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Colorado Mineral and Energy Industry Activities, 2007

by James R. Burnell, Christopher Carroll, and Genevieve Young

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Cover figure captions *(clockwise from top right):*

Coal tipple at the King Coal Mine.

Wind power old and new; Peetz Table wind farm.

Uranium mine portal, Uravan District.

Jim Burnell, CGS, in Cash gold mine, Boulder County.

Background—Aerial view of drilling pads looking north along Piceance Creek valley in the Piceance Basin (photo courtesy of Celia Greenman, DOW).

CONTENTS

EXECUTIVE SUMMARY

The global demand for natural resources has increased dramatically during the 21st century. This increased demand creates shortages and price increases in energy and mineral commodities. Because Colorado is so rich in both energy and mineral resources, the global and national situation kept activity high within the state.

Hydrocarbon production was essentially flat last year, and when production reporting is finalized for the year, it is estimated that natural gas production will be up for 2007. Coal production was up slightly. Gold and silver production were down, whereas molybdenum production was up. Mining claims on federal land increased dramatically. New pipelines and processing facilities were under construction. Prices were up for all commodities except natural gas which is the biggest contributor to revenues (>50%). Employment leveled off from the sharp increases of the previous three years.

The Colorado Geological Survey (CGS) estimates the total value of 2007 mineral and energy production in Colorado to be **$11.811 billion**—less than one percent decrease from the revised* 2006 total value of $11.846 billion (fig. 1, fig. 2, and table 1).

Energy, carbon dioxide, and mineral production values for 2007 are estimated at:

- **Natural gas—$6,803 million**
- **Oil—$1,498 million**
- **Carbon dioxide—$541 million**
- **Helium—$8 million**
- **Coal—$1,075 million**
- **Nonfuel minerals—$1,886 million**
- **Uranium—$0**

The total estimated value of oil, natural gas, and other gas production in 2007 is $8.850 billion, which is down three percent from the 2006 value of $9.110 billion. Colorado natural gas production for 2007 may increase by as much as nine percent over that for 2006 once production reporting is finalized for the year. The average annual price for natural gas declined for the second straight year to $5.15/thousand cubic feet (Mcf) from a 2005 high of $7.39/Mcf. Oil production was slightly down whereas average annual oil prices increased to $65.48 per barrel in 2007 from $60.32 in 2006. The production of carbon dioxide was essentially flat, but the price nearly doubled causing an increase in value from $262 million in 2006 to $541 million in 2007—a 10 percent increase. The price of oil, gas, and carbon dioxide are obtained from the Colorado Oil and Gas Conservation Commission.

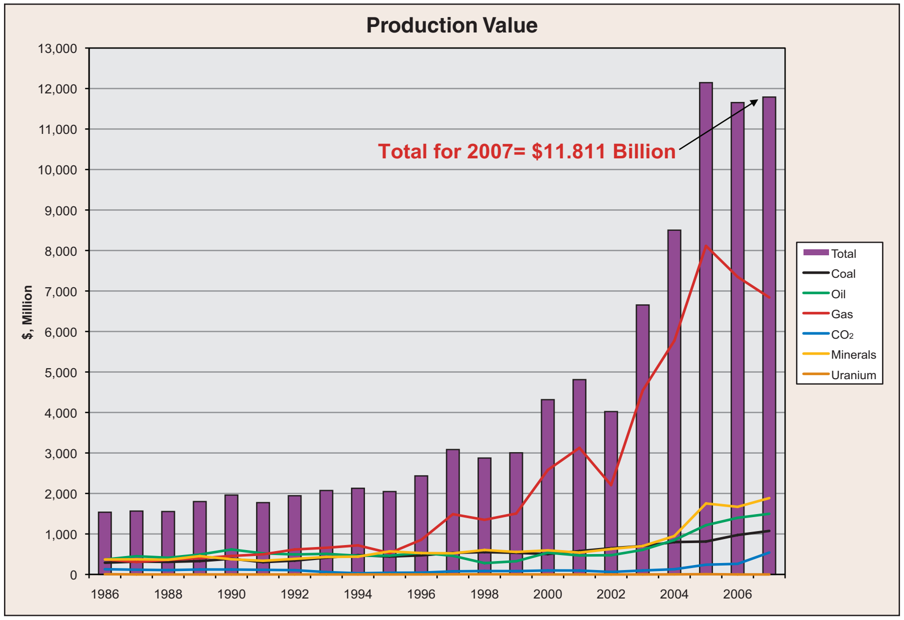


Figure 1. Colorado mineral and energy production value, 1986–2007. Total includes helium value.

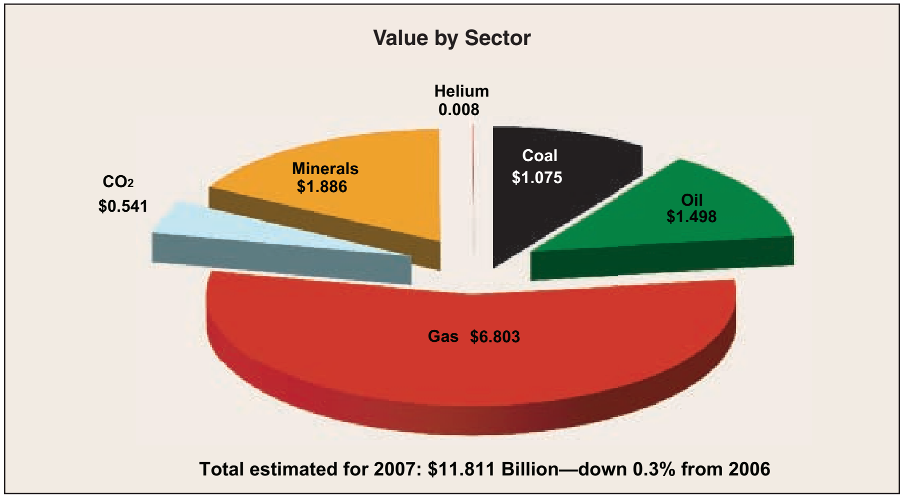


Figure 2. Mineral and energy production value ($ billion) by sector, 2007.

* Estimated production and values are obtained from other state agencies, federal agencies, company annual reports, press releases, mine operators, and other sources. Sources of data are explained in the appropriate section in the following chapters. The 2006 production value is revised to $11,846 million from the original estimated value of $11,609 million (Colorado Geological Survey Information Series 73, *Colorado Mineral and Energy Industry Activities, 2006*). Overall total includes $8 million in helium production.

Table 1. Colorado mineral and energy production and value. Figures for 2006 and 2007 are estimated. "Realized Value" represents the amount calculated by multiplying "Volume Sold" by "Average Price." Red percentage change numbers in parentheses are negative.

2007 (Estimated)	Volume Produced	Volume Sold	Average Price	Realized Value (Millions)	% Change in value from 2006
Hydrocarbon and Gas Production Statistics[1,3]					
Natural gas[5]	1,362Bcf	1,321 Bcf	$5.15/Mcf	$6,803	(9%)
Crude oil	23.2 MMbo	22.9 MMbo	$65.48/bbl	$1,498	6%
Carbon dioxide	383 Bcf	383 Bcf	$1.41/Mcf	$541	107%
Helium	78,612Mcf		$99.00Mcf	$8	(1%)
Estimated Total Value of Hydrocarbons, Carbon Dioxide, Helium				**$8,850**	(3%)
Coal Production Statistics[2]					
Estimated Total Value of Coal Production	36.135 Mst	– –	$29.75/st	**$1,075**	10%
Mineral Production Statistics[3,4]					
Gold	281,820 oz	– –	$655.00/oz	$184	0%
Silver	93,789 oz	– –	$13.38/oz	$1	(29%)
Molybdenum	39,800,000 lbs	– –	$26.81/lb	$1,067	25%
Uranium	0 lbs	– –	$85.00/lb	0	—
Vanadium	0 lbs	– –	$8.08/lb	0	—
Industrial Minerals	– –	– –	– –	$634	2%
Estimated Total Value of Minerals Production				**$1,886**	7%
Estimated Total Value of all Mineral and Energy Production in Colorado				**$11,811**	**(0.3%)**
2006 (Estimated)	**Volume Produced**	**Volume Sold**	**Average Price**	**Realized Value (Millions)**	**% Change in value from 2005**
Hydrocarbon and Carbon Dioxide Production Statistics[1]					
Natural gas[5]	1,251 Bcf	1,213 Bcf	$6.13/Mcf	$7,436	(8%)
Crude oil	23.90 MMbo	23.60 MMbo	$60.32/bbl	$1,412	16%
Carbon dioxide	374 Bcf	373 Bcf	$0.78/Mcf	$262	9%
Estimated Total Value of Hydrocarbons, Carbon Dioxide, Helium				**$9,110**	(5%)
Coal Production Statistics[2]					
Actual Total Value of Coal Production	35.490 Mst	– –	$27.44/st	**$974**	20%
Mineral Production Statistics[3,4]					
Gold	303,484 oz	– –	$610/oz	$185	18%
Silver	127,617 oz	– –	$10.58/oz	$1.40	12%
Molybdenum	36,616,230 lbs	– –	$23.40/lb	$857.0	(16%)
Uranium	0 lbs	– –	$—/lb	$0.0	—%
Vanadium	0 lbs	– –	$—/b	$0.0	—%
Industrial Minerals	– –	– –		$625	8%
Actual Total Value of Non-fuel and Uranium Minerals Production				**$1,762**	(2%)
Estimated Total Value of all Mineral and Energy Production in Colorado				**$11,846**	**(2.7%)**

