobrara Formation.

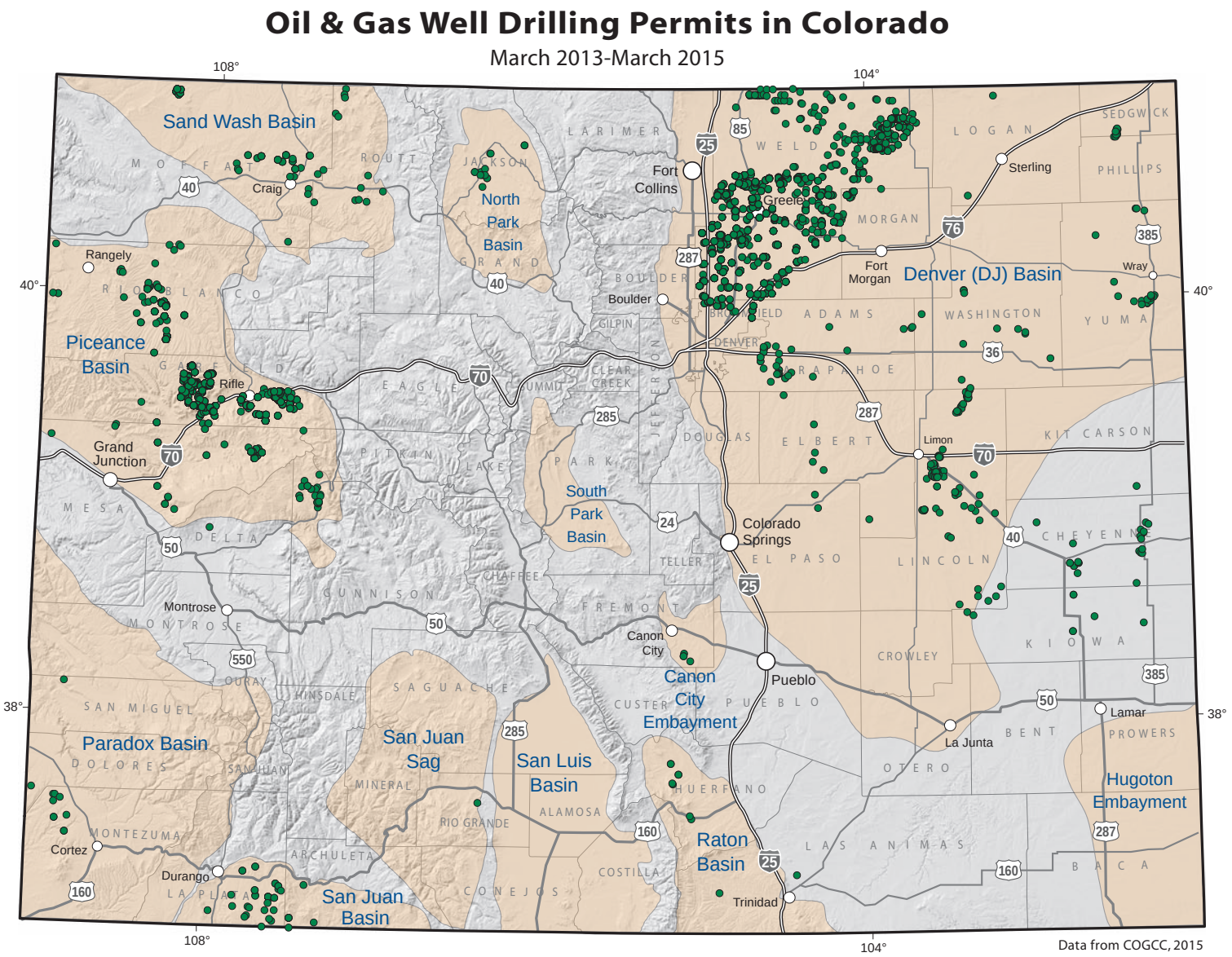


Figure 2-1. Map showing Colorado's sedimentary basins and the location of oil and gas well drilling permits from March 2013 to March 2015.

OIL

Crude oil production statewide increased by a remarkable 45% in 2014 to 94.6 million barrels, from 65.3 million barrels in 2013 (**Figure 2-2**). This increased annual production of 29.3 million barrels over the course of one year is more than the entire statewide annual production in every year from 1994 to 2007. Colorado's oil production in 2014 is nearly five times that of 1999. Of the 94.6 million barrels produced in 2014, approximately 93% (77.29 million barrels) came from Weld County. As of 2013, Colorado is ranked 8th among the states with proven oil reserves of 618 million barrels (**Figure 2-3**), and 7th in oil production (EIA).

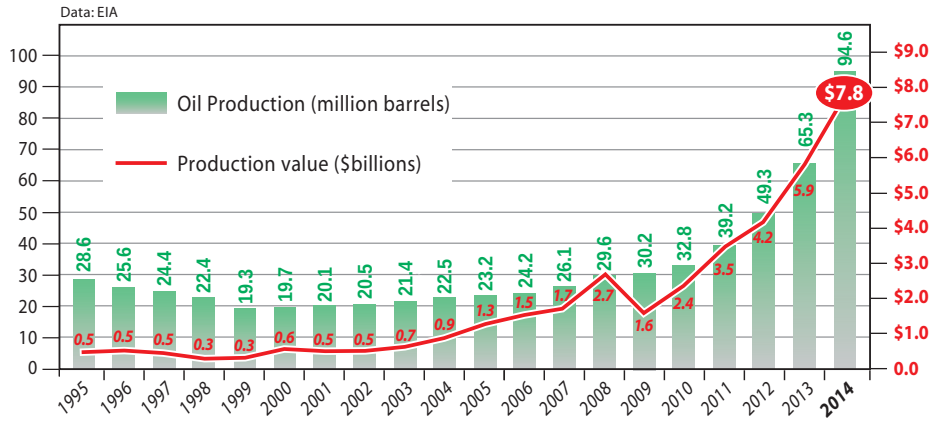


Figure 2-2. Oil production and production value in Colorado, 1995–2014.

After falling precipitously from 2008 to 2009 during the recession, the average annual oil price rose steadily from 2009 to 2013. Another downward trend began in 2014 (**Figure 2-4**) due to a rapid drop in prices in the last few months of the year. The EIA Colorado average annual purchase price for oil declined 8.4% from $90.10 in 2013 to $82.48 per barrel in 2014. However, prices declined very sharply in the second half of 2014, from $92.45 in June to $50.89 per barrel by the end of December. The price drop, which continued into 2015, has resulted in substantially reduced exploration activities. Higher oil production offset lower prices and the annual production value in 2014 rose to $7.8 billion, 32% higher than in 2013 ($5.89 billion).

NATURAL GAS

In 2014, estimated Colorado natural gas production increased slightly to 1.63 trillion cubic feet (Tcf) (**Figure 2-5**), from 1.60 Tcf in 2013. The average annual spot price increased 17.7% from $3.73 per thousand cubic feet (Mcf) in 2013 to $4.39 per Mcf in 2014. Higher average prices resulted in an estimated 2014

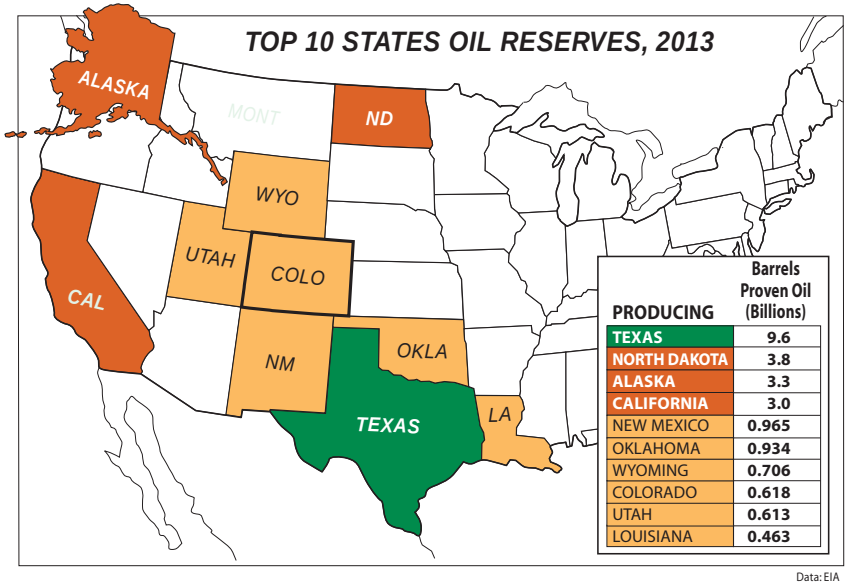


Figure 2-3. Proven oil reserves - top 10 states, 2013.

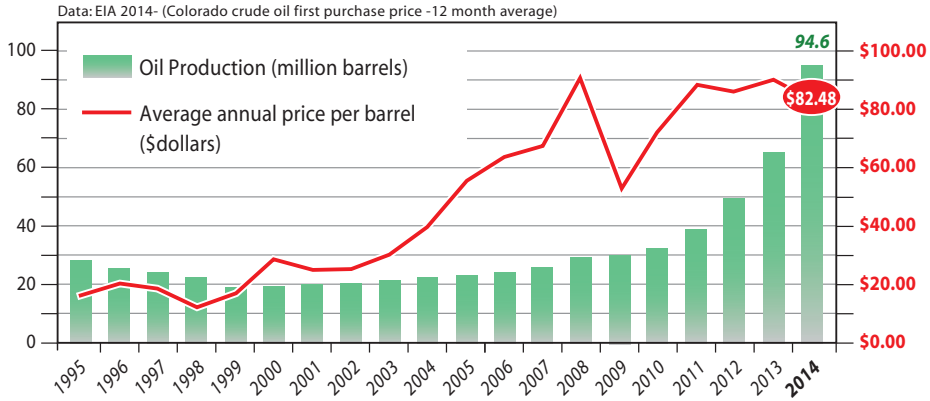


Figure 2-4. Colorado oil production and average annual price per barrel, 1995–2014.

production value of $7.04 billion compared to the 2013 estimated value of $6.01 billion (Colorado Business Economic Outlook Forum, 2015). Average annual spot prices have fluctuated between $2.75 and $4.39 per Mcf since 2009. Natural gas prices started a downward trend at the end of 2014 and have continued downward into 2015 although the price decrease has not been nearly as steep as it has been for oil. Colorado was ranked 6th among the states in the production of natural gas in 2013 (**Figure 2-6**).

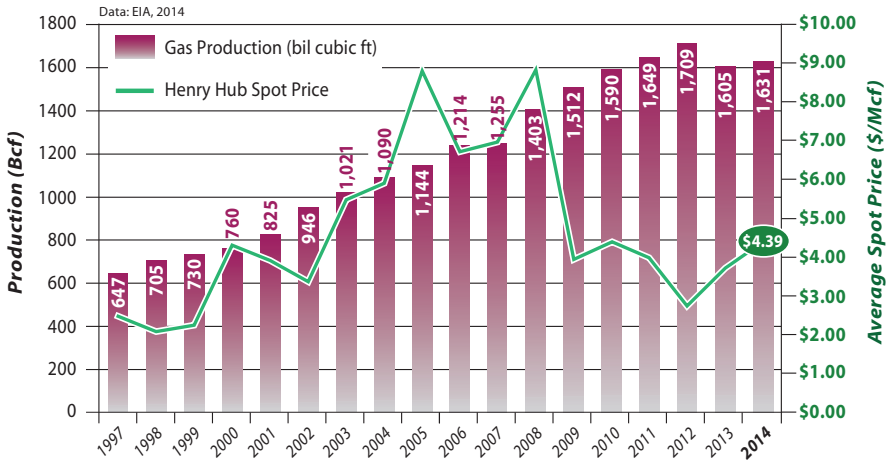


Figure 2-5. Colorado natural gas production and average spot price, 1997–2014.

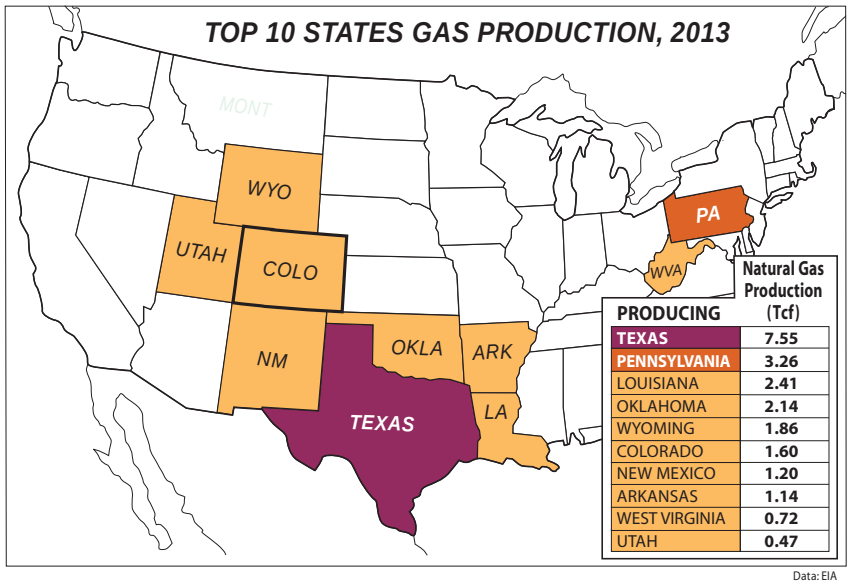


Figure 2-6. Natural gas production - top 10 states, 2013.

COALBED METHANE

Coalbed methane continues to be a significant contributor to natural gas production in Colorado. However, production has been stagnant or declining since 2004. **Figure 2-7** shows the annual Colorado production of coalbed methane and non-coalbed natural gas from 1995 through 2013 (the latest EIA data available for coalbed methane). Coalbed methane's share of natural gas production has been declining due to large increases in production from horizontal drilling and hydraulic fracturing in shale reservoirs. In 2013, coalbed methane production of 444 billion cubic feet (Bcf) was about 28% of the total natural gas output.

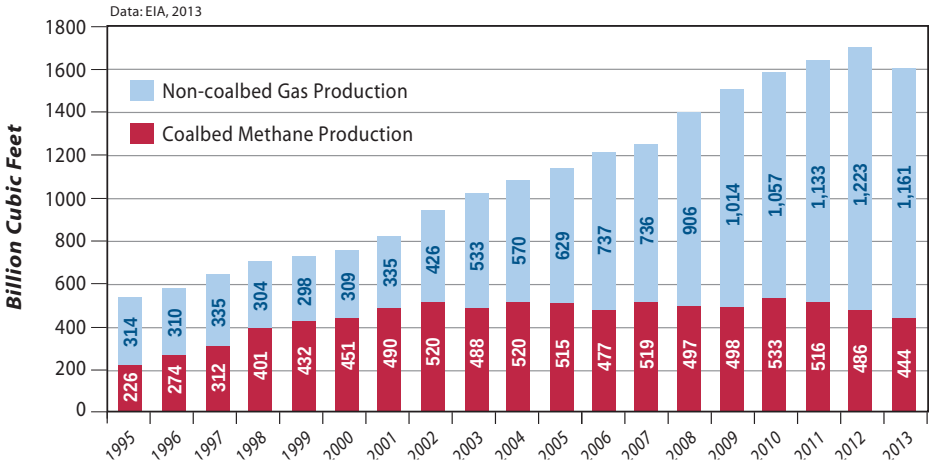


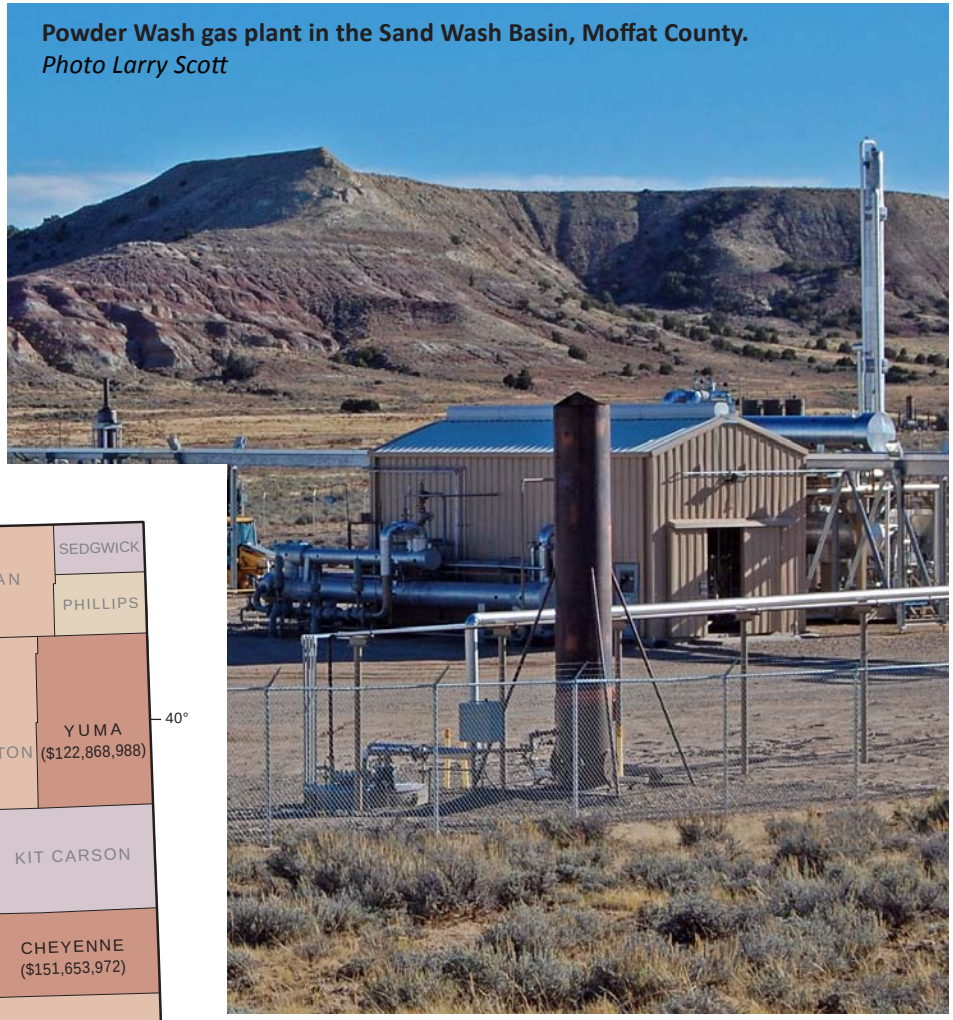
Figure 2-7. Coalbed methane vs. non-coalbed natural gas production in Colorado, 1995–2013.