Coal production continued to increase as mines recovered from technical setbacks in previous years and are on track to continue the climb back to the record production level of 2004. Production increased 10 percent from the 2006 level of 35.49 million tons to 36.135 million tons in 2007. CGS estimates the average price for all coal produced in Colorado to be $29.75 per ton which is eight percent more than 2006. The value of the 2007 Colorado coal production is estimated at $1,075 million—up 10 percent from the revised* 2006 value of $974 million.

CGS estimates the value of the 2006 nonfuel mineral production to be $1,886 million— a seven percent increase from the revised 2006 value of $1,762 million. Molybdenum production and price increased. Although molybdenum prices were up 15% over the previous year, they were still significantly below the 2005 peak of $31.73 per pound. Gold production in the state declined slightly but the average annual price increased dramatically.

Uranium and vanadium production value are reported as zero, but several mines are actively reopening.

Taxes and royalties from mineral and energy production flow directly back to the State of Colorado and local governments. The combined total of federal mineral lease revenues, state severance taxes, Colorado State Land Board mineral royalties and rentals, and county property taxes on mineral properties for 2007 is $657 million— essentially flat with the $663 million collected in 2006.

Table Sources: [1]Colorado Oil and Gas Commission, http://oil-gas.state.co.us/; [2]Colorado Department of Local Affairs, http://www.dola.state.co.us/LGS/FA/EMIA/miner/MinerWebTables.pdf; [3]U.S. Geological Survey Minerals Information, http://minerals.usgs.gov/minerals/pubs/mcs/; [4]Company reports and press releases; [5]Natural gas volumes estimated from Bentek Energy data.

Abbreviations: Bcf—billion cubic feet; Mcf—million cubic feet; MMbo—million barrels; bbl—barrels; Mst—million short tons; st—short tons; oz—ounces; lbs—pounds.

The mineral and energy industries provide the essential elements of modern day life from gasoline for our cars; steel for our buildings, trucks, airplanes, and bridges; copper for wires and electrical parts; and aggregate for our roads. Every day, every citizen, in some way, touches or uses products provided by these industries. The Mineral Information Institute estimates that the average American will use 3.7 million pounds of minerals, metals, and fuels during an average life span of 77.6 years—that is over 47,502 pounds of materials every year for every American (fig. 3).

The mineral and energy industries in Colorado produce a wide variety of materials essential to our daily lives; coal, natural gas, solar, and wind provide electricity; natural gas heats our homes; molybdenum hardens our steel. Sand and gravel are necessary for our homes, offices, roads, driveways, and many other uses.

The Colorado mineral and energy industries enjoyed another strong year. Production varied up and down depending on the commodity, compared with 2006. With the exception of natural gas, prices increased for all commodities. However, because natural gas usually accounts for more than 50 percent of total revenues in Colorado, overall revenues were down slightly from last year. Employment leveled off after several years of sharp increases and average wages remained above $80,000 for the fourth straight year.

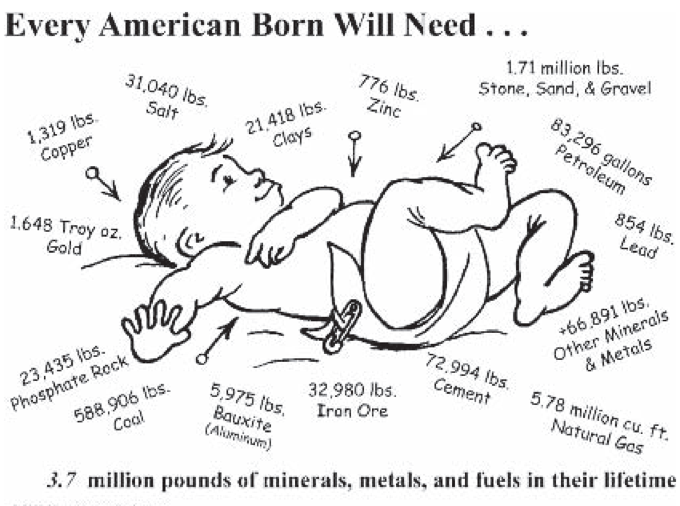


Figure 3. Mineral needs of the average American (Courtesy of the Mineral Information Institute).

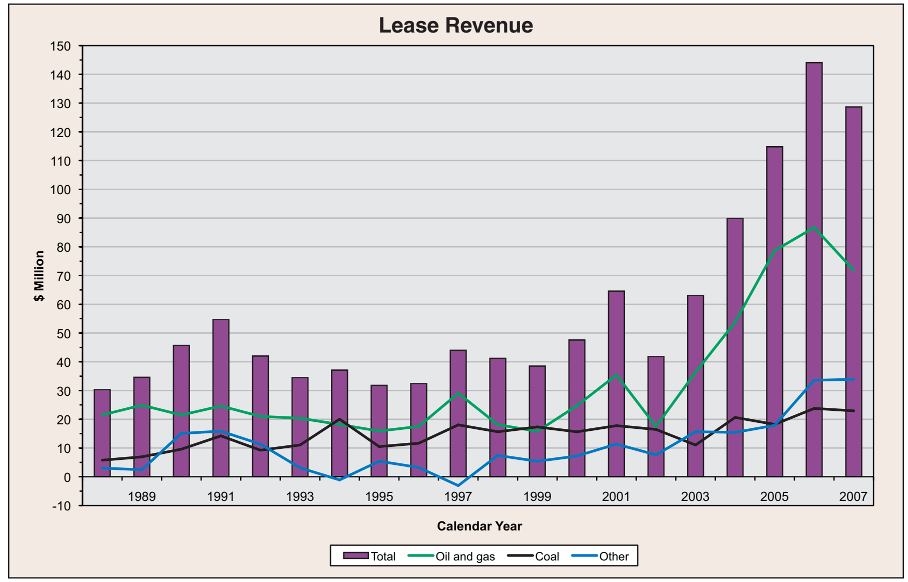


Figure 4. Federal mineral lease revenue by type, 1988–2007. Other category includes other production, rentals, and bonus payments (source: Colorado Department of Local Affairs).

The Colorado Geological Survey (CGS) estimates the total value of 2007 mineral and energy production in Colorado to be **$11,811 million**— a 0.3 percent decrease from the (revised*) 2006 total value of $11,846 million (fig. 1, fig. 2, and table 1).

The value of Colorado's mineral and energy production is realized in many ways including employment, taxes, and royalties that flow back to state and local governments. The value of Colorado's share of federal mineral royalties in 2007 is $129 million—an 11 percent decrease from the 2006 value of $144 million. A substantial portion of the Colorado share of royalties goes directly to public education and local governments (figs. 4 and 5).

Severance taxes are state taxes that are collected on the production of oil, gas, coal and certain minerals. According to Colorado law, 50 percent of the severance tax revenue flows to local governments and 50 percent flows into a state trust fund to "replace" depleted natural resources and to complete water projects. Legislation passed in 1996 allows some of the state share of severance tax to be used by agencies within the Department of Natural Resources that promote and regulate

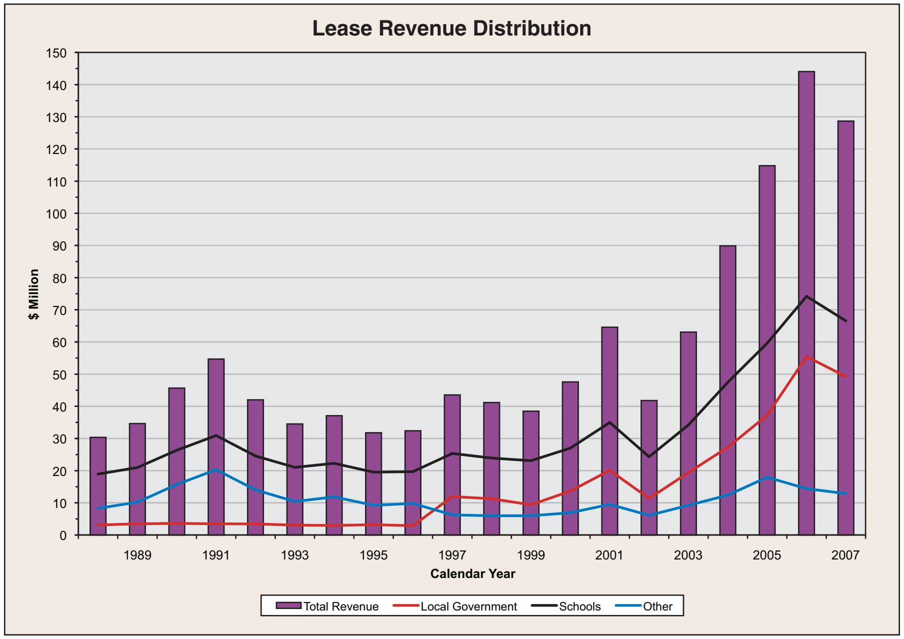


Figure 5. Federal mineral lease revenue and distribution, 1988–2007 (source: Colorado Department of Local Affairs).

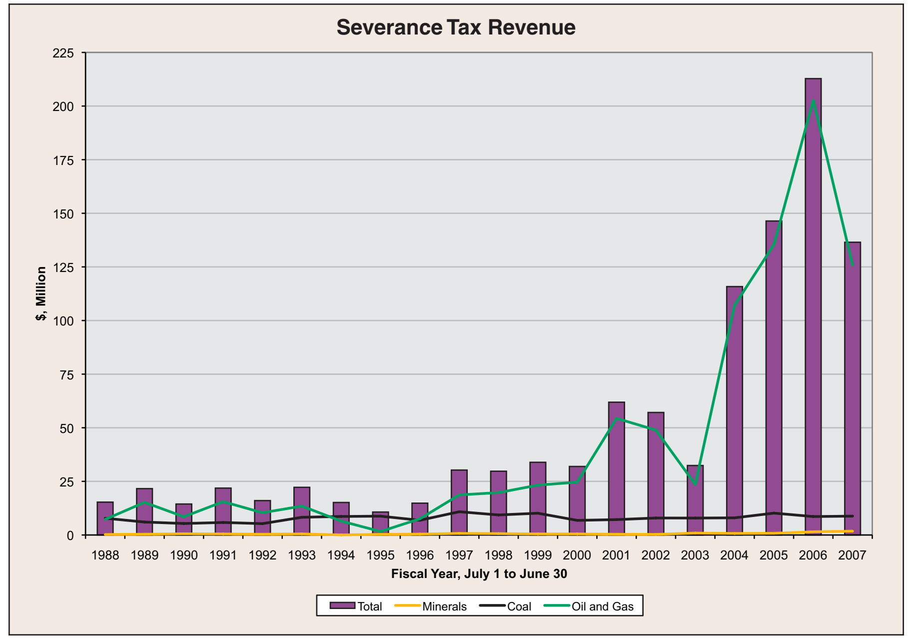


Figure 6. Colorado mineral severance tax revenue, 1988–2007 (source: Colorado Department of Local Affairs).

the mineral and energy industries. In fiscal year 2007, the CGS was eligible to receive $18.0 million of these funds but received only $2.1 million. Severance tax collections in fiscal year 2007 were $136.5 million—down 36 percent from the 2006 severance tax collection of $212.8 million (fig. 6). This dramatic decrease probably reflects the dramatic increase in property tax collections, because current Colorado law allows an offset of property tax payments against severance tax obligations.

Estimated property taxes paid in 2007 to the counties from mineral and energy properties totaled $343 million—up 36 percent from the $253 million collected in 2006 (fig. 7). Property tax revenues lag about two years behind the actual year of production.

In the fiscal year ending on June 30, 2007, the Colorado State Land Board received $49.002 million from mineral royalties, bonuses, and rentals on state-owned land, down nine percent from the $54.291 million collected in fiscal year 2006. The State of Colorado owns over four million acres of mineral land and the revenues from these lands go to the Permanent Fund controlled by the State Land Board. Interest from this fund is distributed by the School Finance Act to the school districts of Colorado (figs. 8 and 9).

The Colorado Department of Labor and Employment tracks employment trends for the state. Employment statistics for the mining and oil and gas extraction industries are included in their Mining category. This sector grew 72 percent (from 12,880 to 22,215) between 2000 and the 3^{rd} quarter of 2007 (fig. 10). The Colorado Business Economic Outlook Forum annual report for 2007 states that about one-third of the employees in this supersector work in each of the following areas: oil and gas extraction, mining, and support activities related to both oil and gas and mining industries. The one percent growth in employment from 21,900 in 2006 to 22,215 in 2007 is a ten-year record high. Wages for workers in the oil and gas and mining business sectors are among the highest in the state and bring a much-needed source of wealth to the rural parts of Colorado. According to the Colorado Department of Labor and Employment, the average annual wage through the 2^{nd} quarter of 2007 for workers in the oil and gas and mining industries was $85,337; about twice the average of $41,288 for all statewide job categories (fig. 10).

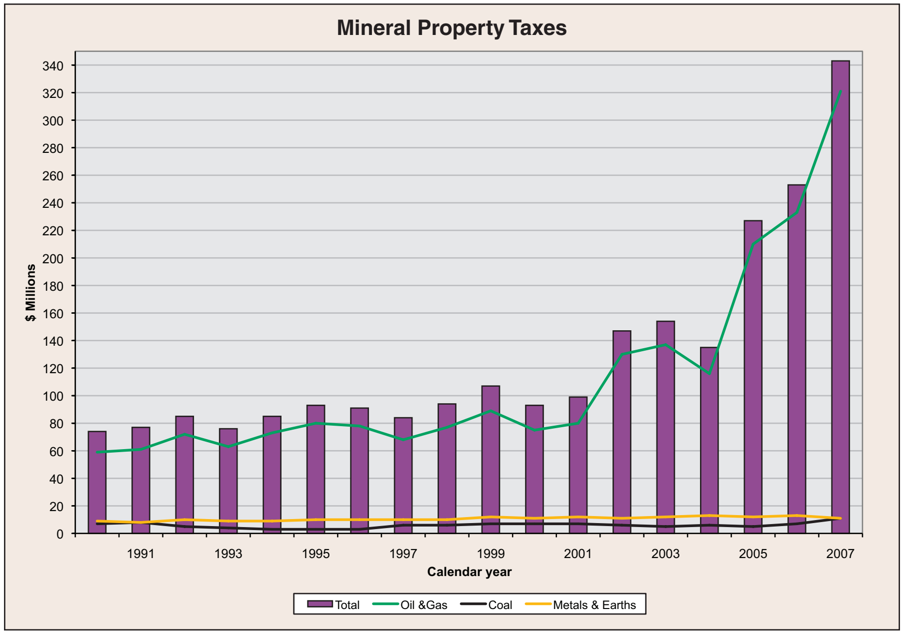


Figure 7. Property tax collections from Colorado mineral properties, 1990–2007 (source: Colorado Department of Local Affairs).