According to U.S. Environmental Protection Agency (EPA) estimates, Colorado has the largest coalbed methane resources in the U.S. The Piceance Basin tops the list with resources ranging between 80 and 136 Tcf. A close second is the Sand Wash Basin with resources estimated at 101 Tcf. The other basins containing lesser amounts of coalbed methane resources in Colorado overlap adjoining states of Utah (Uinta Basin – 8 to 10 Tcf) and New Mexico (Raton Basin – 10.2 Tcf).

Hiawatha field in the Sand Wash Basin, northwestern Colorado has the potential to produce both natural gas and coalbed methane. *Photo Larry Scott*

COUNTY RANKINGS - OIL AND GAS PRODUCTION

Thirty-eight of Colorado's 64 counties produce crude oil or natural gas, often both. To rank each county's contribution to the state's total production value in 2014, production for each county was multiplied by average annual prices. We used the EIA's "Colorado First Purchase" average annual price for oil of $82.48 per barrel, and an EIA-sourced average annual spot price for natural gas of $4.39 per Mcf. **Figure 2-8** shows the total oil and natural gas production value by county for 2014. **Figure 2-9** shows the total oil production produced or sold by county for 2014. Weld County is by far the largest oil producer, with Rio Blanco and Garfield counties a distant 2nd and 3rd. **Figure 2-10** shows the total natural gas production produced or sold by county for 2014. Garfield County is the largest natural gas producer in the state, with 561.71 Bcf produced in 2014.



Powder Wash gas plant in the Sand Wash Basin, Moffat County.
Photo Larry Scott

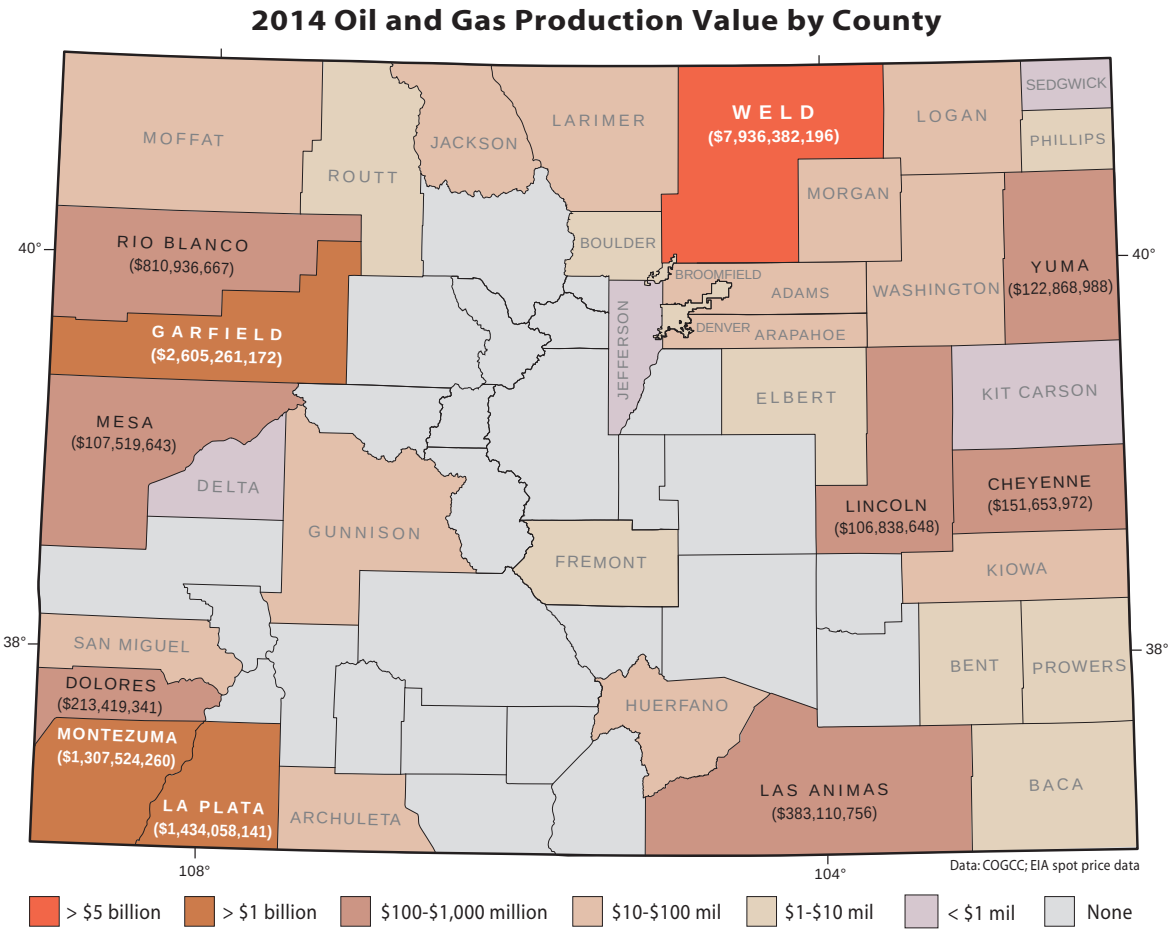
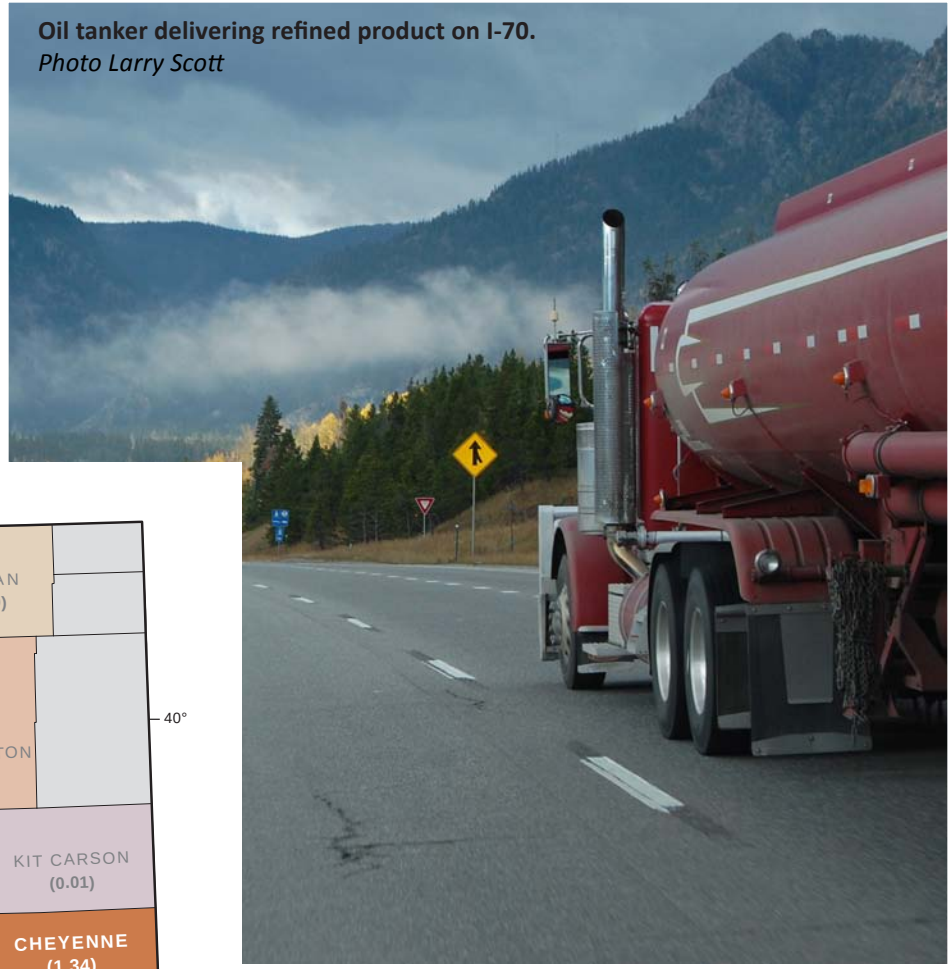


Figure 2-8. Combined oil and natural gas production value by county in Colorado, 2014.

DRILLING PERMITS

The bulk of new oil and natural gas drilling continued to be centered in Weld County, followed by lesser though still significant amounts in Garfield, Rio Blanco, La Plata, Las Animas, Mesa, Yuma, and Moffat counties. Drilling permits in 2014 totaled 4,190, up slightly from 4,025 reported for 2013. **Figure 2-11** shows the number of drilling permits per year for both oil and natural gas from 1994 through 2014. **Figure 2-1** (page 5) shows the location of issued permits from March 2013 to March 2015. The number of permits is down significantly from the 8,027 permits reported in 2008. The decline is likely related to a continued drop in coalbed methane drilling and companies pulling more permits in 2008 before anticipated regulatory changes. Coalbed methane wells tend to be shallower and more closely spaced than conventional or unconventional shale natural gas/oil wells.



Oil tanker delivering refined product on I-70.
Photo Larry Scott

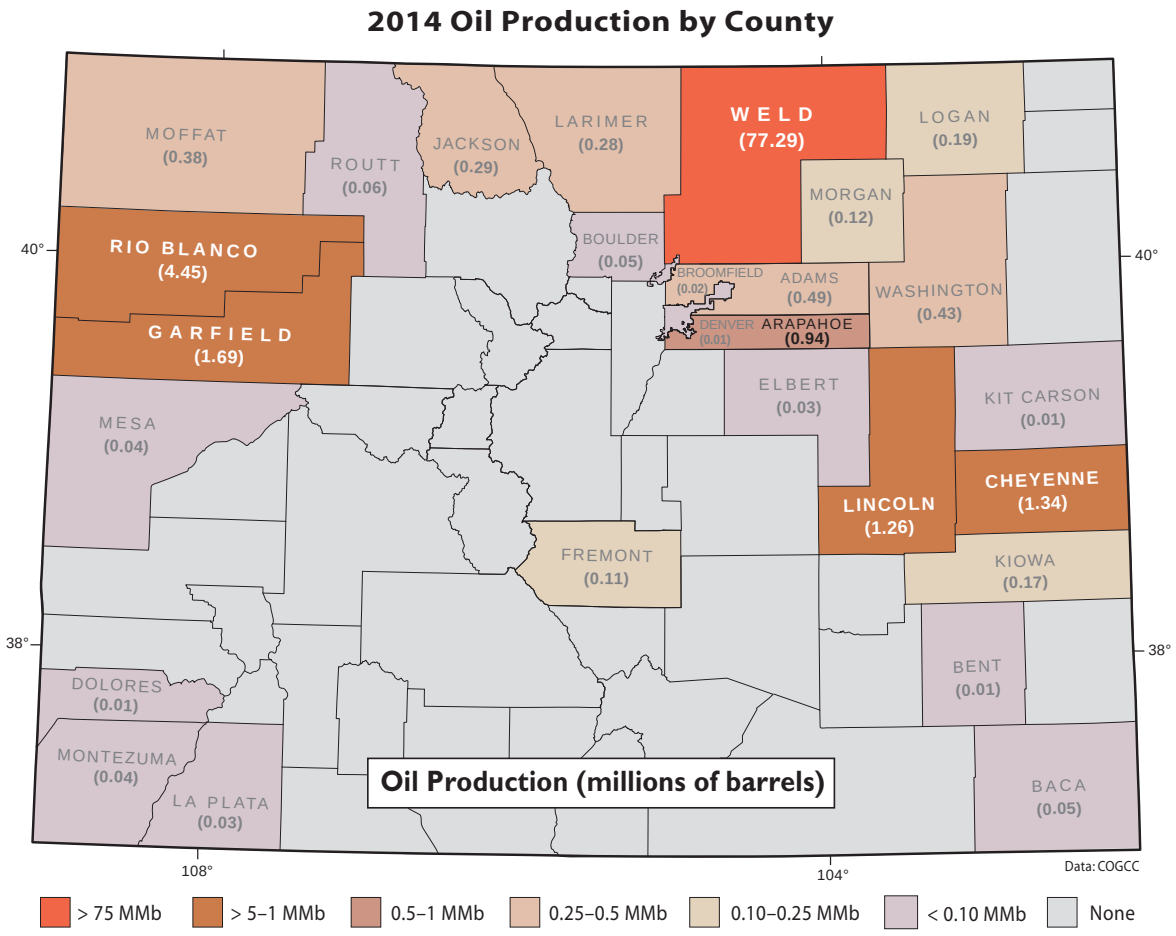


Figure 2-9. Total oil production by county in Colorado, 2014.

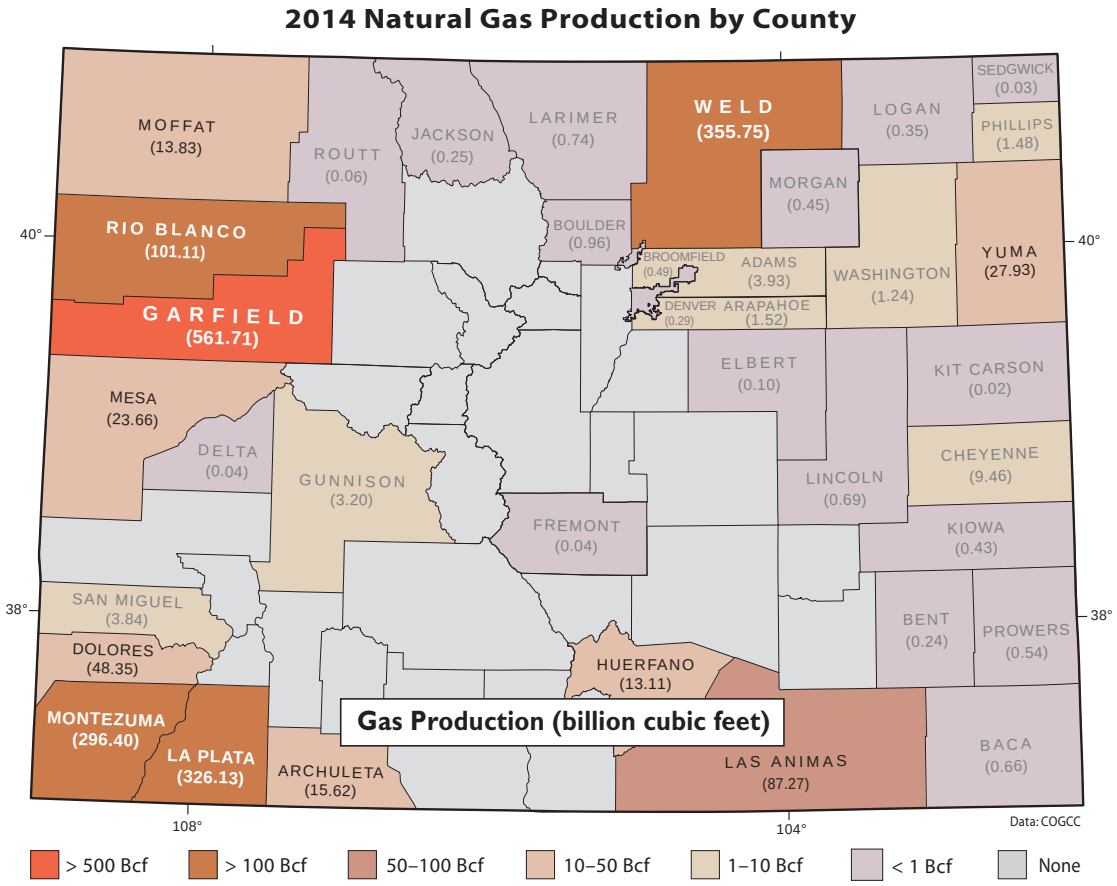


Figure 2-10. Total natural gas production by county in Colorado, 2014.

Pumpjack operates in the Piceance Basin, Rio Blanco County. *Photo Mike O'Keeffe, CGS.*

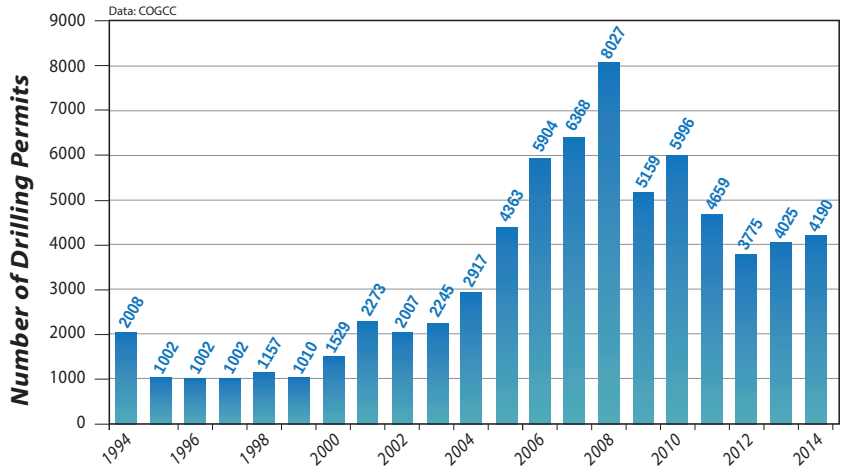


Figure 2-11. Annual oil and gas drilling permits in Colorado, 1994–2014.

OIL SHALE RESEARCH

More than half of the world's known oil shale resources are contained within the Green River Formation. The Green River Formation covers about 16,000 square miles in parts of Wyoming, Colorado, and Utah and contains an estimated 4.3 trillion barrels of oil within a solid bituminous material called kerogen. Oil shale is different than "shale oil." "Shale oil", such as that now being produced in large quantities from the Niobrara Formation, is liquid oil within shale that can be recovered by horizontal drilling and hydraulic fracturing. Oil shale, on the other hand, is more difficult and expensive to convert the kerogen to recoverable liquid oil. Following passage of the National Energy Policy Act of 2005, the Colorado Office of the Bureau of Land Management (BLM) awarded seven oil shale Research, Development and Demonstration (RD&D) leases. During three rounds (2005, 2009 and 2012) of solicitation and nomination, the following companies were awarded leases: Shell Frontier Oil and Gas Inc. (Shell) – 3 leases; Chevron USA (Chevron)- 1 lease; American Shale Oil LLC – 1 lease; ExxonMobil Exploration Company – 1 lease; and Natural Soda Holdings – 1 lease.

In 2012 and 2013, Shell and Chevron discontinued oil shale development research projects on their leases. According to an article in the Grand Junction Sentinel, the other companies are actively involved in oil shale research. American Shale Oil continues research at their lease site utilizing a proprietary process. Pending final permits from state regulators, ExxonMobil plans to hydraulically fracture the oil shale, fill the fractures with an unspecified conductive material, and then electrically heat the shale. Natural Soda Holdings is currently mining (via in-situ hot water injection) and recovering nahcolite from its mining site located just north of its RD&D lease. Pending regulatory approval, Natural Soda Holdings proposes to recover oil on its RD&D lease by first injecting hot water to recover the nahcolite then heat the oil underground using either a downhole burner or a closed loop steam system. Research projects have been ongoing for more than a century in the quest to develop an economically viable process for recovery of oil from oil shale. Such efforts likely will continue into the future given the vast oil resource present in the Green River Formation.

The Roan Plateau in Garfield County. The upper strata (Green River Fm) is the main source of oil shale in Colorado. *Photo CGS archive.*

SUMMARY

Coal mining in Colorado continues to be a critical energy industry that accounts for the majority of the state's electric power fuel supply. In 2014, 59% of Colorado's electricity was generated by coal-fired power plants, while 22% came from natural gas, and 18% from renewable sources (wind, hydroelectric, solar, biomass). In 2013, 64% of Colorado's electricity was generated by coal-fired power plants. This declining trend is due to: (1) the low price of natural gas relative to coal combined with many power plants across the U.S. converting from coal to natural gas; (2) new greenhouse gas regulations, potential additional regulations and taxes, designed to cut carbon dioxide emissions have increased operating costs and investment risks for coal-fired power plants, and; (3) the growing use of renewable energy. In 2010, the Colorado State Legislature passed the Clean Air Clean Jobs Act , which promoted the replacement of six aging coal-fired power plants located on the Front Range with natural gas power plants. The 160 megawatt (MW) Arapahoe Station coal-fired plant in Denver was shut down in 2013, and the 44 MW Clark Station plant in Cañon City was closed in 2012. Once the remaining four coal plants are closed or replaced, the Colorado Mining Association estimates annual coal sales will decline by up to 4 million tons.

Overall, coal production has decreased 39% in the last 10 years as indicated in **Table 1** and **Figure 2-12**. Production in 2014 was 22.98 million tons, down over 5% from the 24.27 million tons mined in 2013. The production value for coal in 2014 was $867 million, down 5% from $912 million in 2013. Coal prices have risen fairly steadily since 2001 (**Figure 2-13**). The average price per short ton in Colorado in 2014 was $37.75, up slightly from the 2013 price of $37.58. Employment in the coal mining industry has dropped nearly 34% from a recent high of 2,279 jobs in 2012 to 1,512 jobs in 2014 (**Figure 2-14**) according to the Colorado Division of Reclamation Mining and Safety (DRMS). The loss of high-paying mining jobs in small rural communities greatly impacts local and regional economies.

The coal mined in Colorado ranges from subbituminous to bituminous with a British thermal unit (Btu-heating value) content ranging from 9,850 Btu (subbituminous) to a high of 12,581 Btu (bituminous). Colorado has comparatively clean coal as evidenced in the coal analyses shown in **Table 2**.

Table 1. Coal production, price, value, and employment, 2001–2014.

Year	Production Short Tons (Millions)	Colorado Average Annual Coal Price $/Short Ton	Product Value (Millions)	Coal Miner Employment
2001	33.41	$17.30	$578	1761
2002	35.20	$18.44	$649	1854
2003	35.88	$19.59	$703	1859
2004	39.81	$20.09	$800	1903
2005	37.82	$21.50	$813	1963
2006	35.49	$27.44	$974	2065
2007	36.14	$26.20	$947	2069
2008	32.34	$28.81	$932	2124
2009	28.58	$31.29	$894	2247
2010	25.21	$30.66	$773	2061
2011	27.03	$33.77	$913	2254
2012	28.04	$37.54	$1,053	2279
2013	24.27	$37.58	$912	1857
2014	22.98	$37.75	$867	1512

Data: DOLA; EIA avg. sales price of coal by state; CGS reports 2001-2008; Colorado Division of Reclamation, Mining, and Safety (DRMS).

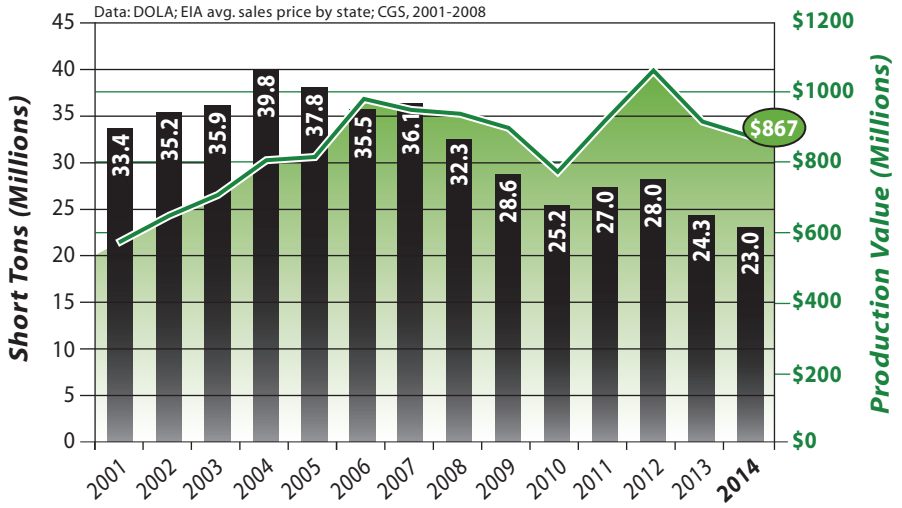


Figure 2-12. Production and value of coal mined in Colorado, 2001–2014.

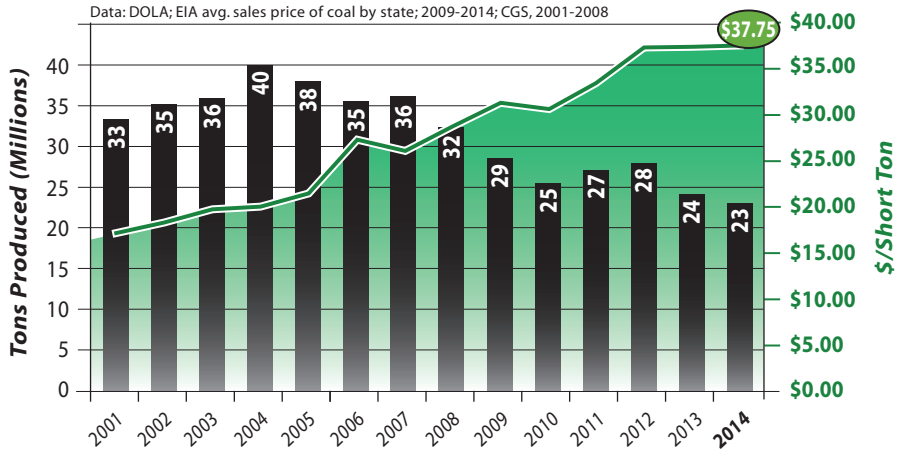


Figure 2-13. Coal production and average yearly coal price in Colorado, 2001–2014.

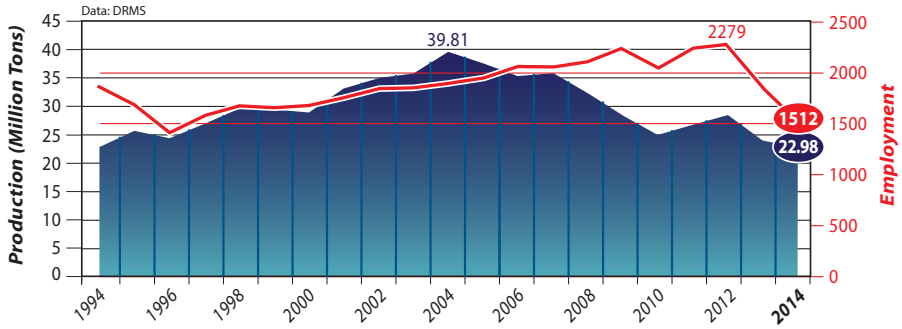


Figure 2-14. Coal production and employment in Colorado, 2001–2014.

Working coal beds at a surface mine in NW Colorado. *Photo CGS archive.*

Because it typically contains less sulfur and other contaminants than eastern U.S. coals, some Colorado coal is shipped to eastern power plants to help them reduce sulfur emissions and comply with air quality standards.

Table 3 compares average coal quality values for the Central Appalachian and Illinois Basin coal regions to average Colorado coal quality values.

Table 2. Average coal quality values for mineable coal beds from coal mines in Colorado by coal region.

Analyses	Denver Region	Green River Region	North Park Region	Raton Mesa Region	San Juan Region	Uinta Region	South Park Region	Canon City Region
Ash %	11.2	9	12.4	16.1	12.7	6.8	6.4	9.8
Sulfur %	0.3	0.6	0.5	0.7	0.8	0.6	0.5	0.8
BTU (per lb.)	9,072	10,973	9,483	12,541	12,758	11,879	9,780	11,130
Mercury (ppm)	---	<0.02	---	0.035	0.03	0.02	---	0.185

Mercury values are from the U.S. Geological Survey National Coal Quality Inventory at active mines in 2001 (Colorado Geological Survey Information Series 58).

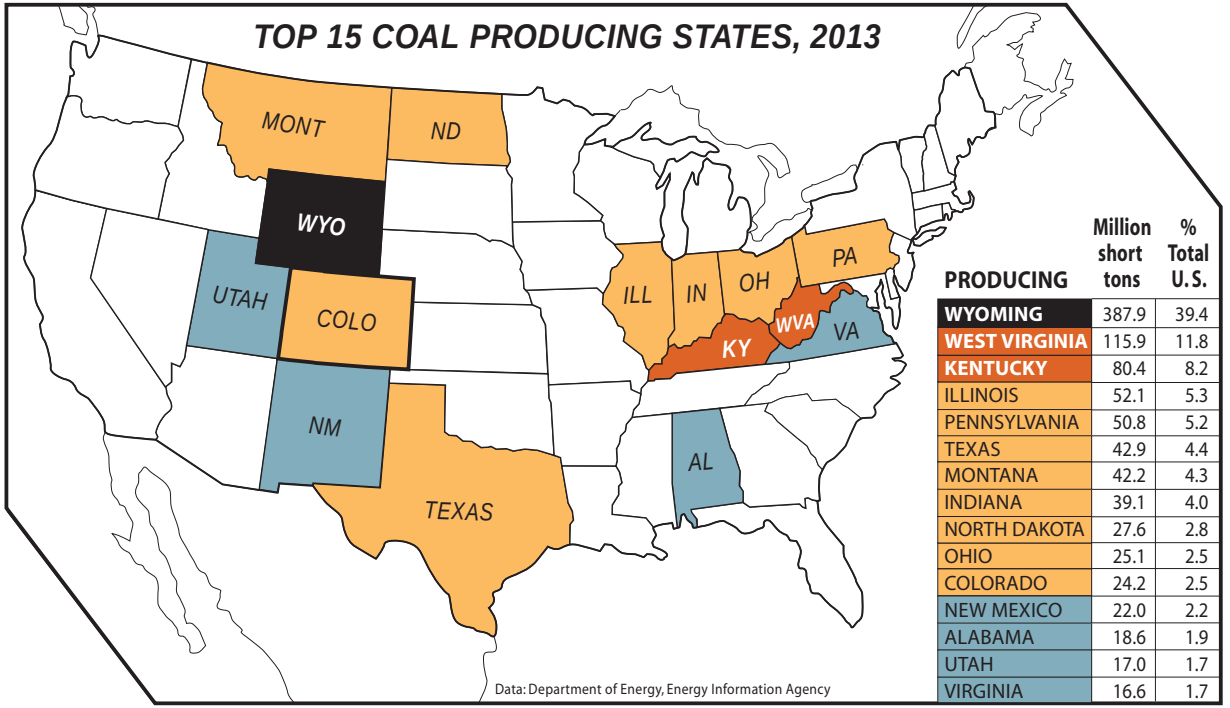
Table 3. Average coal quality values for major coal producing regions in the eastern U.S. vs Colorado averages.

Analyses	Colorado Average (from Table 2)	Central Appalachian Region	Illinois Basin
Ash %	10.55	7.24	11.10
Sulfur %	0.60	1.05	3.0
Btu (per lb.)	10,952	13,540	11,200
Mercury (ppm)	0.06	0.21	0.12

There are currently 8 active coal mines in Colorado (**Table 4**). The New Elk Mine west of Trinidad produced a small amount of coal in 2014 before closing late in the year. Colorado is ranked 11th in coal production in the U.S. (**Figure 2-15**). The mines are shown on the map in **Figure 2-16**, along with power plants and coal regions. Wyoming, the leading producer by far, mined 16 times more coal than Colorado in 2013.

CARBON CAPTURE AND STORAGE

In 2007, CGS published Resource Series 45, CO_2 Sequestration Potential of Colorado. It provides detailed characterization of the carbon dioxide emissions and carbon storage potential of Colorado. In 2010, CGS evaluated the potential for sequestering CO_2 in three strata in the Colorado Plateau. Currently there are no carbon capture and storage (CCS) projects in Colorado. According to the National Conference of State Legislatures (NCSL), Colorado along with 12 other states offer financial incentives such as tax exemptions, credits, and deductions for coal plants, technologies, and equipment for separating and capturing CO_2 from power plant flue gas.



PRODUCING	Million short tons	% Total U.S.
WYOMING	387.9	39.4
WEST VIRGINIA	115.9	11.8
KENTUCKY	80.4	8.2
ILLINOIS	52.1	5.3
PENNSYLVANIA	50.8	5.2
TEXAS	42.9	4.4
MONTANA	42.2	4.3
INDIANA	39.1	4.0
NORTH DAKOTA	27.6	2.8
OHIO	25.1	2.5
COLORADO	24.2	2.5
NEW MEXICO	22.0	2.2
ALABAMA	18.6	1.9
UTAH	17.0	1.7
VIRGINIA	16.6	1.7

Figure 2-15. Top 15 coal-producing states in 2013.

Table 4. Active coal mines in Colorado, 2014.

Mine	Operator	County	Mine Type	2014 Production (tons)
Bowie #2	Bowie Resources Ltd.	Delta	Underground	2,407,598
Colowyo	Colowyo Coal Co. L.P.	Moffat	Surface	2,481,775
Deserado	Blue Mountain Energy	Rio Blanco	Underground	1,937,531
Foidel Creek	Twenty Mile Coal Co.	Routt	Underground	6,659,492
King II	National King Coal LLC.	La Plata	Underground	970,790
New Horizon North	Western Fuels-CO LLC	Montrose	Surface	283,618
Trapper Strip	Trapper Mining Co.	Moffat	Surface	1,943,717
West Elk	Mountain Coal Co.	Gunnison	Underground	6,283,478
New Elk	Clime Mining Co.	Las Animas	Underground	14,238 (closed late 2014)

Data: Colorado Division of Reclamation, Mining and Safety (DRMS).