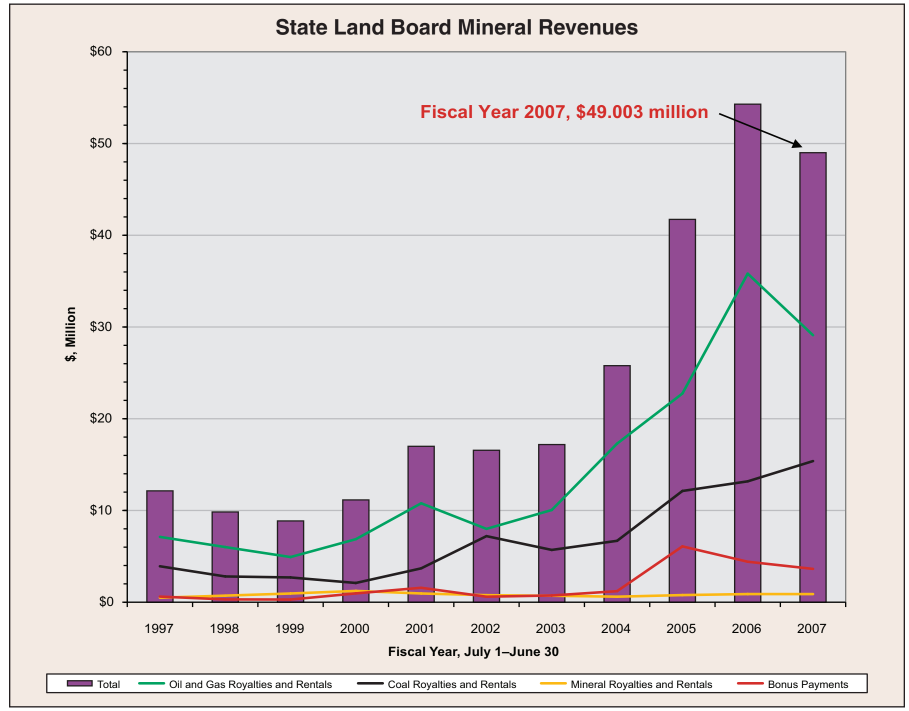


Figure 8. Colorado State Land Board Mineral Revenues, 1997–2007. Bonus payments are payments received from auctions of State mineral leases (source: Colorado State Land Board).

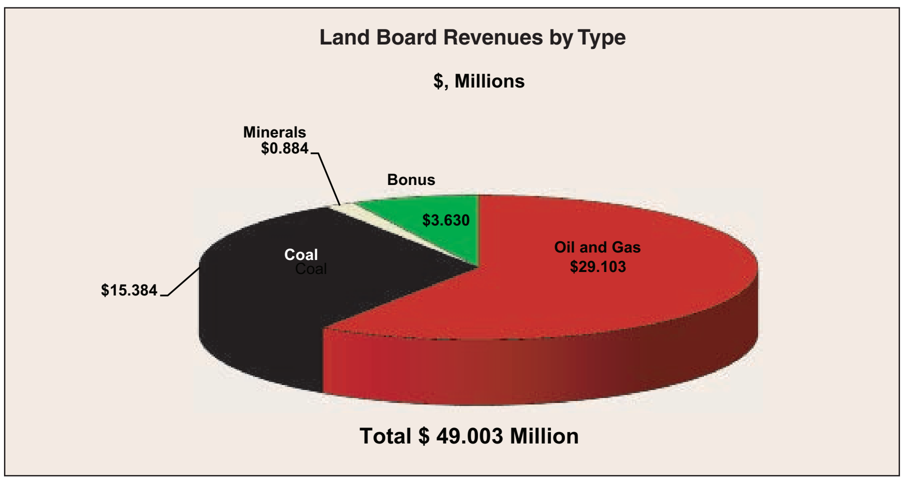


Figure 9. Colorado State Land Board mineral revenues, July 1, 2005–June 30, 2007. Bonus payments are payments received from auctions of State mineral leases (source: Colorado State Land Board).

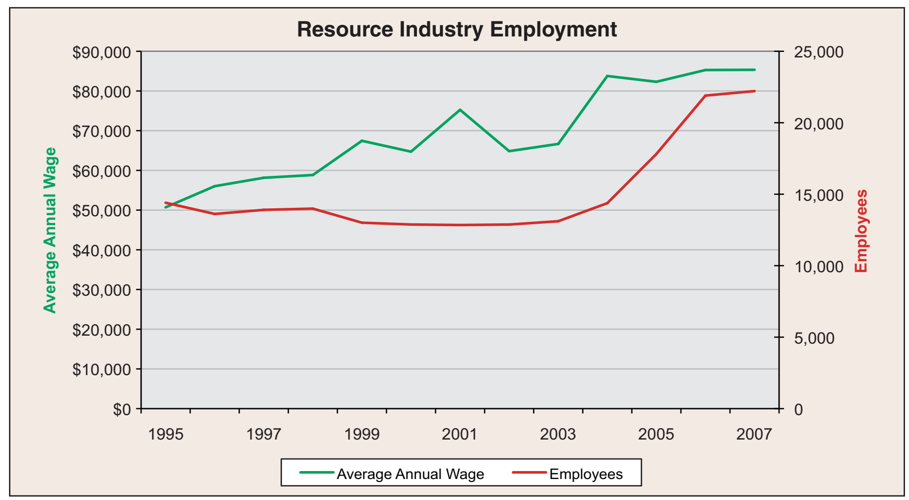


Figure 10. Colorado mineral and energy industry employment and wages, 1995–2007 (source: Colorado Department of Labor and Employment).

CONVENTIONAL ENERGY RESOURCES: OIL AND NATURAL GAS

Introduction

Colorado has substantial oil and natural gas energy resources distributed in several energy-rich sedimentary basins, including the Sand Wash, Piceance, Paradox, and San Juan basins in the western part of the state, and the Denver and Raton basins as well as the Las Animas Arch-Hugoton Embayment area in the east (fig. 11). Eight of the nation's 100 largest natural gas fields and three of its 100 largest oil fields are found in Colorado.

Colorado oil production typically accounts for about one percent of the annual U.S. total; most of this production occurs in the Denver and Piceance basins. Colorado has two refineries in Commerce City north of Denver. However, these refineries are insufficient to supply Colorado's refined market demand. Additional supplies are brought into the state by several petroleum product pipelines from Wyoming, Texas, and Oklahoma. Major products from oil refining include liquid petroleum gas, gasoline (or petrol), naphtha (used in producing high octane gasoline), kerosene and related jet aircraft fuels, diesel fuel, fuel oils, lubricating oils (such as motor oils and greases), paraffin wax (used in the packaging of frozen foods), asphalt and tar (used in tar-and-gravel roofing and road surfacing), petroleum coke (used in specialty carbon products or solid fuel), and petrochemical feedstocks for further processing.

Although Colorado's proven oil reserves account for only about one percent of the U.S. total, Colorado has enormous deposits of oil shale (kerogen in marlstone), which can be converted into crude oil through heating. Colorado's oil shale deposits, concentrated in the western part of the state, hold an estimated one trillion barrels of oil—as much oil as the entire world's proven oil reserves. Although this natural resource holds tremendous promise, oil shale development remains speculative and faces several major obstacles involving technological feasibility, economic viability, resource ownership, and environmental considerations. Five oil shale pilot projects are approved by the Bureau of Land Management (BLM) in Colorado.

Colorado is a major, natural gas-producing state. Natural gas from Colorado basins typically account for about six percent of annual U.S. natural gas production. Coalbed methane (natural gas produced from coal seams) accounts for about 40 percent of Colorado's natural gas production.

The industrial and residential sectors are the leading consumers of natural gas in Colorado. About three-fourths of Colorado households use natural gas as their primary energy source for home heating, one of the highest shares in the nation. In addition to heating, natural gas is also used in the generation of electricity. The Public Service Company of Colorado (Xcel Energy) is the major distributor of gas in Colorado, with more end-use customers in a single state than any other in the Rocky Mountain region (EIA, 2007c). Colorado Interstate Gas Company provides nearly all of the gas to Xcel Energy. Some natural gas is rich in liquids that can be economically extracted. Products that are extracted include natural gas liquids (oil), acid gases (such as carbon dioxide and hydrogen sulfide), other gases (such as nitrogen and helium), water vapor and liquid water, liquid hydrocarbons (such as natural gas condensate or crude oil), and very small amounts of mercury.

Colorado uses only about 40 percent of its natural gas production. The remainder is transported to eastern and western markets. Colorado's natural gas production is growing. Consequently, a new pipeline is being built to carry natural gas to eastern consumers. The pipeline system, known as the Rockies Express, originates in the Piceance Basin and began interim service in January 2008 as far east as Brown County, Kansas. It will ultimately terminate in Clarington, Ohio.

A recent study estimated the total economic contribution for all oil and gas-related activities within Colorado to be $22.9 billion or 6.1 percent of the total gross state product (in 2005$) (Colorado Energy Research Institute, 2007). This estimate includes economic contributions from employment, income, industry output, and taxes. A significant portion of this economic contribution comes directly from the sale of oil and natural gas product. Records were broken in 2005 when the value of oil and natural gas hit an all time high of $9.39 billion, in part, because of the impact of the Gulf Coast hurricane season (fig. 12). In the last two years, this value has moderated significantly primarily because of the volatility in natural gas prices and limitations in gas pipeline export capacity in Colorado.

The total value of oil and gas production in 2007 is estimated at $8.30 billion, a 6.2 percent decrease over the revised 2006 value of $8.85 billion. Although oil production declined somewhat during 2007, the value of that production increased six percent because of an offsetting 8.6 percent escalation in oil price. In contrast, the value of natural gas production for 2007 is down because of a significant decline in natural gas prices in Colorado for the year; the average price of $5.15 per thousand cubic feet (Mcf) is down 16 percent from the 2006 price of $6.13. (At the time of report preparation, the 2007 production volumes are incomplete. This necessitates the use of estimates for the 2007 calendar year; estimates that will be revised as Colorado producing counties complete their annual reporting to the Colorado Oil and Gas Conservation Commission (COGCC)).

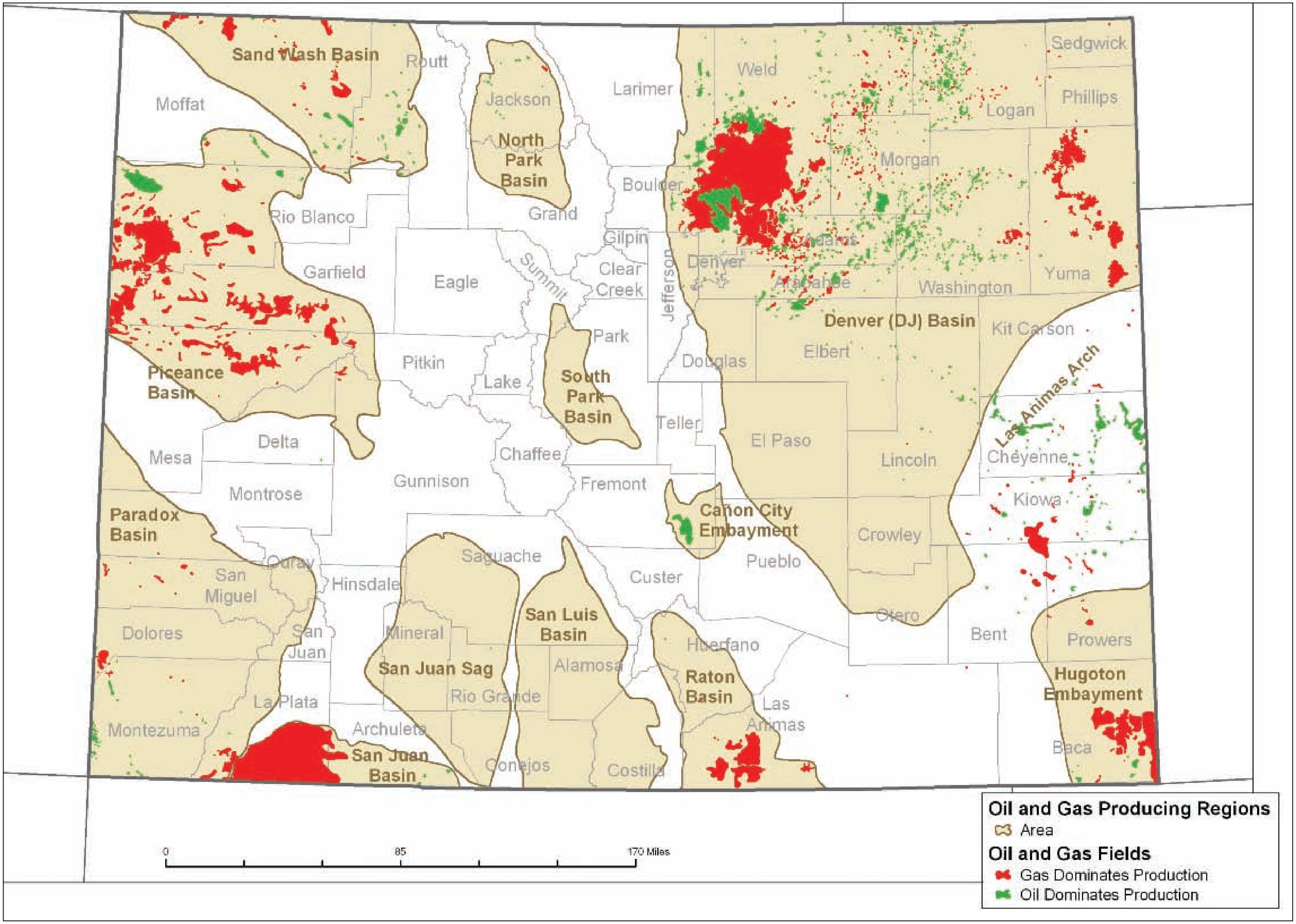


Figure 11. There are approximately 1,400 oil and gas producing fields in Colorado. Gas production dominates many of these fields making Colorado a gas-rich region.

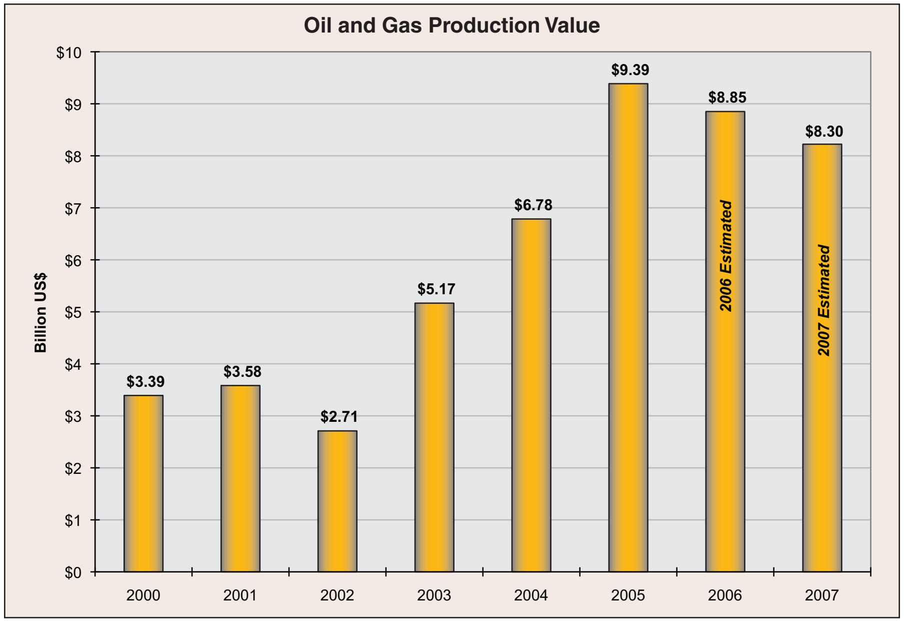


Figure 12. The value of oil and gas production in Colorado increased nearly three-fold between 2000 and 2005. The decline in value in the last two years results from price volatility in the gas market and limitations in gas pipeline capacity out of the Rocky Mountain region (COGCC, 2007; Bentek Energy, 2008).