Tandem-trailer haul truck leaving a NW Colorado mine. *Photo CGS archive.*

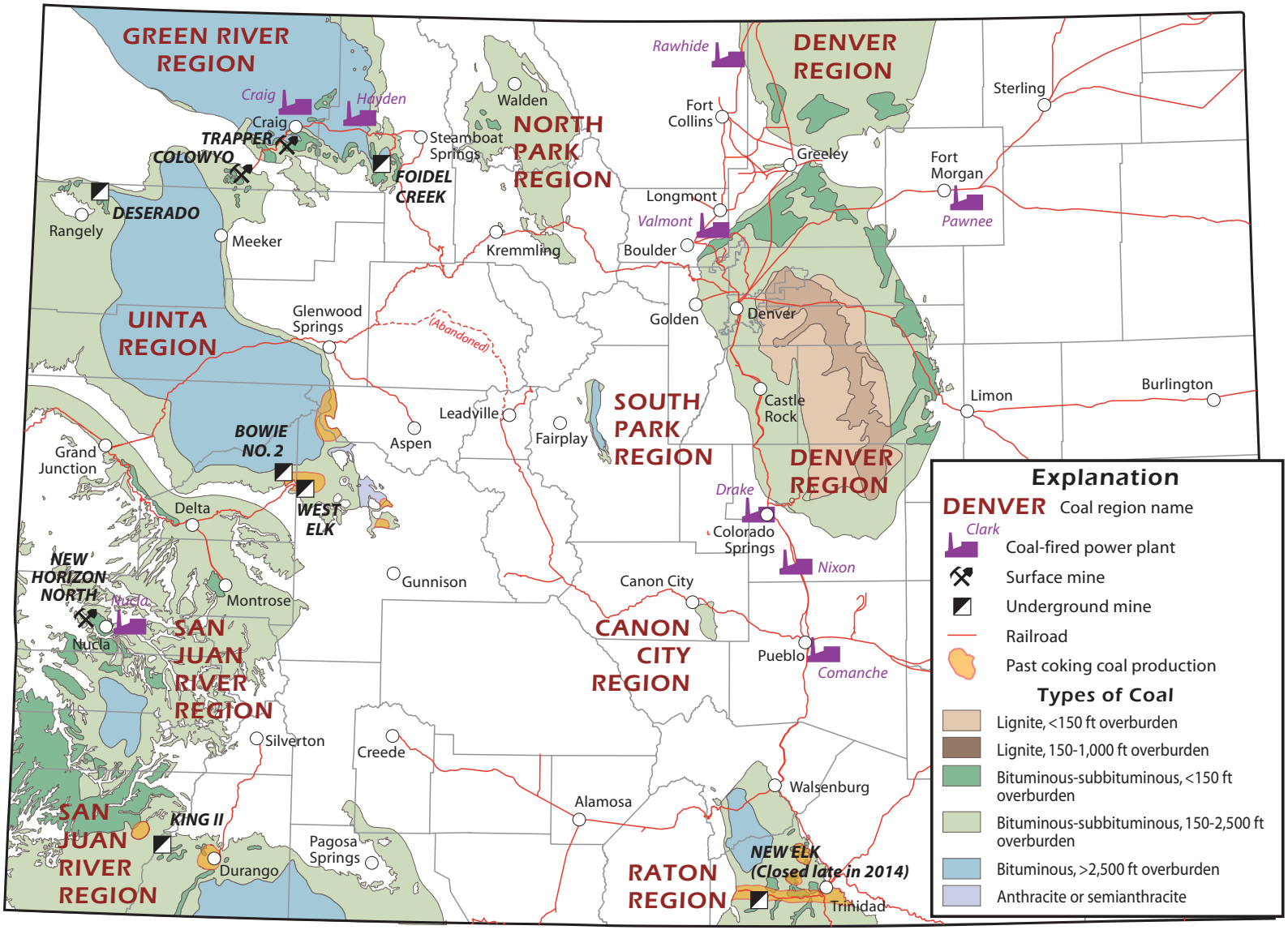


Figure 2-16. Locations of active coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2014.

SUMMARY

In 2014, nuclear energy produced 19.4% (98.6 gigawatts-electric [GWe]) of the electricity generated in the U.S., down slightly from a high of 20.6% in 2001. This energy is produced at 61 commercial nuclear power plants located in 30 states, none of which are in Colorado. Worldwide, nuclear energy provided about 11% of electrical generation in 2014, down from a peak of about 18% in 1996. International Atomic Energy Agency (IAEA) data indicate the world presently consumes 372 GWe of nuclear power annually. By the year 2035, annual consumption of nuclear-generated power is estimated to range from 399 GWe to 678 GWe (**Figure 2-17**), depending on a number of variables and scenarios. Nuclear energy remains the largest contributor to reliable electric power without producing significant greenhouse gas emissions. According to the 2014 Intergovernmental Panel on Climate Change (IPCC), the life-cycle CO_2-equivalent global warming potential from nuclear power is lower than solar photovoltaic, solar thermal, geothermal, or hydroelectric power.

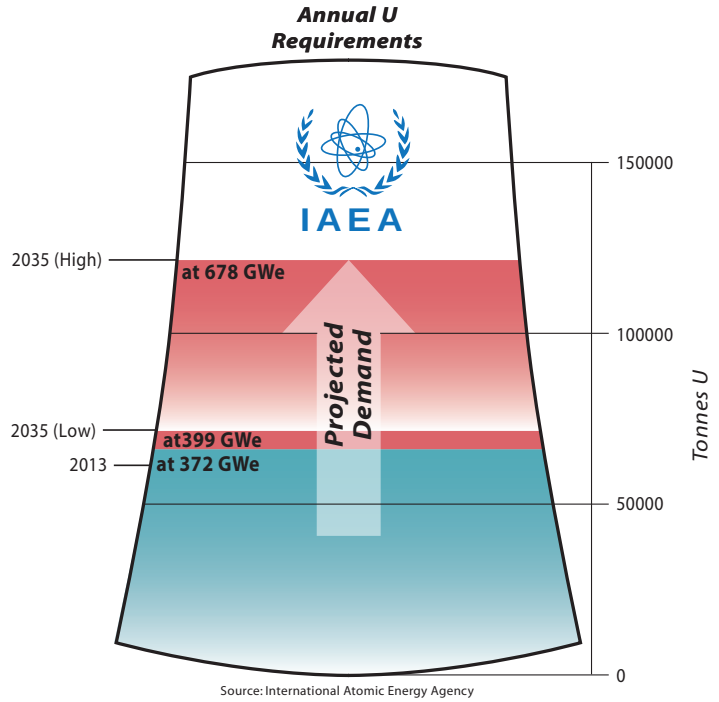


Figure 2-17. Projections of future world uranium requirements.

In terms of annual uranium requirements in 2014, approximately 155 million pounds of U_3O_8 was consumed to supply 432 nuclear reactors worldwide. Of the 432 reactors, 99 (23%) are operating in the U.S. The U.S. contributes only 3% (4.9 million lbs.) of the total uranium required globally. Considering the projections for increased nuclear power generation worldwide by 2035, there may be a shortfall in uranium without a significant increase in exploration and development.

Figure 2-18 shows the average annual uranium prices since 2002. Since 2011 prices have been trending downward. Low U_3O_8 prices in 2014 reflect factors such as the slowing down of reactor construction, the ongoing impacts of the Fukushima disaster in Japan which resulted in the shutdown of many Japanese reactors, and the decision by Germany in 2011 to close all of its nuclear plants by 2022. The low prices and slowdown in reactor construction may be temporary. In 2015, China will increase their construction activity to previous levels, and Japan will likely re-start additional shutdown reactors. Prices are projected to rise in response to new construction activity as the need for additional uranium increases with each nuclear start up.

Uranium production in the U.S. has been increasing since 2011 (**Figure 2-19**), but is still not as high as 1996 levels. Texas, Wyoming, Arizona, and Nebraska were the only states with producing uranium mines in 2014. There are no operating uranium mines or mills in Colorado; though, it has been a major producer in the past.

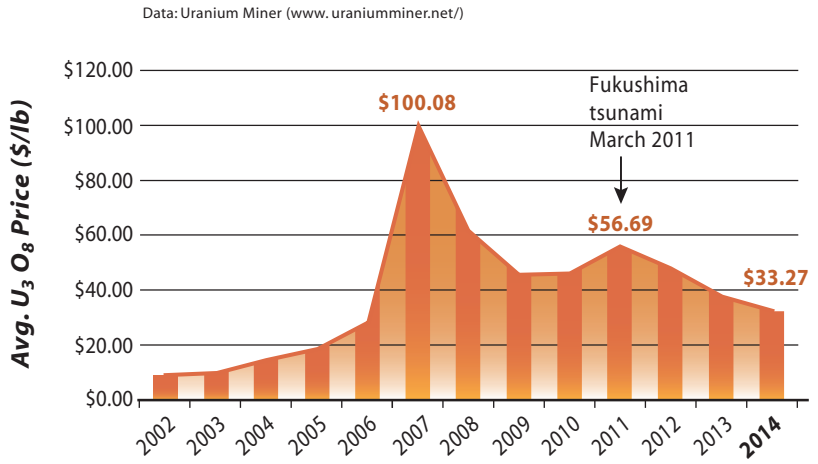


Figure 2-18. Average annual U_3O_8 price per pound, 2002–2014.

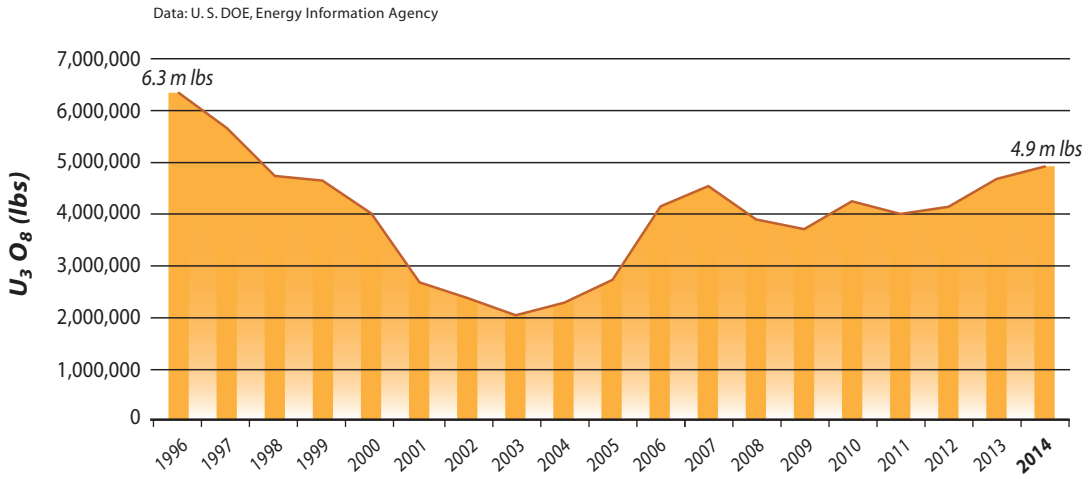


Figure 2-19. Annual production of uranium concentrate in U.S., 1996–2014.

Waste rock piles from inactive uranium mines in Dolores County. *Photo John Keller.*

URANIUM EXPLORATION AND DEVELOPMENT IN COLORADO

Very little uranium exploration or development activity was reported in Colorado in 2014. Even though a number of mines and a new mill are permitted, there was little activity reported at these facilities. However, there was extensive activity at the corporate level among companies that own uranium properties in Colorado.

In November 2014, Energy Fuels Inc. sold their licensed and permitted 500 tons-per-day Piñon Ridge Uranium Mill (San Miguel County) and associated uranium properties to private investor group Baobab Asset Management LLC. Later in November, Homeland Uranium acquired the Piñon Ridge Mill and properties, and changed their name to Western Uranium Corporation. Energy Fuels retained their Whirlwind Property located in Mesa County. This is an underground mine containing 169,000 tons of measured and indicated resources containing 1.1 million pounds of U_3O_8 and 3.3 million pounds of vanadium (V_2O_5). Inferred resources total 437,000 tons containing 2.0 million pounds of U_3O_8 and 8.0 million pounds of V_2O_5 (*www.energyfuels.com*).

On October 29, 2014 Azarga Resources completed a merger with Powertech Uranium Corp. and changed the name of the merged company to Azarga Uranium Corp. Among the new company's many assets, located primarily in South Dakota and Wyoming, is the Centennial uranium property in Weld County, Colorado. This property contains indicated resources of 9.3 million pounds of U_3O_8 and inferred resources of 2.0 million pounds of U_3O_8. Additional information on the Centennial uranium deposit is found on the Azarga website (*www.azargauranium.com*). Press releases indicate the property has not had any significant activity since 2010.

Black Range Minerals Ltd. owns the Hansen/Taylor Ranch uranium deposit located in the Tallahassee Creek mining district north of Cañon City in Fremont County. According to a March 31, 2012 company press release, this property contains indicated resources of 8.9 million pounds of U_3O_8 and inferred resources of 10.8 million pounds. The company envisions using a newly developed mining and concentration method called "underground borehole mining and ablation" *(http://www.blackrangeminerals.com/content/ablation-joint-venture/)*. Use of this proprietary ablation technology, developed by Ablation Technologies LLC, could potentially result in significant reduction of feedstock for a mill, and a reduction in chemical reagents for processing. Test work is ongoing. Western Uranium Corp. is proposing to take over Black Range Minerals in an all-share deal. The Black Range Minerals board has approved the proposed takeover offer as of early 2015.

Pacific Metals Corp. owns the Graysill Mine Project located in San Juan and Dolores Counties at an elevation of 11,000 ft (*http://www.pacificgoldcorp.com/*). The area received attention in 2013-2014 with the introduction of Senate Bill 841 (S.841); the *Hermosa Creek Watershed Protection Act of 2013*. This designates specified federal lands in the San Juan National Forest in Colorado as: (1) the Hermosa Creek Watershed and Protection Area, and (2) the Hermosa Creek Special Management Area. The Graysill project area abuts the northern boundary of the Hermosa Creek Watershed and Protection Area and has been specifically excluded from the Watershed Protection Act impacted lands boundary. The property includes the historic Graysill uranium mine which produced uranium and vanadium sporadically from the 1940s into the 1970s.

RENEWABLE ENERGY RESOURCES

In 2004, Colorado was the first state in the nation to establish a Renewable Portfolio Standard (RPS) by ballot initiative. The RPS was enacted to promote growth in the renewable energy industry. It requires utilities to generate or purchase specified percentages of their total electrical power capacity from renewable sources within a defined time frame. The RPS was revised by the Colorado legislature in 2007 and again in 2010 to further increase the standards for renewables. Currently, for municipal utilities and cooperatives, the RPS requirement is 10% renewables by 2020. For investor owned utilities, the requirement is 30% renewables by 2020. **Figure 3-1** shows the growth in renewable energy electrical generating capacity in Colorado since 2005.

In 2014, Colorado generated about 18% of its electricity from renewables which is up from 17% renewables in 2013 (EIA).

A critical factor to consider when comparing output and capital costs of the energy sources is their capacity or efficiency factors, because no power plant operates at 100% of its designed capacity continuously. The net capacity factor of a power plant is the ratio of its actual output over a period of time to its potential output if it were possible for it to operate at full nameplate capacity continuously. **Table 4** is derived from the National Renewable Energy Laboratory's (NREL) Transparent Cost Database. It shows a range of capacity factors for the various types of power plants based on studies conducted between 2007 and 2014.

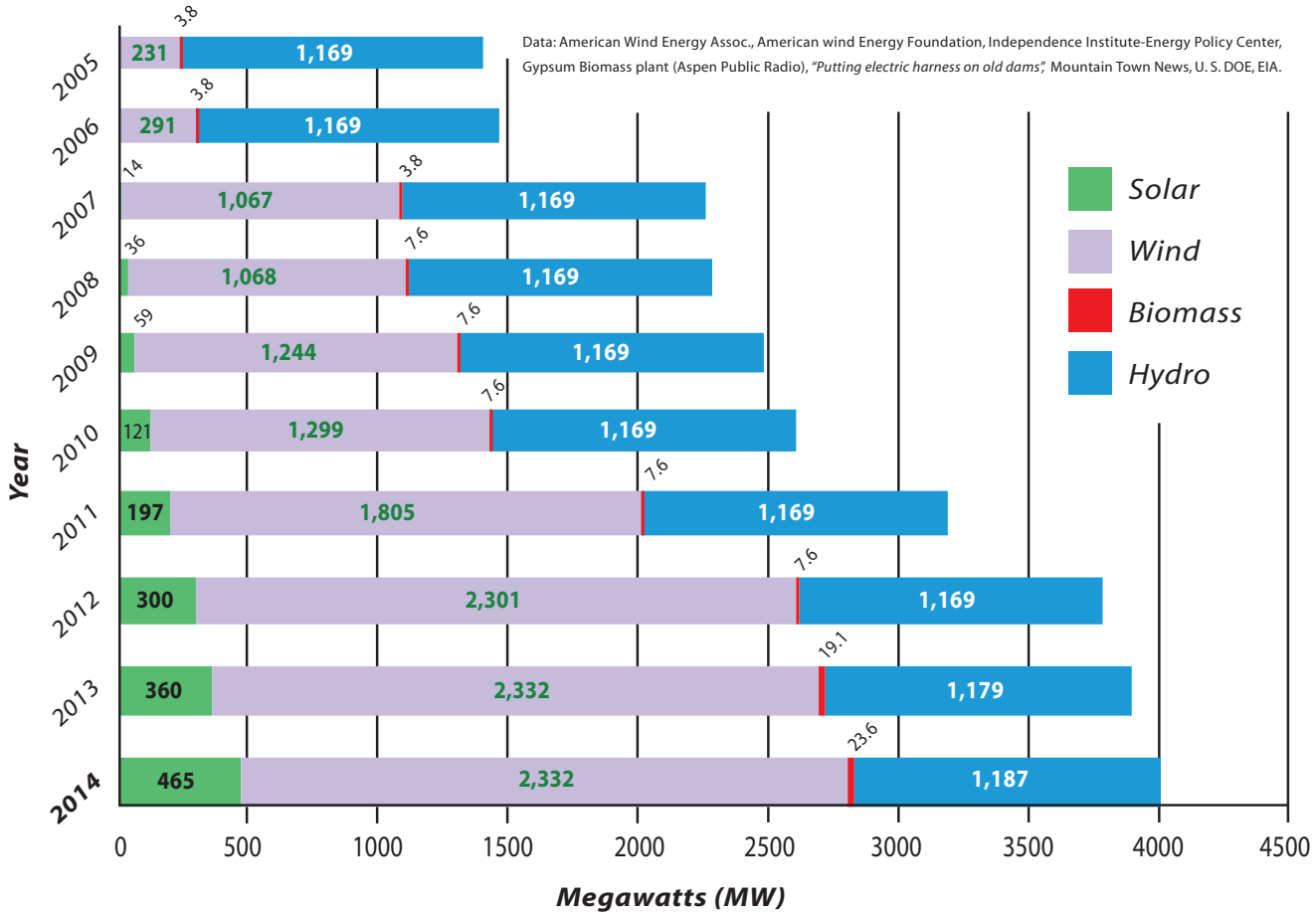


Figure 3-1. Colorado renewable electric generating capacity (megawatts), 2005–2014.