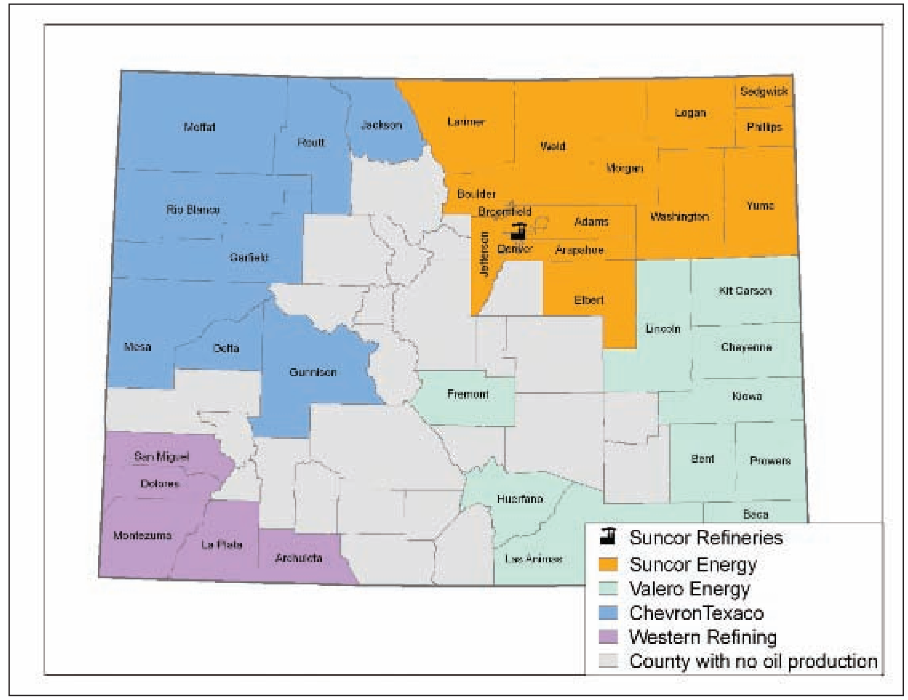


Figure 13. The Suncor refineries in Commerce City purchase oil produced in northeastern Colorado. Valero Energy purchases oil produced in southeastern Colorado for processing at their McKee Refinery in the Texas Panhandle. ChevronTexaco purchases most of the oil produced in northwestern Colorado for processing in the Salt Lake City area of Utah. Western Refining purchases oil produced in southwestern Colorado for processing at their Bloomfield and Gallup Refineries in northwestern New Mexico (COGCC, 2007).

Commodity Prices

Oil and natural gas prices vary according to many factors, but it usually boils down to supply and demand. When there are shortages in supply, such as natural gas after Hurricane Katrina, prices go up. When there is lower heating demand for natural gas in the summer, prices go down.

The price that oil and natural gas producers in Colorado receive is also dependent on how many options they have for selling their product. If they have just one refinery, or one natural gas pipeline that they can sell to, then they are likely to receive lower prices. Conversely, if there were multiple options for selling their product, then competition to get their product might result in higher prices. That is why the addition of a major pipeline from the Rockies is expected to raise overall prices to Colorado natural gas producers. That is also why the import of crude oil from Canada's oil sands to the Suncor refinery in Commerce City may reduce the price offered to local oil producers.

Oil and natural gas prices for Colorado are tracked by the Colorado Oil and Gas Conservation Commission (COGCC) and made publicly available via their website (**http://oil-gas.state.co.us/**). Colorado's so-called "oil price" is actually a computed oil price composite index. This weighted index is based on the geographic quadrant of the state in which the production occurs (NW, SW, NE, or SE) and the refinery that is purchasing the production (ChevronTexaco, Shell, Suncor or Valero) (figs. 13 and 14).

Using the formulation highlighted in the box below, the state's average oil price is weighted relative to the volumes purchased and the price paid. This oil index has shown strong growth in recent years. Since 2002, oil prices have increased nearly three-fold from $23.52 per barrel to $65.48 per barrel in 2007 (fig. 15).

> ***Colorado Weighted Average Oil Price Composite Index*** =
> 0.35 NW (ChevronTexaco) + 0.05 SW (Western Refining) +
> 0.40 NE (Suncor) + 0.20 SE (Valero)

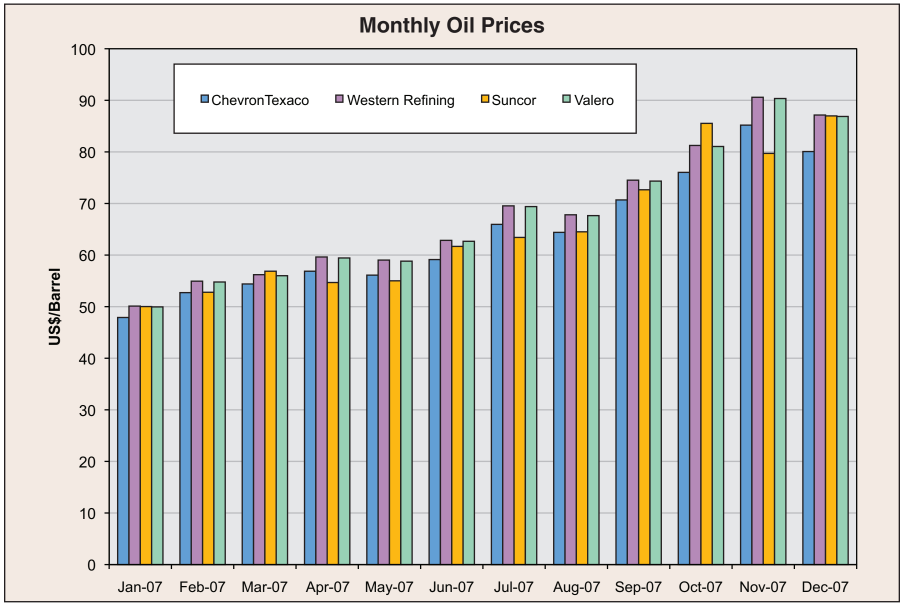


Figure 14. Oil prices paid by the various refiners generally vary by $5 per barrel or less. Prices steadily increased throughout 2007, beginning the year near $50 per barrel and ending in the mid-$80s—a remarkable 72 percent increase for the year (COGCC, 2007).

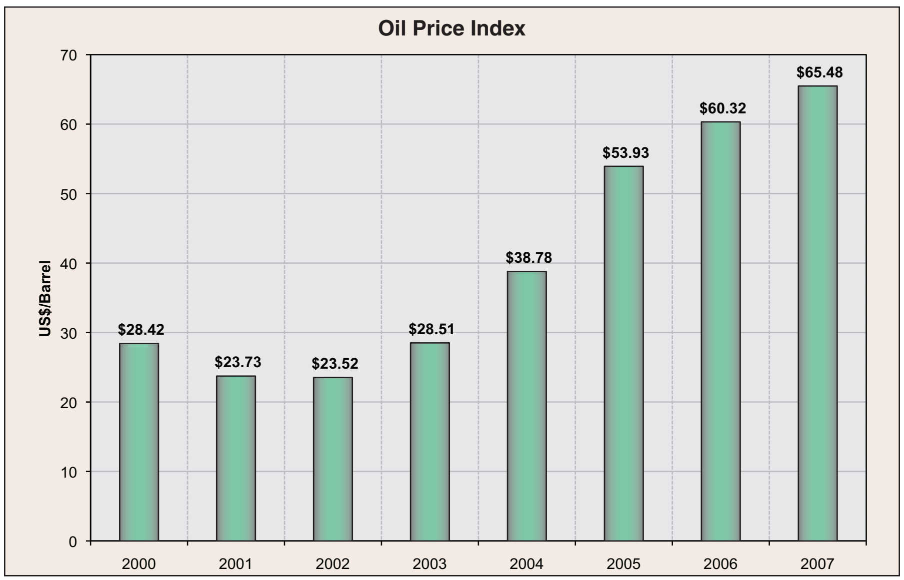


Figure 15. Colorado's oil price index has increased nearly three-fold since 2002, rising sharply from $23.52 per barrel in 2002 to $65.48 per barrel in 2007 (COGCC, 2007).