Photo Larry Scott

Table 4. Power plant capacity factors. Data: NREL

Plant Type	Minimum %	Median %	Maximum %
Natural Gas Combustion Turbines	10	**45**	92
Natural Gas Combined Cycle	40	**85**	93
Coal-Pulverized & Scrubbed	80	**84.6**	93
Nuclear	85	**90**	90.2
Biomass	75	**80**	85
Hydro	35	**50**	93.2
Geothermal-enhanced	80	**90**	95
Solar PV	11.4	**20.3**	30
Wind-onshore	27	**40**	54

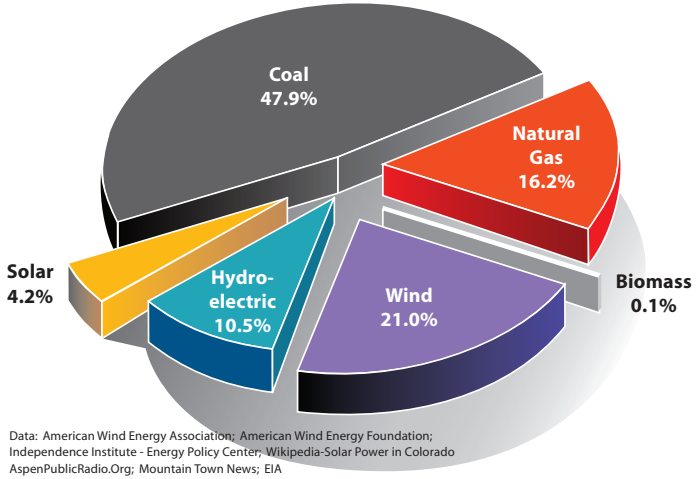


Figure 3-2. Electric power capacity in Colorado, 2014.

WIND

Wind is the largest renewable electrical power source currently in use in Colorado. By 2014, a total of 1,530 commercial wind turbines were installed in the state. These wind turbines, located mostly in the eastern part of the state, equates to an installed capacity of 2,332 MW. Wind now accounts for 21% of the total installed capacity of all electric power sources in Colorado (**Figure 3-2**). Figure 3-1 shows the ten-fold growth of wind power in Colorado from 230 MW in 2005 to 2,332 MW of installed capacity in 2014. Colorado wind farms generated 7.4 million megawatt hours (MWh) of electrical power in 2014 compared to 0.8 MWh in 2005 (**Figure 3-3**).

Approximately 19 wind energy manufacturing facilities are located in Colorado. The largest of these are owned by the Danish company, Vestas, which has manufacturing facilities located in Windsor, Brighton and Pueblo. According to the Denver Business Journal, Vestas was expected to have 2,800 employees in Colorado by the end of 2014, an increase of about 1,500 people compared to the end of 2013.

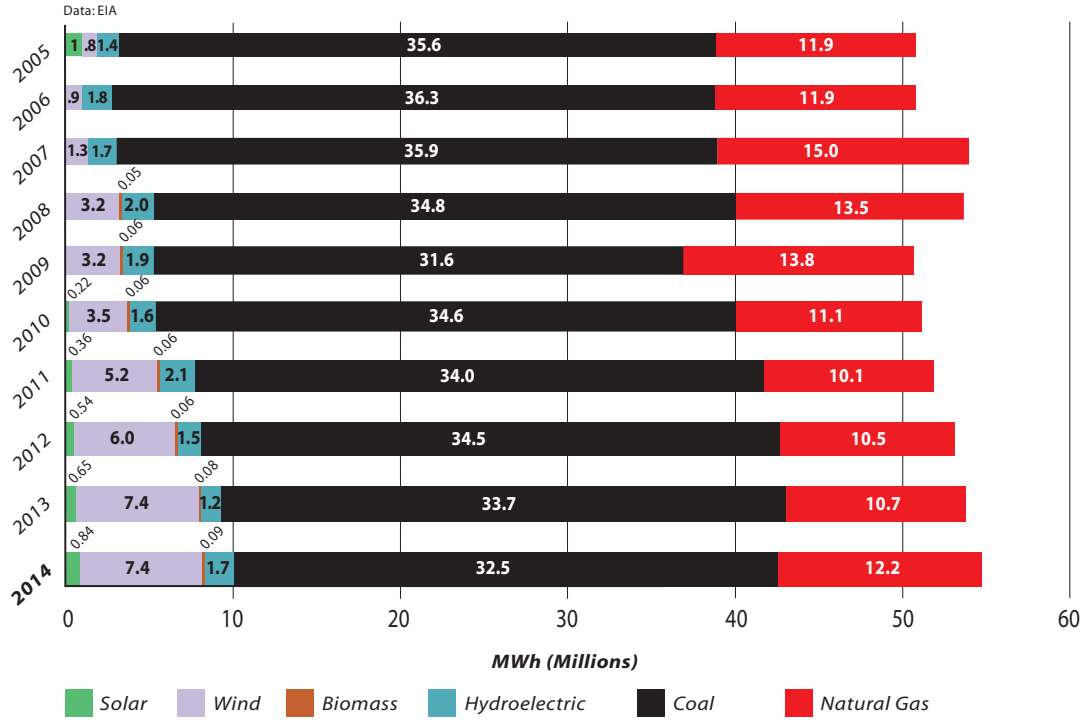


Figure 3-3.Electrical generation in millions of megawatt hours (MWh) in Colorado 2005-2014.

SOLAR PHOTOVOLTAIC

Commercial photovoltaic power stations and rooftop residential/industrial solar installations have grown dramatically in Colorado from less than 1 MW in 2005 to 465 MW of installed capacity in 2014 (Fig. 3-1). Solar constituted 4.2% of the installed electrical power capacity in Colorado in 2014 (Fig. 3-2).

In March of 2015, the Denver Post reported that 24,232 residential and industrial customers have installed 223 MW of rooftop solar PV since 2006. This is nearly half of the total of 465 MW of solar PV capacity installed in the state since 2006. As of 2014, there are 11 commercial solar power stations located across Colorado. The largest commercial solar project scheduled for construction in 2015 is the 156 MW Comanche Solar Project near Pueblo. This facility will be the largest solar energy plant east of the Rockies. SunEdison, Inc. acquired the project in 2014 and will manage construction, operation, and maintenance. The electricity will be sold to Xcel under a 25-year agreement.

According to an analysis by the Solar Foundation, Colorado ranked 11th in the nation for employment in the solar industry, with 4,200 workers as of November 2014, up from the 3,600 reported in 2013. Between favorable net metering laws for residential and industrial customers and a variety of financial incentives, grants, and loans available through the Clean Energy Fund, Colorado is one of the most active states in the nation for the development of solar power.

HYDROELECTRIC

Because of the rugged topography with many creeks and rivers in the western part of the state, Colorado has a long history of harnessing hydroelectric power. In 1891, the Ames Power Station in San Miguel County supplied the power for the world's first alternating current generating station. In 2014, a total of 38 dams and associated hydroelectric power plants were located along streams and rivers with headwaters in mountainous terrain. These facilities have a combined nameplate capacity of 1,187 MW, or 10.5% of the state's total electric power capacity (figs. 3-1 and 3-2). However, they have a low capacity factor in Colorado, and thus provided only 1.7 million MWh (3.1%) of the actual electricity generated (fig. 3-3). To meet the existing RPS, a new hydroelectric facility must have a rated capacity under 30 MW. As of March 2015, three construction projects were underway, including Lake Granby (1.2 MW), Pueblo Reservoir (7 MW) and South Canal Drop east of Montrose (1 MW). These new facilities will add an additional 9.2 MW to the current 1187 MW hydroelectric capacity.

The Shoshone dam still diverts water into a tunnel for use at the downstream Shoshone generating station (15.0 MW capacity) using the drop in elevation in Glenwood Canyon as the power source. *Photo Larry Scott.*

BIOMASS

Biomass is any organic matter that can be readily converted to a fuel for use as an energy source. In 2013, the state's first fully biomass-fueled power plant was commissioned near Gypsum in Eagle County. The $56 million plant, rated at 11.5 MW, relies mainly on beetle-killed trees from within a 75-mile radius of the plant that are hauled to the facility, chipped, and used as fuel. Wood waste from the local landfill is also used. On January 1, 2014, the Colorado Springs Drake power plant launched a 1-year pilot program of mixing wood waste matter (e.g. wood chips and sawdust) with coal for the power plant fuel. The Colorado Springs Gazette reported that the plant would burn about 60 tons of wood per day, generating about 4.5 MW of electricity, or 2% of the plant's total. The total installed biomass capacity for the state is 23.6 MW, which is about 0.1% of the total installed electric power capacity for Colorado (Fig. 3-1).

GEOTHERMAL

Currently, there are no operating geothermal power plants in Colorado. A collaborative effort is being made in the Pagosa Springs area to study the potential for developing such a facility. Governor Hickenlooper signed a

Natural source at Pagosa Springs resort, Archuleta County. *Photo Larry Scott.*

geothermal bond bill in May 2014 providing $1.98 million in state funding, matching the U.S. Department of Energy's investment in geothermal energy exploration at the Pagosa Verde project. The project leverages a $3.8 million award from the DOE for evaluating the geothermal resource potential at Pagosa Springs. Pagosa Verde LLC is a private local alternative energy company which is leading the project. Six new thermal-gradient exploratory test wells were approved and drilling was initiated in November 2014.

Geothermal energy is currently being used in Colorado in two ways: geoexchange/geothermal heat pumps, and direct use. Geoexchange/geothermal heat pumps rely on a constant earth temperature of around 55 degrees F at shallow depths for space and water heating. These systems can be implemented almost anywhere by residential and commercial facilities, and do not require unusually warm groundwater. This application is growing rapidly in Colorado. Direct use applications rely on low to moderate temperature geothermally heated water (>100 degrees F) for heating. Warm water is circulated in pipes to heat buildings and green houses, while for spas and aquaculture warm/hot water is used directly.

Nonfuel mineral production includes metals, industrial minerals, and construction materials including aggregate and cement. The USGS estimates that the total value of all nonfuel minerals produced in Colorado in 2014 was $2.32 billion; 10% higher than the 2013 value of $2.11 billion, and more than triple the 2004 value of $762 million. Nationally, Colorado ranked 12th in the value of nonfuel mineral production. **Figure 4-1** shows the growth of nonfuel mineral production value in Colorado since 1994. The rapid increase in value from 2003 and 2008 was mainly due to sharply rising prices for both molybdenum and gold.

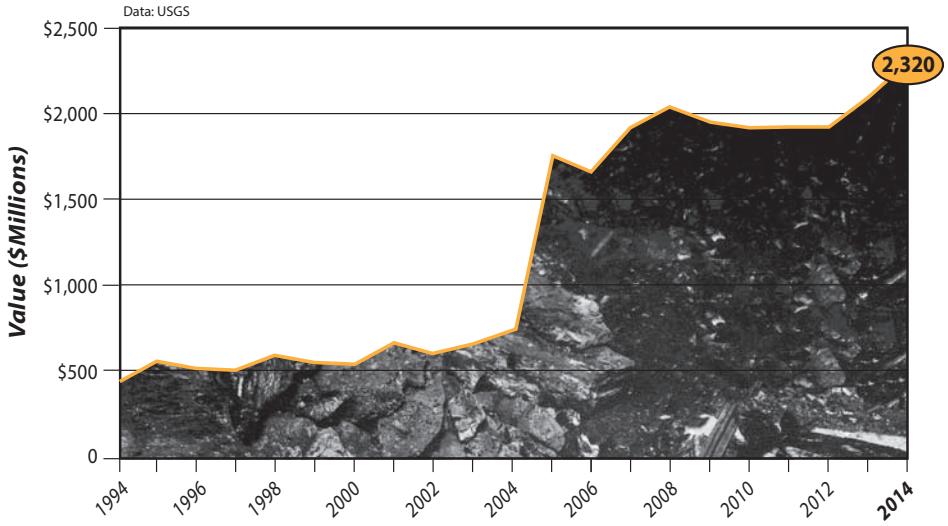


Figure 4-1. Total nonfuel mineral production value in Colorado, 1994–2014.

METAL MINING

Molybdenum, gold, and silver are currently mined in Colorado. CGS estimates that the 2014 production value of these metals was $893 million. This is about 7% over the 2013 production value of $835 million. Increased molybdenum production at the Climax and Henderson mines, owned by Freeport-McMoran (Freeport), combined with a small molybdenum price increase, accounted for the gain in value. Gold and silver production values declined during this period due to both lower production and lower prices.

MOLYBDENUM PRODUCTION

Molybdenum is used primarily as an alloy in high-strength and high-temperature steels. Freeport's Climax molybdenum mine is located 13 miles northeast of Leadville at the top of Fremont Pass. Freeport restarted open pit commercial operations at Climax in 2012 after the mine had been shut down for 17 years. The mine site includes a 25,000 metric ton per day mill facility. Freeport also operates the Henderson underground mine located 42 miles west of Denver near the town of Empire. The mine has been in operation since 1976 and consists of a large block-cave mining operation. Ore from the mine, which is on the east side of the Continental Divide, is transported on a 15-mile conveyer system through a tunnel to a 32,000 metric ton per day mill on the west side of the Continental Divide. Most of the concentrate from the Climax and Henderson mills is sent to a refining facility in Fort Madison, Iowa. The combined Climax/Henderson molybdenum oxide (MoO_3) production totaled 51 million pounds in 2014, an increase of about 4% over the 2013 production of 49 million pounds. Colorado's molybdenum production and the average annual MoO_3 price from 1995 to 2014 is shown in **Figure 4-2**. Colorado is the top molybdenum producer in the U.S. (**Figure 4-3**), and the U.S. is the second largest producer in the world, behind China.

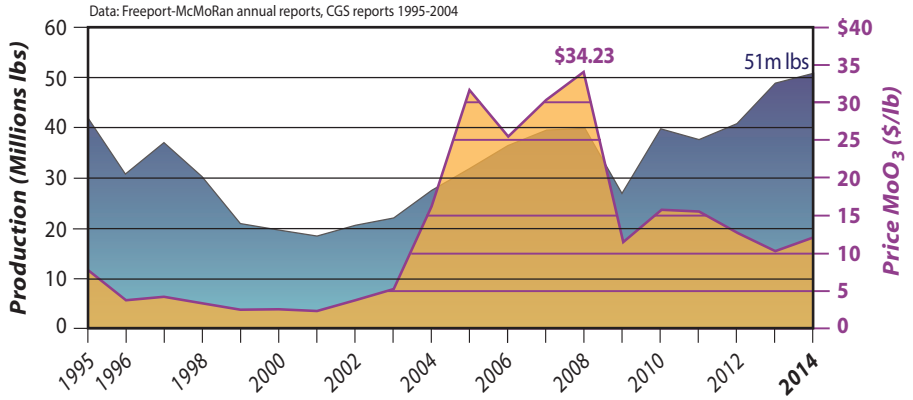


Figure 4-2. Colorado molybdenum production and average annual price per pound, 1995–2014.

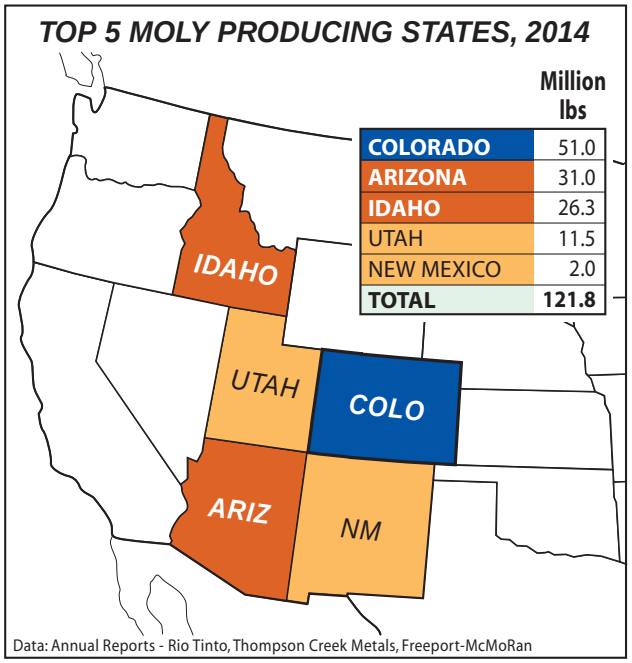


Figure 4-3. Top five molybdenum producing states, 2014.

GOLD AND SILVER PRODUCTION

The Cripple Creek and Victor Gold Mining Company (CC&V), a wholly-owned subsidiary of the South Africa-based gold mining company AngloGold Ashanti, operated the only major producing gold mine in Colorado in 2014. The open pit gold mine, located in Victor southwest of Colorado Springs produced 200,000 ounces of gold and 110,373 ounces of silver in 2014. Gold production decreased by about 13% compared to the 2013 total of 230,373 ounces. Lower gold prices in 2014 combined with lower gold and silver production contributed to a production value decrease of about 18%, from $328.1 million in 2013 to an estimated $269.3 million in 2014. The company is planning a major expansion over the next several years, and will shift a portion of the mine to a new underground operation. **Figure 4-4** shows the annual average price of gold and Colorado gold production from 1990 to 2014. **Figure 4-5** shows the price of silver and Colorado silver production from 2005 to 2014. Colorado is ranked fourth among the gold producing states in the nation (**Figure 4-6**), lagging far behind number one, Nevada. In June 2015, Colorado-based Newmont Mining Corp. announced it had agreed to purchase the Cripple Creek & Victor mine for $820 million cash and a 2.5% royalty from any gold produced from the planned new underground operation.

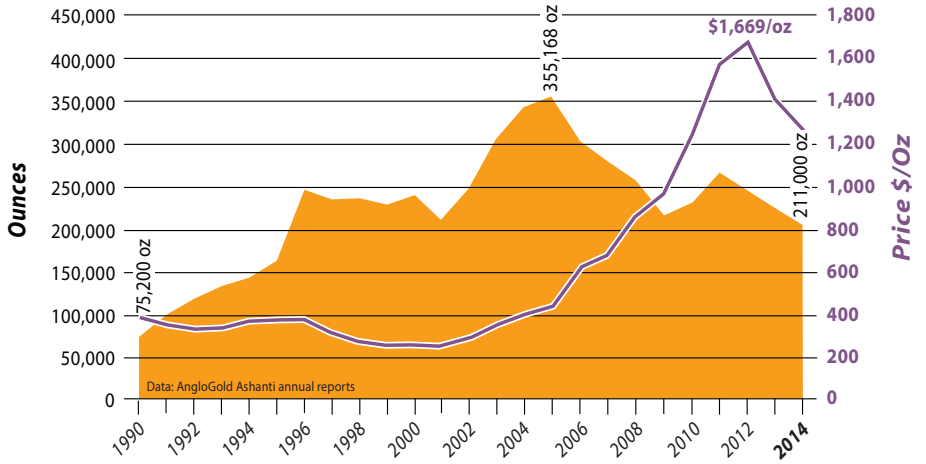
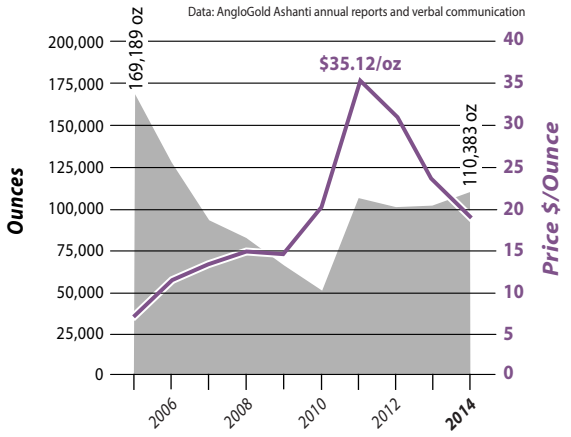
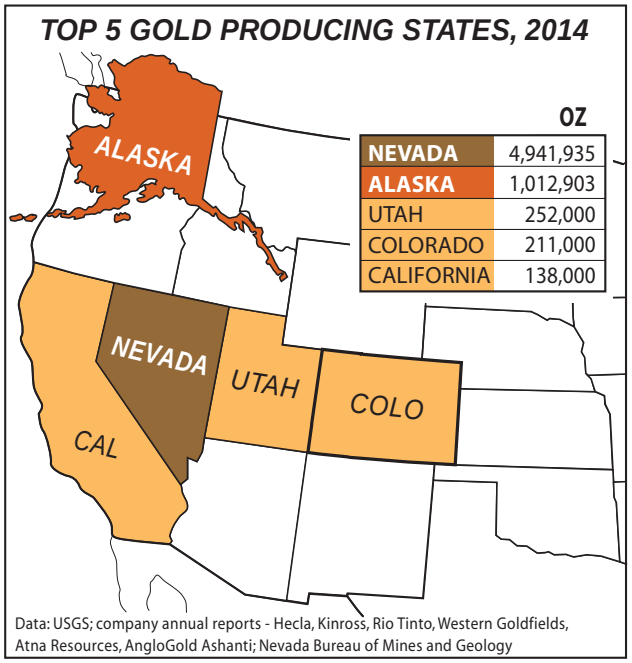


Figure 4-4. Colorado gold production and average annual price per ounce, 1990–2014.

The Revenue Mine is located in Ouray County near the town of Ouray. The mine, now owned by Fortune Minerals Ltd., initiated production at the end of 2014. It made its first shipments of concentrate to a smelter in Canada and is ramping up production to a rate of 400 tons of ore per day. The mine produces primarily silver (mine plan average grade of 14.6 ounce per ton (oz/ton), with byproduct credits of gold (0.02 oz/ton), lead (2.26%) and zinc (0.90%). The mine has measured and indicated resources of 16.3 million ounces of silver.

Figure 4-5. Colorado silver production and average annual price per ounce, 2005–2014.





	OZ
NEVADA	4,941,935
ALASKA	1,012,903
UTAH	252,000
COLORADO	211,000
CALIFORNIA	138,000

Figure 4-6. Top five gold producing states, 2014.

A small amount of placer gold is reportedly recovered from some sand and gravel aggregate operations along some Colorado rivers and streams including the South Platte, Arkansas and Colorado Rivers, as well as Clear Creek. Additionally, a few small lode gold mines operated by private individuals or small groups likely produce, but do not report, small tonnages of high-grade gold and silver ore. There are currently 39 active gold mining permits in the Colorado Division of Reclamation, Mining, and Safety (DRMS) database.

METAL EXPLORATION AND DEVELOPMENT ACTIVITIES

The precious metal exploration industry worldwide has been hurt by falling metals prices since 2012. This downward price trajectory has made it difficult for most companies to raise financing for exploration. The periodical Mining Engineering reported in their May 2015 issue that worldwide, budgets for nonferrous mineral exploration declined 26% in 2014 compared to 2013. Budgeted early-stage exploration declined 32%, reflecting an ongoing trend since 2004 away from early-stage projects to a focus on exploration in and near existing mines. 2012 was a peak year for global metals exploration budgets.

A few of the exploration and development projects in Colorado that have undergone at least some activity in past several years include:

Golden Wonder Gold Mine: The Golden Wonder is a narrow vein, high-grade underground gold mine located near Lake City in Hinsdale County. This previous gold producer is owned by LKA Gold Inc., which has conducted underground exploration drilling, drifting, surface mapping, geophysical surveys, and surface drilling. The development program is self-funding by sales of gold derived from high-grade vein material encountered during exploration.

Dawson Gold Project: This project is owned by Zephyr Minerals and is located about 5 miles southwest of the town of Cañon City, in Fremont County. The Dawson Property hosts a Precambrian-aged, stratabound copper-gold deposit with an estimated resource of 150,800 ounces of gold contained in 392,000 metric tons grading 11.97 grams/tonne of gold.

San Juan Silver Project: Hecla Mining Company's wholly-owned subsidiary, Rio Grande Silver, completed a 2,660 foot decline in 2012 to re-access the underground workings of the historic Bulldog silver mine located in the Creede mining district in Mineral County. In 2014, Rio Grande Silver amended their Plan of Operations to allow surface exploration drilling. Several years of underground drilling resulted in the development of an indicated resource of 7,619,600 ounces of silver, and inferred resources of 33,096,400 ounces.

Mount Emmons Molybdenum (AKA Lucky Jack Mine) Project: U.S. Energy Corp. has controlled the Mount Emmons molybdenum deposit for many years. The project, located near Crested Butte in Gunnison County, contains a historical resource of 220 million tons of 0.366% MoS_2, and is currently on "care and maintenance" status. The mine proposal has met strong resistance from environmental groups over the years since it was first discovered in the 1970s. In 2013, the U.S. Forest Service reviewed U.S. Energy's Mine Plan of Operations (MPO) and determined that it contained sufficient information to begin scoping and analysis under the National Environmental Policy Act (NEPA). No activity was reported for 2014.

Rare Earth Minerals Projects: U.S. Rare Earth Inc. has mining claims covering two rare earth mineral occurrences in Colorado: the Wet Mountain deposits located in Custer and Fremont Counties and the Iron Hill Carbonatite Complex located in Gunnison County. Both of these locations were discussed in a 2010 USGS Scientific Investigations Report 2010-5220 titled "The Principal Rare Earth Elements Deposits of the United States-A Summary of Domestic Deposits and a Global Perspective." U.S. Rare Earths Inc. did not indicate on their website that any exploration or development activities were conducted on these properties in 2014.

Klondike Tellurium-Gold Property: The Klondike tellurium-gold property is located in Saguache County, south of the old mining town of Bonanza. The Klondike mine produced gold ore in the early 1900s from silicified breccias in

volcanic rocks. Surface sampling by First Solar, Inc. in 2006 found very high tellurium grades of up to 3.3% (33,000 ppm), along with locally high gold grades. Tellurium occurs principally as the native element and as altaite, a lead-telluride mineral. First Solar is the world's largest manufacturer of thin-film solar modules and tellurium is a critical element in the photovoltaic material. Tellurium grades at Klondike were the highest encountered in the company's nationwide exploration program. First Solar acquired the land in 2010 and began systematic exploration including geophysical investgations. However, the company discontinued their tellurium development program in early 2012, and sold the property to Colorado Klondike LLC.

Vanadium Projects: Vanadium in Colorado is mostly associated with the sandstone-hosted uranium deposits located in western Colorado on the Colorado Plateau. Because of low uranium and vanadium prices, there are no mines currently in production. The last vanadium production reported was in 2005. If any of the Colorado Plateau uranium mines re-open in the future, then by-product vanadium production would also likely begin again.

Cresson pit at Cripple Creek & Victor gold mine, Teller County. *Photo John Keller archive.*

CONSTRUCTION SAND, GRAVEL, and CRUSHED STONE AGGREGATE

The primary uses of sand, gravel and crushed stone are concrete aggregate, road base, coverings (paver base, walkways, bedding etc.), construction fill, and asphaltic concrete aggregate. There are well over 1000 active permits for aggregate pits and quarries in Colorado according to a public database provided by the DRMS. Most of these permits are for alluvial sand and gravel pits, but there are also a large number of crushed stone aggregate quarries. These mining operations vary widely in size from small, local "mom and pop" operations on three acres, to large commercial quarries over 500 acres in size. The aggregate industry experienced strong growth in 2014 due to increasing construction activity.

The USGS estimates that Colorado produced an estimated 51.7 million tons of aggregate (combined sand-and-gravel and crushed stone) in 2014, a 13% increase over the 2013 total of 42.8 million tons. Sand and gravel production rose 18% to 40.0 million tons, from 33.8 million tons in 2013. According to the USGS, in 2014 the average price for sand and gravel in Colorado was $8.00 per ton, a slight increase over the 2013 price of $7.78. Crushed stone production is estimated by the USGS to have increased to 11.7 million tons in 2014, a 30% increase over the estimated 2013 production of 9.0 million tons. **Figure 4-7** shows the combined production of both sand-and-gravel and crushed stone aggregate in Colorado from 1994 to 2014. The USGS estimated average price for crushed stone in Colorado was $8.52 per ton in 2014, slightly higher than the 2013 price of $8.27 per ton. **Figures 4-8 and 4-9** show Colorado production and average annual prices for sand and gravel aggregate and crushed stone aggregate. The combined Colorado production value of sand-and-gravel and crushed stone aggregate in 2014 is estimated to be $419.7 million, 24% higher than the 2013 value of $337.5 million.

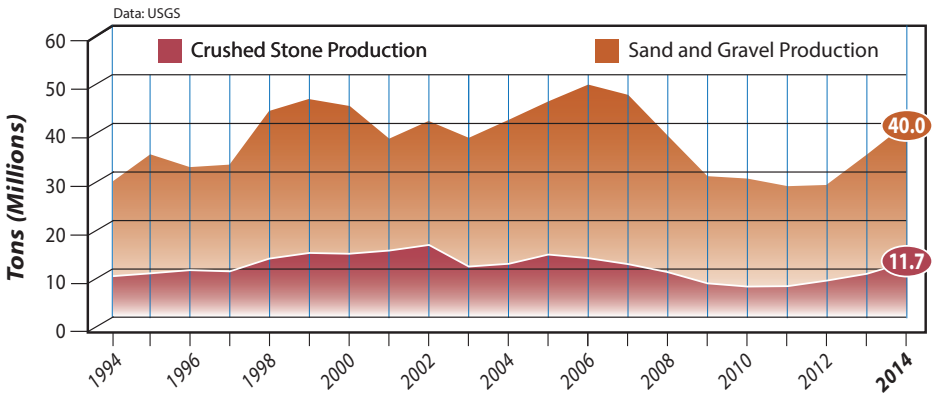


Figure 4-7. Aggregate production in Colorado, 1994–2014.

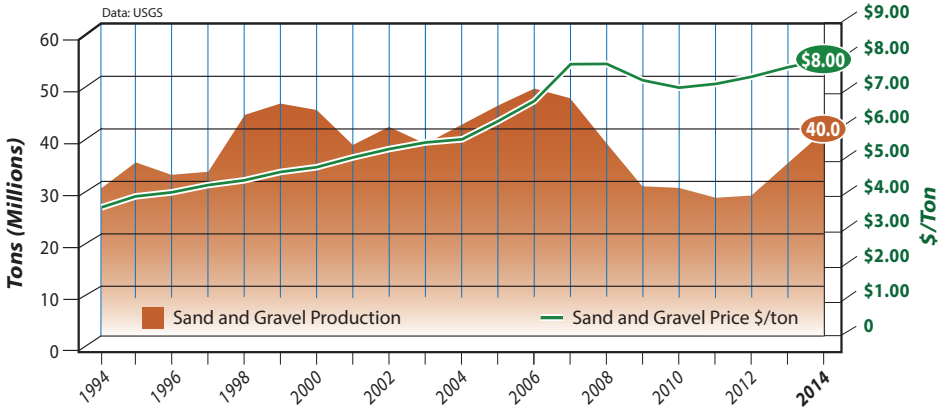


Figure 4-8. Price and production of sand and gravel aggregate in Colorado, 1994–2014.

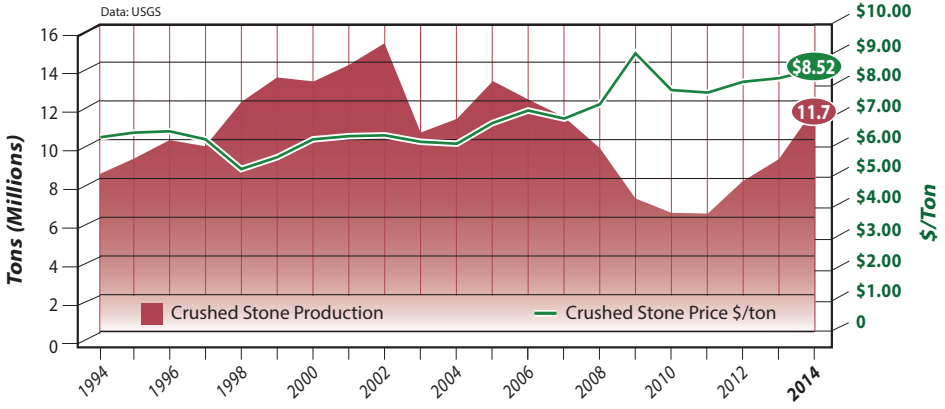


Figure 4-9. Price and production of crushed stone aggregate in Colorado, 1994–2014.

With the resurgence of the Colorado's economy and housing market in recent years, there has been a significant increase in new residential and commercial construction. Colorado currently enjoys the 5th fastest growing economy in the U.S., as reported by CNN. With the rise in construction

High view of Holcim (US) Inc's limestone and shale surface mine, Fremont County. *Photo John Keller archive.*

activity, aggregate production is by necessity expanding. Construction has been particularly strong in the Denver, Boulder, and Fort Collins metro areas. According to the *Colorado Business Review* from the LEEDS School of Business at CU-Boulder, construction activity in the state is expected to increase by 11.5% in 2015.