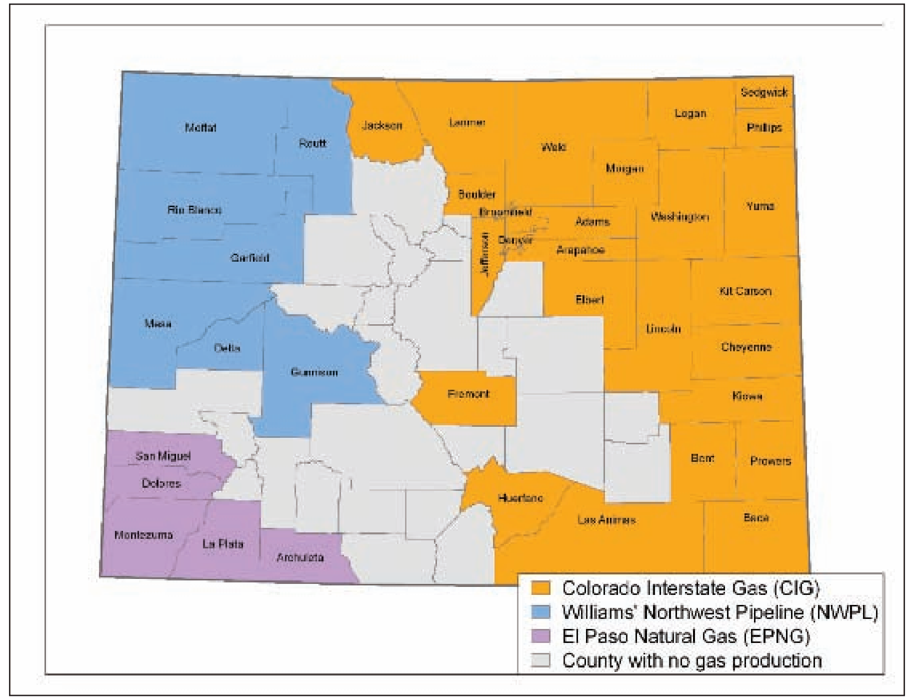


Figure 16. Gas produced in eastern Colorado is transported via Colorado Interstate Gas (CIG). Williams' Northwest Pipeline (NWPL) takes the gas produced in the northwestern part of the state, and El Paso Natural Gas (EPNG) takes the gas produced in the southwestern part of the state (COGCC, 2007). Figure 32 in the Natural Gas Distribution section provides a simplified natural gas pipeline map for the western U.S.

As with Colorado's oil index, the often-quoted "natural gas price" is also a computed composite index. This weighted index is based on the geographic area of the state in which the production occurs and the pipeline infrastructure that it supplies (figs. 16 and 17). Natural gas is priced according to its Btu-content (British thermal units), a price that varies with increasing concentrations of non-methane components.

Using the formulation highlighted in the following box and figure 17, the state's average gas price is weighted relative to the transporting pipeline and the price paid. This index has shown strong recovery in recent years, particularly between 2002 and 2005. Gas prices increased from an annual average of $2.42 per Mcf in 2002 to $7.39 in 2005, representing a three-fold increase in four years. Since the nation-wide price spikes resulting from the 2005 Gulf Coast hurricane season, gas prices in Colorado have declined 30 percent to an annual average of $5.15 per Mcf in 2007 (fig. 18).

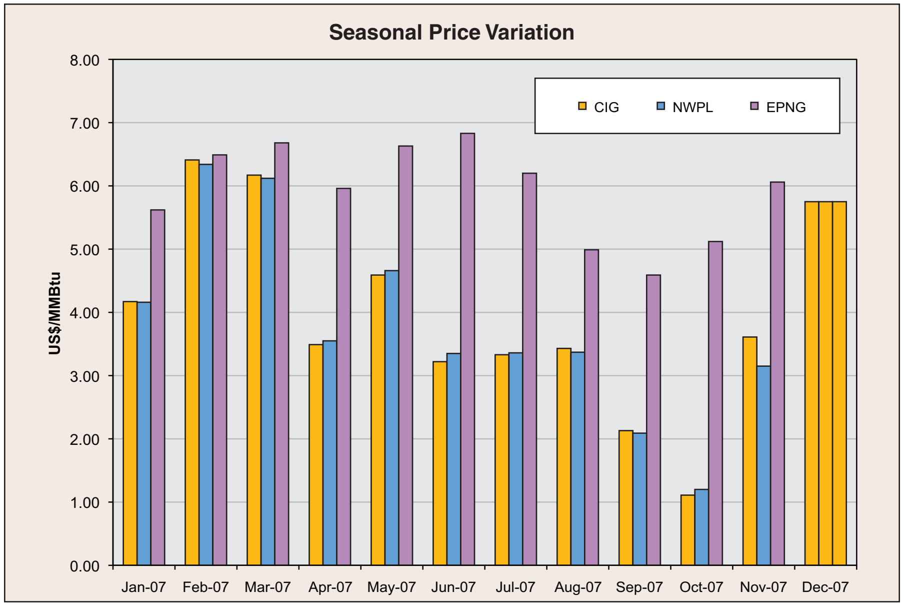


Figure 17. Seasonal variations in gas prices are typical—higher prices in colder months and lower prices in warmer months. In previous years, prices for all three pipeline companies have more closely tracked each other. However, EPNG has been able to support higher gas prices in 2007 because it has access to southwestern markets. The lower prices for CIG and NWPL reflect the constrained production in the Rockies (COGCC, 2007). An average CIG price of $5.75 was assumed for the entire state for December 2007.

Colorado Weighted Average Gas Price Composite Index =
0.20 Rocky Mountains (Northwest Pipeline) +
0.50 San Juan Basin (El Paso Natural Gas Pipeline) +
0.30 Rocky Mountains (Colorado Interstate Gas Pipeline)

The opening of the Kern River pipeline expansion in mid-2003 provided Colorado operators (among others in the Rockies) the opportunity to compete in markets in California. This increased competition provided stronger natural gas prices for Colorado producers (fig. 18). Prior to the opening of the Kern River expansion, Colorado gas prices were falling because of limited pipeline capacity to transport Colorado natural gas to other markets. The post-Kern River pipeline period saw a significant expansion in the gas market, yielding more favorable prices for Colorado producers. However, as existing pipelines have approached their full capacity, gas prices in Colorado have once again declined. The new, Rockies Express pipeline is expected to reverse this trend.

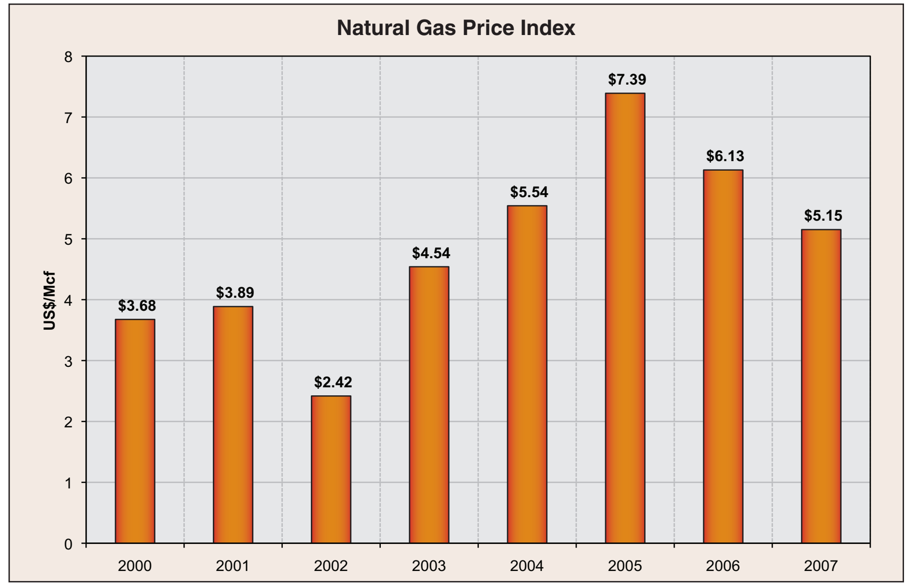


Figure 18. Gas prices increased three-fold between 2002 and 2005. Since the nation-wide price spikes resulting from the 2005 Gulf Coast hurricane season, gas prices in Colorado have declined 30 percent to an annual average of $5.15 per Mcf in 2007; Mcf = Thousand Cubic Feet (COGCC, 2007).

Production Volumes and Values

For the fifth consecutive year, natural gas production in Colorado exceeded 1 trillion cubic feet (Tcf) (fig. 19). Natural gas production in 2007 is estimated to be 1.321 Tcf which is a 8.9 percent increase from the 1.213 Tcf produced in 2006 (Vince Matthews, Colorado Geological Survey, written communication). Colorado's annual gas production in 2006 represented six percent of total U.S. production, making Colorado the 7th largest gas producing state in the nation (EIA, 2007b). In 2003, coalbed methane production represented 50 percent of the total natural gas produced in Colorado. Since then, coalbed methane production has fallen from 500 billion cubic feet (Bcf) in 2003 to 460 Bcf in 2007, representing an eight percent decline.