CEMENT

Cement in Colorado is primarily used in residential and commercial construction projects. Three portland cement plants are currently operating in the state: the Holcim (US) Inc. plant in Florence, the GCC Rio Grande Inc. plant in Pueblo, and the CEMEX plant near Lyons. Both CEMEX and GCC Rio Grande Inc. are Mexican based multinational companies, and Holcim is a Swiss based company. Both CEMEX and Rio Grande sell primarily to Colorado markets, while Holcim sells both in Colorado and in surrounding states. CGS estimates that cement production in Colorado was 2.7 million tons in 2014, up about 13% from the 2012 production reported by the PCA. The average cement price per ton for 2014 was $98.50 per ton, a 3.7% increase over the 2013 price of $95.00 (**Figure 4-10**).

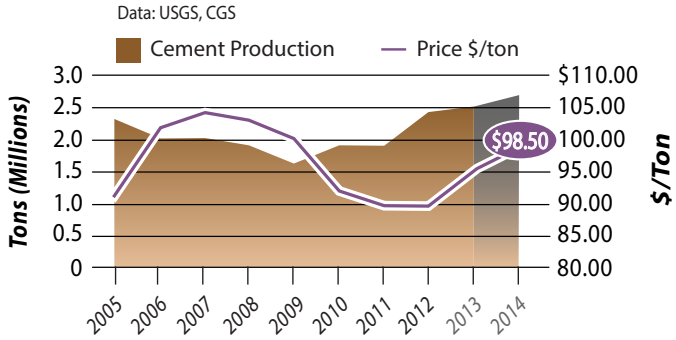


Figure 4-10. Price and production of cement in Colorado, 2005–2014.

CLAY AND SHALE

Common clay is mined primarily in eastern Colorado along the Front Range and used mostly to make bricks and tiles. Common clay (or shale) is also an ingredient in the manufacture of cement and lightweight aggregate. There are three brick manufacturers in Colorado: Acme Brick Co., Robinson Brick Co., and Summit Brick and Tile Co. As with other construction materials, clay production has increased substantially since the recession of 2007-2009. Common clay production in Colorado in 2013 was estimated by the USGS to be 228,000 tons, compared to the low of 61,000 tons in 2009. The USGS has not published production data for Colorado for 2014 as of this writing. **Figure 4-11** shows common clay production and pricing for the years 2005-2013.

The Pierre Shale is mined in northern Jefferson County and used to make lightweight aggregate primarily for cinder blocks. Trinity Expanded Shale and Clay Company operate this mine and associated production plant. The shale is first crushed to specified size ranges, and then heated to over 2000°C in a rotary kiln, causing the shale to expand greatly in volume while retaining strength. Production information is proprietary and was not provided to CGS for this report. Shale is also used as a cement additive and mined by the cement companies near their locations in Lyons, Pueblo, and Florence.

A small amount of bentonite clay is mined in Colorado, typically < 10,000 tons per year, although specific production information is withheld by the USGS. One bentonite mine has an active permit from the DRMS. Rio Grande Bentonite intermittently operates a small mine in Conejos County. Bentonite is often used as an absorbent (such as in cat litter or to clean up hazardous liquid spills) and as a containment barrier (such as in clay liners for landfills).

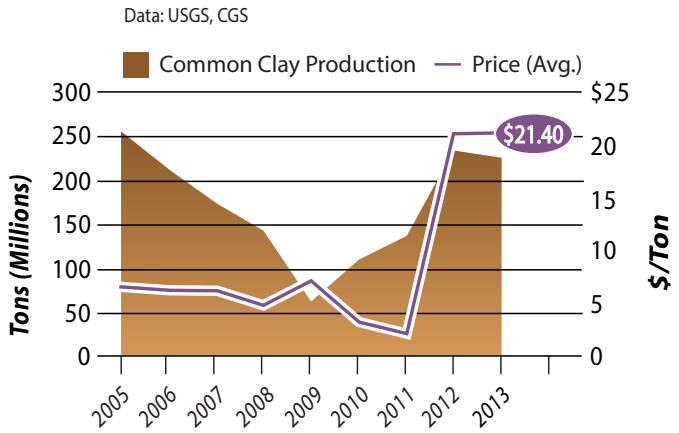


Figure 4-11. Production and average price of common clay in Colorado, 2005–2013.

High quality refractory clays have been produced historically from the Dakota and Dawson Formations. Refractory clay is used in the manufacture of refractory ware such as crucibles and high temperature firebricks for kilns. Current market conditions have not warranted recent mining of these deposits.

GYPSUM

Gypsum mined in Colorado is used for wallboard production, as an ingredient in cement production, and as a soil conditioner. American Gypsum Inc. operates a large gypsum quarry and wallboard (drywall) manufacturing plant in Eagle County, near the town of Gypsum. American Gypsum Inc. does not publicly release annual gypsum production figures. Nationally, wallboard products purchased have increased slightly from 21.8 million square feet in 2013 to 22.0 million square feet in 2014. With the resurgence of the housing market and associated new home construction in Colorado, the wallboard market will likely remain robust.

Gypsum is mined in smaller quantities in Fremont County for cement manufacturing and for use as a soil conditioner. Cement manufacturer Holcim operates the Coaldale gypsum quarry southeast of Salida, and GCC Rio Grande runs the Salt Canyon Project north of Florence. U.S. Soil Conditioning Co. operates the small Maverick Placer gypsum mine, also in Fremont County east of Salida.

Old clay pits are easily seen from I-70 approaching Morrison exit, Jefferson County. *Photo CGS archive.*

SODIUM BICARBONATE (NAHCOLITE)

Sodium bicarbonate (also known as baking soda) is used primarily in food and baking, personal care products, pharmaceuticals, animal nutrition, agriculture, water treatment, air quality, and other industrial applications. Colorado is home to the only mine in the world that produces sodium bicarbonate from its naturally-occurring form; the mineral nahcolite. Located in Rio Blanco County, the solution mine is operated by Natural Soda, Inc. High-grade nahcolite (>80 percent) is recovered from the "Boise bed" of the Green River Formation. Hot water is pumped down approximately 1,900 feet to dissolve the nahcolite. Other wells return the mineral-saturated water to the surface where the sodium bicarbonate is recovered by cooling the water. Natural Soda completed an expansion project in 2013 to double the mine's production capacity to 250,000 tons per year. Production in 2014 totaled 182,787 tons, a 33% increase over the 2013 total of 137,940 tons. **Figure 4-12** shows annual production at the facility for 2005-2014. Another sodium bicarbonate solution mine in Rio Blanco County, American Soda, has not been in production since 2004.

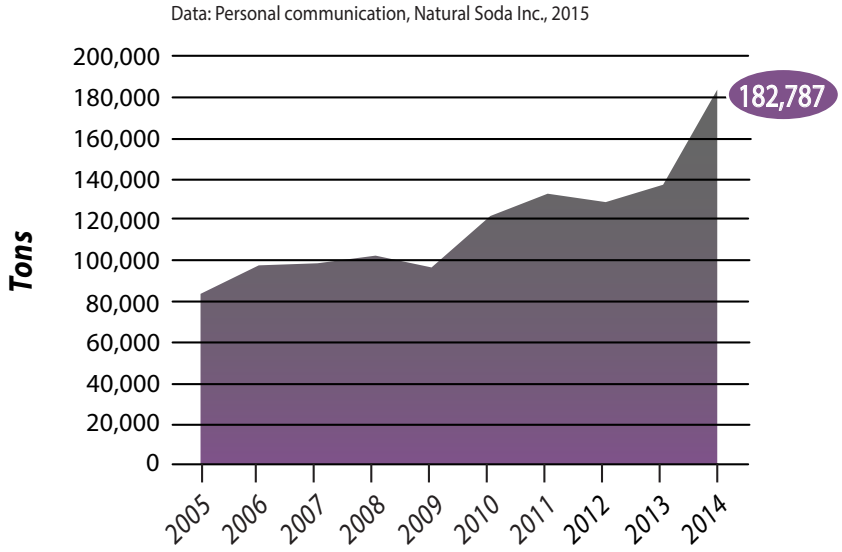


Figure 4-12. Sodium bicarbonate (nahcolite) production in Colorado, 2005–2014.

SILICA

Sandstone is mined by Holcim for use as a silica additive in their cement manufacturing plant in Florence. The sandstone is mined from the same area as the limestone and shale used to make the cement. Cemex also mines sandstone in Boulder County and it is also used as a silica additive in cement production.

Well-rounded quartz sand, from eolian deposits in the Colorado Springs area, was mined in past years for silica sand. Most of this sand was used for filtration and water well packing purposes. The region has potential for additional silica sand resources. The average price nationally for silica sand reported by the USGS for 2014 was $56.00 per ton. Depending on the application and other factors, prices are highly variable. Demand for proppant sand, which is used in the hydraulic fracturing process to hold open rock fractures and facilitate the flow of oil and gas to wells, has skyrocketed in recent years. Most proppant sand is currently mined in the Midwest and South. In 2015, the CGS will initiate a field evaluation of sandstone formations and surficial sand deposits throughout the state for their potential suitability as proppant sand.

LIMESTONE, CALCIUM CARBONATE, and LIME

Limestone is mined by CEMEX, GCC Rio Grande, and Holcim (US) Inc. for making cement. Deposits are located near their facilities in Lyons, Pueblo, and Florence, respectively. Pete Lien & Sons mines high-purity limestone from deposits located in northern Colorado and southern Wyoming and grinds the rock into a fine powder (ground calcium carbonate) at their Laporte facility in Larimer County. This material is used for a variety of purposes such as filler for roofing shingles; fire suppression in underground coal mines; as an additive for animal feed; manufacture of pharmaceuticals, fertilizer, and filler; and as an additive in glass manufacturing. Colorado Lime Co. operates the Monarch Quarry on the east side of Monarch Pass west of Salida. Facilities in Delta and Salida process the high-purity limestone and produce ground calcium carbonate ("rock dust") and screened limestone products for use mainly in coal mining and agriculture. Limestone and dolomite are also mined locally for crushed rock aggregate.

Lime is made by calcining high-purity limestone to form calcium oxide, commonly called quicklime. When water is mixed with lime, it forms hydrated or slaked lime. Pete Lien & Sons produces hydrated lime at their Laporte plant. The hydrated lime is used primarily in water and wastewater treatment, asphalt concrete treatment for anti-strip purposes, soil amendment processing, and other environmental applications. Western Sugar Cooperative Inc.'s Fort Morgan plant operates a lime kiln which supplies the quick lime (converted to milk of lime with the addition of sweeteners) and carbon dioxide off-gas for the sugar purification system. According to data provided by the USGS, lime sold for an average of $116 per ton nationally in 2014, down 1.5% from the average price of $117.8 in 2013.

DIMENSION STONE and DECORATIVE STONE

Dimension stone is any visually appealing rock that is quarried, cut, or shaped into useful forms. In Colorado, sandstone, granite, marble, rhyolite, and alabaster (a form of gypsum) are quarried for use as dimension stone. Dimension stone is used to construct buildings, wall cladding, monuments, floor tiles, walkways (flagstone), landscaping features, and sculptures.

Decorative stone is any type of rock that is used in its natural form for aesthetic purposes. It includes "river rock" (rounded cobbles), and "moss rock", which is natural uncut boulders or cobbles with a thin veneer of colorful lichen ("moss") in visually appealing patterns. In Colorado, various types of rock are locally sourced for decorative use. **Figure 4-13** shows Colorado dimension stone production for the period from 2005-2013 based on USGS data.

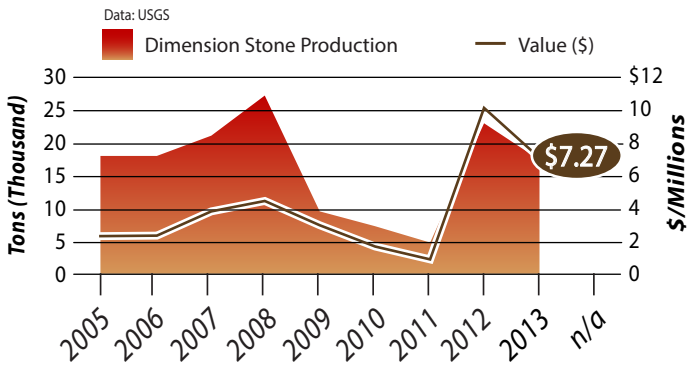


Figure 4-13. Production and product value of dimension stone in Colorado, 2005–2013.

Data were not available for 2014 as of this writing. Average annual prices and production are highly variable from year to year. Colorado has many dimension stone and decorative stone producers. A cross-section of these companies along with a listing of their more significant products are summarized below:

Colorado Rose Red - Granite dimension stone used for monuments, head stones, landscape boulders, pavers, veneers (cladding), and signs

Colorado Alabaster Supply - Alabaster for sculpting

Colorado Stone Quarries - Yule Marble dimension stone for building cladding, funerary stone

Arkins Park Stone - Sandstone dimension stone for building and home cladding

Siloam Stone - Sandstone for building and home cladding, decorative moss rock and field stone

Stone Wholesale - Sandstone for building and home cladding, decorative moss rock

Monarch Stone Co. - Dimension stone for building, flagstone, decorative moss rock, and river rock

Colorado Rose Sandstone - Sandstone for building cladding and walkways

Schmidt Stone Quarry - Rhyolite mainly used for building cladding

Colorado Flagstone - Quartzite (hard sandstone) for building stone, cladding, and flagstone applications

PEAT

Peat is a brown, soil-like material characteristic of boggy, acidic ground, consisting of partly decomposed vegetable matter. It is widely mined, cut, and dried for use in gardening and as a fuel. The less decayed material called sphagnum moss is the highest quality peat. Hypnum moss, reed sedge, and humus are of decreasing quality because of increased decay. Colorado is a very minor producer of peat, and most deposits occurr at high elevations in wetlands areas (or areas that were formerly wetlands during wetter climates) near river or creek valleys. There are three active peat mining permits for operations located in Teller, Alamosa, and Park counties. The USGS reported an average price for peat nationally of $25 per ton in 2014. Consumption in the U.S. totaled 1.4 million tons in 2014. Minnesota and Florida are the leading producing states.

GEM AND SPECIMEN MINERALS

Because of its diverse geological environments, Colorado is home to a variety of gem and specimen minerals. These include diamonds derived from kimberlite pipes in the Stateline district of Larimer County, aquamarine found in granite on Mount Antero in Chaffee County, amazonite in several areas within the Pikes Peak granitic batholith west of Colorado Springs, and rhodochrosite (Colorado's State Mineral) which is found in several places, but most notably at the Sweet Home mine near Fairplay in Park County.

The "Prospectors" television show highlights the ongoing mining activity for aquamarine on Mount Antero and amazonite/smoky quartz near Lake George. Other interesting gems and mineral specimens found in Colorado include turquoise mined near Cripple Creek in Teller County and a few other areas, and peridot in the Badger Creek area of Park and Fremont counties. Most of the gem and specimen minerals are not consistently mined, nor are production and value consistently reported by the small operators. The Kelsey Lake diamond mine in northern Larimer County, which was a larger commercial-scale operation, has been idle since 2002.

INDUSTRIAL GASES (NON-ENERGY)

CARBON DIOXIDE

Naturally occurring carbon dioxide gas (CO_2) is produced from the following areas in Colorado: McElmo Dome, Montezuma County; Sheep Mountain Field, Huerfano County; McCallum Field, Jackson County. CO_2 is produced from wells in a similar way to natural gas production. The carbon dioxide is primarily used in enhanced oil recovery (EOR). EOR is the implementation of various techniques for increasing the amount of crude oil that can be extracted from an oil field. Enhanced oil recovery is also called improved oil recovery or tertiary recovery (as opposed to primary and secondary recovery). In this process, CO_2 is injected into oil reservoirs to stimulate greater recovery. Other uses for the CO_2 extracted from the Colorado fields include welding gases, the manufacture of dry ice, and in the food and beverage industry. In 2014, Colorado produced and sold 355 billion cubic feet (Bcf) of CO_2 at an estimated average price of $2.08 (per Mcf) for an estimated value of $738 million. **Figure 4-14** shows Colorado's CO_2 production for the period between 2005 and 2014.

HELIUM

Grade-A helium is produced by DCP Midstream LLC at the Ladder Creek gas plant facility located in Cheyenne Wells in southeastern Colorado. According to records on file with the COGCC, the facility produced only a minimal amount of helium in 2014. A new helium-producing facility is being constructed by Air Products Corp. next to the Doe Canyon CO_2 gas extraction plant operated by Kinder Morgan in Dolores County, southwestern Colorado. The helium plant will extract approximately 230 MMcf per year of helium from the CO_2 when fully operational in the spring of 2015. The price for grade-A helium in 2014 was about $200 per Mcf. This is a private industry price with some producers adding a surcharge to the $200/Mcf price. Helium has numerous uses such as metallurgy, fiber optics, semiconductor manufacturing, magnetic resonance imaging (MRI), lifting high-altitude scientific research balloons, blimps and party balloons, breathing atmospheres for deep diving or unique blood gas medical mixtures, analytical chemistry, pressurizing and purging pipes and other critical equipment, leak detection, and other advanced applications.

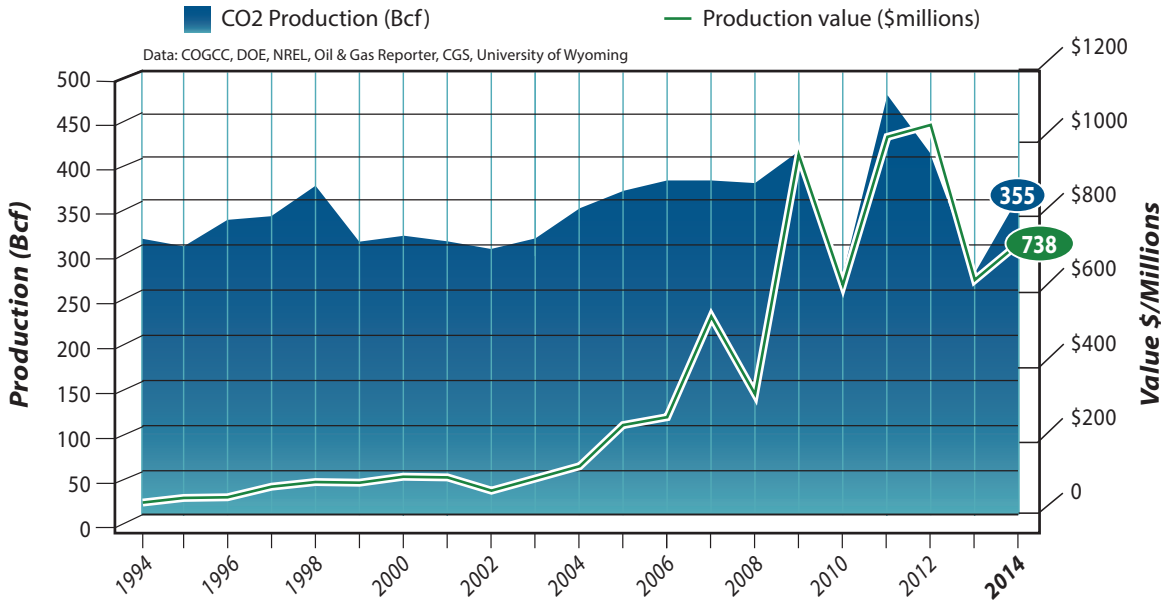


Figure 4-14. CO_2 production and production value in Colorado, 1994–2014.

INFORMATION SOURCES and ACKNOWLEDGEMENTS

We thank our colleagues at the Colorado Geological Survey (CGS) and other state organizations including the Colorado Oil and Gas Conservation Commission, (COGCC), the Colorado Division of Reclamation Mining and Safety (DRMS), and the Colorado Department of Local Affairs (DOLA), all of who readily provided data and expertise that greatly assisted the research. Larry Scott of CGS produced the graphics, maps, and the layout of the publication.

We thank Brianne Tobin for assistance with constructing most of the tables and charts for the report. Technical reviews by Jim Cappa, Consulting Geologist and former Chief of the Mineral and Mineral Fuels Section of the Colorado Geological Survey, Mike O'Keeffe, Matt Morgan, and Lesely Sebol of CGS greatly improved the manuscript. This project was funded through severence tax funds.

Air Products Corp - New Helium Production, Doe Canyon Facility	http://www.airproducts.com/company/news-center/2013/10/1028-air-products-thinks-outside-the-box-in-obtaining-new-helium-source.aspx
Alabaster Producer - Colorado	http://www.coloradoalabaster.com/
American Oil Shale Corp - AMSO	http://amso.net/
Anglo-Ashanti Annual Reports 2005-2014	http://www.anglogoldashanti.com
Arkins Park Stone - Dimension Stone Sandstone	http://www.arkinsparkstone.com/
Aspen Public Radio - Gypsum Colorado Biomass Power Plant	http://aspenpublicradio.org/post/gypsum-biomass-plant-first-its-kind-state - pg 32
Azarga Uranium Corp	http://azargauranium.com/
BBC - Neodymium magnets use in wind turbine generators-March 2014	http://www.bbc.com/news/magazine-26687605
Black Range Minerals - Ablation Test Work	http://www.blackrangeminerals.com/content/wp-content/uploads/2014/10/24-Oct-2014-Further-Positive- Results-From-Ablation-Testwork.pdf
Black Range Minerals - Proposed Take Over	http://www.blackrangeminerals.com/content/wp-content/uploads/2015/02/30-Jan-2015-Proposed-Takeover-Offer.pdf
Bowie Resource Partners LLC	http://bowieresources.com/
Cemex - Lyons Cement Plant	http://www.cemexusa.com/ProductsServices/Cement.aspx
Colorado Geological Survey (CGS) - Energy Resources	http://coloradogeologicalsurvey.org/energy-resources/electricity/
CGS - Geological Survey; annual mineral reports, legacy	http://coloradogeologicalsurvey.org/energy-resources/data-statistics/annual-reports-legacy/
CGS - Geothermal Resources in Colorado	http://coloradogeologicalsurvey.org/wp-content/uploads/2013/08/COGeothermalResources_Powerplantsforwebv2.pdf
CGS Colorado Mineral and Energy Industry Activities, 2001-2008	Information Series 63, 67, 69, 73, 75, 77
CGS Rock Talk Vol 8 No 2	http://coloradogeologicalsurvey.org/wp-content/uploads/2013/08/rtv8n21.pdf
CNN – America's 6 Fastest Growing State Economies, 06/11/2015	http://money.cnn.com/gallery/news/economy/2015/06/11/6-fastest-growing-states/2.html
Colorado Business Economic Outlook Forum 2015; Univ. of Colorado, LEEDS School of Business	http://www.colorado.edu/leeds/centers/business-research-division/brd-publications/colorado-business-economic-outlook
Colorado Department Of Local Affairs - Severence Tax	http://www.colorado.gov/cs/Satellite/DOLA-Main/CBON/1251589672852
Colorado Division of Reclamation Mining and Safety (DRMS) – numerous web sites and databases	http://www.mining.state.co.us
Colorado Flagstone Inc - Flagstone	http://www.coloradoflagstone.com/

Colorado Hydroelectric Power Plants	http://globalenergyobservatory.org/list.php?db=PowerPlants&type=Hydro
Colorado Klondike, LLC	unpublished reports; personal communications
Colorado Oil and Gas Conservation Commission - COGCC	http://cogcc.state.co.us/
Colorado Rose Red Inc - Granite Dimension Stone	http://www.thebluebook.com/iProView/796350/colorado-rose-red-inc/manufacturers/
Colorado Rose Sandstone Co - Sandstone Dimension Stone	http://redsandstone.com/
Colorado Springs Business Journal	http://csbj.com/2015/02/26/gold-mine-for-sale/
Colorado Springs Gazette	http://gazette.com/springs-utilities-to-launch-pilot-program-to-burn-wood-biofuel/article/1511375
Colorado Stone Quarries - Yule Marble	http://www.coloradoyulemarble.com/
Colorado Stone Wholesale Corp - Dimension Stone Sandstone, Mossrock	http://www.stonewholesalecorp.com/
Colorado Trust Lands - Proceeds Distribution	http://trustlands.state.co.us/sections/Minerals/Pages/Minerals.aspx
Colorado Trustlands Report	http://trustlands.state.co.us/Documents/FY%202011-12%20Income%20and%20Inventory%20Report%20FINAL.pdf
Comanche Solar Power Plant - Sunedison	http://communityenergysolar.com/sunedison-partners-with-community-energy-on-colorados-largest-solar-power-plant/
Cripple Creek and Victor Gold Mining Co.	http://www.ccvgoldmining.com/downloads/CCV_Fall_2014_FINAL.pdf
Denver Business Journal	http://www.bizjournals.com/denver/
Denver Business Journal - Rare Earths in Colorado	http://www.bizjournals.com/denver/news/2010/11/17/usgs-colorado-is-home-to-rare-earth.html?page=all
Denver Post - Gypsum Colorado Biomass Power Plant	http://www.denverpost.com/news/ci_27130804/gypsum-biomass-power-plant-engulfed-active-three-alarm
Denver Post, numerous articles	http://www.denverpost.com/
Drilling Edge	http://www.drillingedge.com/
Durango Hearld - Monday Feb 3 2014	http://www.durangoherald.com/2014/02/03
Energy Information Agency (EIA), uranium production report	http://www.eia.gov/uranium/production/quarterly/pdf/qupd_tbl1.pdf
EIA, Coal Data	http://www.eia.gov/coal/
EIA, First Purchase Price Colorado Oil	http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=F004008__3&f=A
EIA, Crude Oil, Natural Gas And Liquides Reserves Annual Report 2013	http://www.eia.doe.gov/pub/oil_gas/data_publications/crude_oil_natural gas_reserves/historical/2013/cr2013.html
EIA - Colorado State Profile and Energy Estimates	http://www.eia.gov/state/?sid=CO
Energy Fuels Inc.	http://www.energyfuels.com/
Energy Inc.	http://www.bizjournals.com/denver/blog/earth_to_power/
Energy Policy Center - Independence Institute - Hydroelectric Power	http://energy.i2i.org/2013/04/02/co-hydro-fails-to-put-new-in-reneable/
Engineering and Mining Journal - EM&J - Digital Edition	http://www.e-mj.com/home/digital-edition-archives.html#.VPnVf_nF9Ro
Enhanced Oil Recovery - CO_2 price	http://www.aogr.com/magazine/editors-choice/industrial-co2-supply-crucial-for-eor
EPA - Estimates of Coal Bed Methane Reserves	http://www.epa.gov/ogwdw/uic/pdfs/cbmstudy_attach_uic_ch05_basins.pdf
Freeport MacMoRan Inc - Climax Mine	http://www.climaxmolybdenum.com/
Freeport MacMoRan Inc - Henderson Mine	http://www.fcx.com/operations/USA_Colorado_Henderson.htm,
Freeport-McMoRan Form 10-K 2008 - 2010 Molybdenum Production	http://investors.fcx.com/files/doc_financials/quarter/10_k2010/FCX2010_Form10-K.pdf

Freeport-McMoRan Form 10-K 2014 - Molybdenum Production-Colorado	http://investors.fcx.com/files/doc_financials/annual/10_K2014.pdf
GCC Rio Grande Inc - Pueblo Cement Plant	http://gccusa.com/pueblo
Governors Office of State Planning and Budgeting - Severance Taxes Receipts Estimate 2014-1015 Fiscal Year	https://docs.google.com/file/d/0B8926UIVO3_zVTRkLUZocWtILVE/edit
Grand Junction Sentinel - Whitebanks Alabaster Mine and marble exploration	http://www.gjsentinel.com/special_sections/articles/forest-service-authorizes-restricted-alabaster-min
Greeley Tribune Jan 4 2015 - Oil Production Colorado	http://www.greeleytribune.com/news/feature2/13743683-113/oil-production-colorado-rangely
Hecla Mining Co - San Juan Silver Project	http://www.hecla-mining.com/operations/operations_predevelopment_bulldogequity.php
Hermosa Creek Watershed Protection Act	https://www.congress.gov/bill/113th-congress/senate-bill/841
Holcim Florence Portland Cement Facility	https://www.google.com/#q=holcim+florence+plant
International Atomic Energy Commission - IAEA	http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/NFC/documents/uranium/tm-isl-2013/02.Pool_2013_U_supply_demand_prices.pdf
Kinross Gold - Fort Knox Alaska Mine-2013 gold Production	http://www.kinross.com/media/252586/kinnross%202013%20form%2040f.pdf
Kitco Average Annual Gold Prices 2005-2014	http://www.kitco.com/scripts/hist_charts/yearly_graphs.plx
Kitco Average Annual Silver Prices 2005-2015	http://www.kitco.com/scripts/hist_charts/yearly_graphs.plx
Lazard's Levelized Cost of Energy Analysis Version 8.0 - 2014	http://www.lazard.com/PDF/Levelized%20Cost%20of%20Energy%20-%20Version%208.0.pdf
LKA Gold - Investor Presentation-September 2015	http://lkagold.com/uploads/LKA_Issuer_Presentation_9-14.pdf
Mining Weekly - Dawson Gold Project-PR	http://www.miningweekly.com/article/zephyr-minerals-to-start-mine-planning-at-high-grade-colorado-flagship-2015-04-08
Monarch Stone Co. - Flagstone, Mossrock, Dimension Stone	http://www.monarchstonecompany.com/
Mountain Town News - Problems and Promises of Biomass in Colorado	http://mountaintownnews.net/2014/03/06/problems-and-promises-of-biomass-in-colorado/
Mountain Town News -Putting the Electric Harness on old Dams	http://mountaintownnews.net/2015/03/10/putting-electric-harness-old-dams/
National Conference of State Legislatures - NCSL	http://www.NCSL.ORG
National Mining Association	http://www.nma.org/
Natural Gas Energy Generation - Colorado Independent Energy Association	http://www.ciea-colorado.org/index.php/natural-gas.html
Natural Soda Inc	http://naturalsoda.dublinblue.com/
National Renewable Energy Laboratory (NREL): Transparent Cost Database-2012	http://en.openei.org/apps/TCDB/methods.html
Nuclear Energy Institute	http://www.nei.org/Knowledge-Center/Nuclear-Statistics/US-Nuclear-Power-Plants
Pacific Metals Corp.	http://www.pacificgoldcorp.com/pmet/properties/pacificmetals/overview.html
Pete Lien & Sons - Hydrated Lime, Calcium Carbonate, Aggregate, Crushed Stone	http://www.petelien.com/index.php/locations
Portland Cement Association	http://www.cement.org/docs/default-source/GA-Pdfs/cement-industry-by-state-2014/colo
Schmidt Construction - Rhyolite Quarry	http://www.schmidtconstruction.net/quarries/splitstone.html
Siloam Stone Inc - Sandstone Dimension Stone, Fieldstone, Mossrock	http://www.siloamstone.com/
Society for Mining, Metallurgy, and Exploration (SME)	Mining Engineering, May 2015; http://me.smenet.org/
Solar Foundation	http://pre.thesolarfoundation.org/solarstates/colorado

Solar Energy Industries Association - SEIA	http://www.seia.org/state-solar-policy/colorado
Solvay - Sodium Carbonate to Sodium Bi-Carbonate Conversion Plant	http://www.solvaychemicals.us/EN/aboutus/locations/parachute.aspx
The Grand Junction Daily Sentinel	http://www.gjsentinel.com/
The Niobrara News	http://www.niobraranews.net/
The Northern Miner - Digital Edition	http://www.northernminer.com/
The Watch Media	http://www.thewatchmedia.com/pinon-ridge-uranium-mill-and-assets-set-to-be-sold-for-2-million/
Tribble Stone Co - Sandstone Dimension Stone	http://www.tribblestone.com/
Trinty Expanded Shale and Clay Colorado Facility	http://www.trinityesc.com/
Univ. of Colorado, Leeds School of Business: Colorado Business Review, Jan. 2015	https://www.colorado.edu/leeds/sites/default/files/attached-files/CBR-2015-Issue1_0.pdf
University of Wyoming: CO_2 Costs - 2012	http://www.uwyo.edu/cee/_files/docs/cook-benjamin-economic-contribution-co2-eor.pdf
Uranium Miner	http://www.uraniumminer.net/
U.S. Department of the Interior Bureau of Land Management (BLM)	http://www.blm.gov/co/st/en/BLM_Programs/minerals/oil_and_gas.html
U.S. Department of Energy (DOE) - Natural Gas & Oil Production by state	http://www.eia.gov/state/rankings/#/series/48
U.S. DOE, Carbon Dioxide Enhanced Oil Recovery - Conversion Factors	DOE Pub March 2010 Carbon Dioxide Enhanced Oil Recovery, page 11
U.S. DOE, Energy Information Agency (EIA), numerous data	https://www.eia.gov
U.S. DOE - U.S. Coal Prices by Region-2014	https://www.quandl.com/data/DOE/COAL-US-Coal-Prices-by-Region
U.S. DOE - geothermal press release 6/3/2014	http://energy.gov/eere/articles/colorado-takes-steps-expand-geothermal-development
U.S. Energy Corp	http://www.usnrg.com/molybdenum
U.S. Geological Survey (USGS) Crushed Stone, Table 4, early draft	Minerals Yearbook: Stone Early Draft Minerals USGS Crushed Stone Publication
USGS Mineral Commodity Statistics, numerous	http://minerals.usgs.gov/minerals/pubs/commodity/
USGS Mineral Industry Survey, Gold Production by State	http://minerals.usgs.gov/minerals/pubs/commodity/gold/mis-201501-gold.pdf
USGS Minerals Yearbook Common Clays-2009	http://minerals.usgs.gov/minerals/pubs/commodity/clays/myb1-2009-clays.pdf
USGS Minerals Yearbook Common Clays-2012	http://minerals.usgs.gov/minerals/pubs/commodity/clays/myb1-2012-clays.pdf
USGS - Colorado Minerals Information, numerous	http://minerals.usgs.gov/minerals/pubs/state/co.html
U.S. Rare Earths - Wet Mountains and Powderhorn Rare Earth Deposits	http://www.usrareearths.com/
Western Sugar - Fort Morgan Quicklime Plant-2015	http://www.westernsugar.com/
Western Uranium	http://www.homelanduranium.com/
Wind Energy Foundation	http://www.windenergyfoundation.org/wind-at-work/case-studies/colorado
Wikipedia	http://en.wikipedia.org/wiki/Wind_power_in_Colorado
Wikipedia - Solar Power in Colorado	http://en.wikipedia.org/wiki/Solar_power_in_Colorado
World Nuclear Association	http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/Appendices/US-Nuclear-Fuel-Cycle-Appendix-1--US-Uranium-Mining-and-Exploration-/
World Nuclear News	http://www.world-nuclear-news.org/NN-China-resumes-new-reactor-approvals-1003155.html