Oil production in 2007 is estimated to be 22.9 million barrels, a three percent decrease from the 23.6 million barrels produced in 2006 (fig. 20). Although growth in oil production had been slow and steady since 2000, a modest decline in oil sales is expected for 2007 because of slower than expected growth in natural gas production. The processing of raw natural gas (as produced at the wellhead) results in natural gas liquids and natural gas condensate, among many other things. These liquid products as well as crude oil are counted as oil. Thus, when gas production moderates, liquids or oil production often moderates as well.

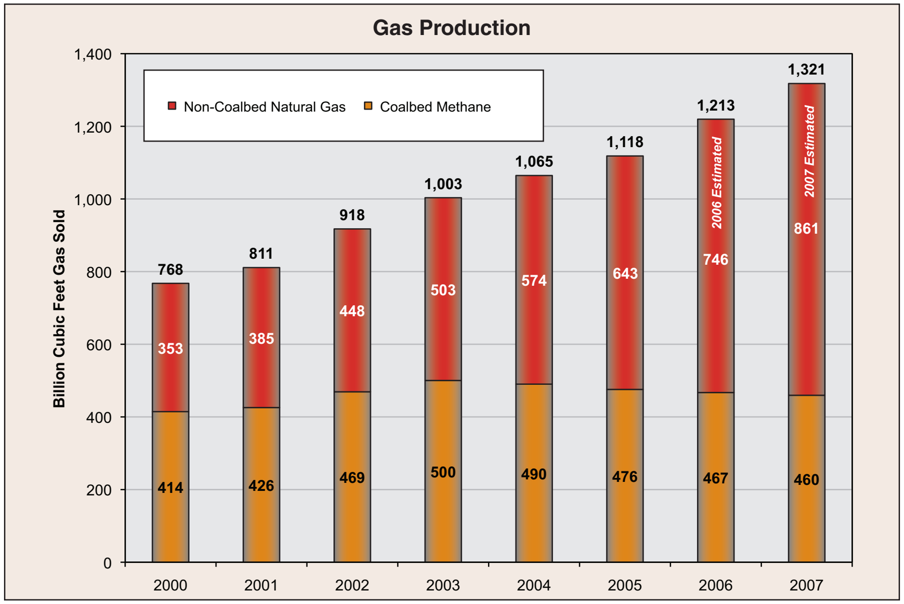


Figure 19. Colorado is the 7th largest gas producing state in the nation and for the fifth consecutive year, the state's natural gas production exceeded 1 Tcf (COGCC, 2007; EIA, 2007b; Bentek Energy, 2008).

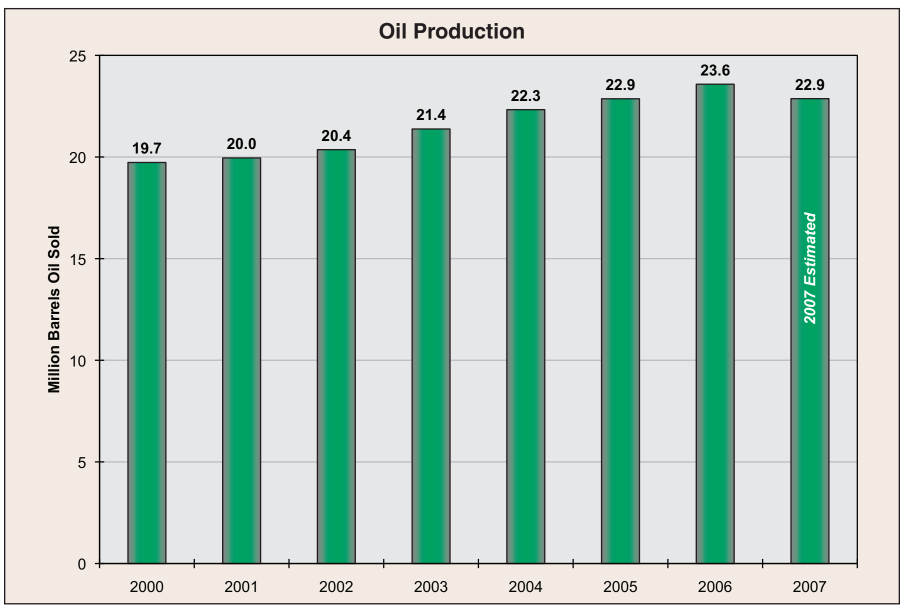


Figure 20. Colorado oil sales declined about three percent in 2007 (COGCC, 2007).

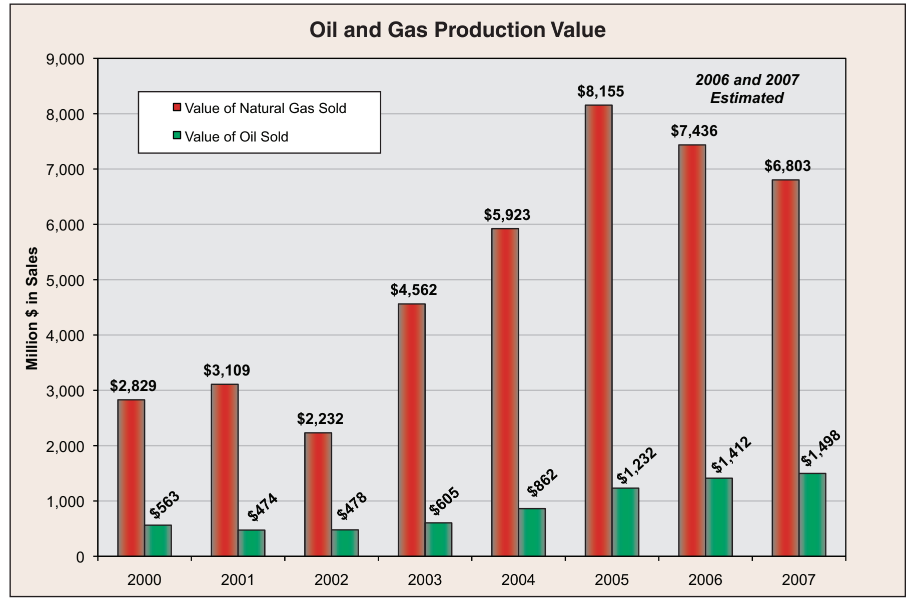
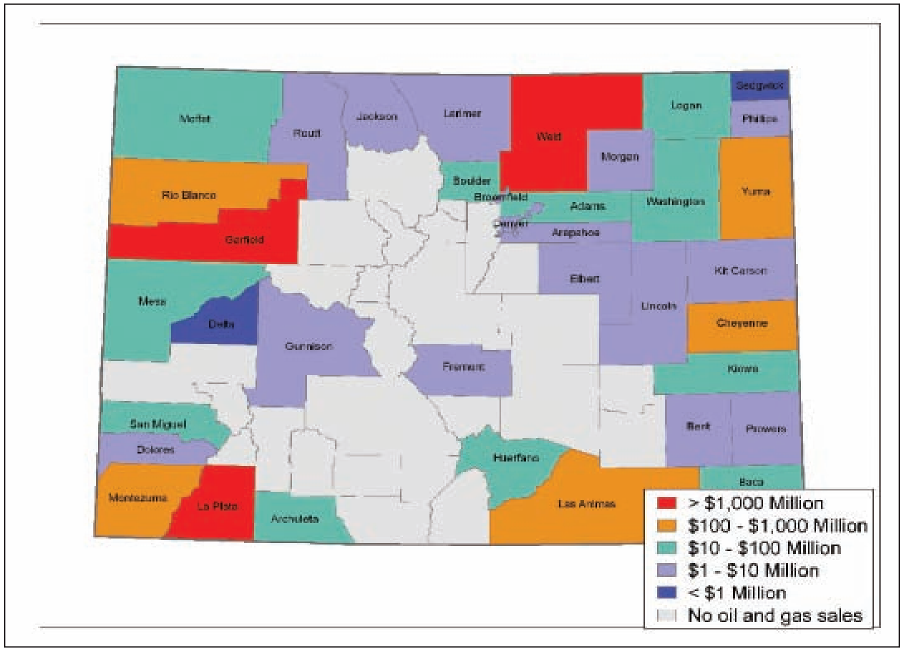


Figure 21. The value of natural gas sales estimated for 2007 represents about 83 percent of the 2005 peak value of $8.155 billion; oil value has shown only a modest gain this year (COGCC, 2007).

The combined value of oil and natural gas production in Colorado is estimated at $8.30 billion for 2007, a 12 percent decline from the state's record-breaking high in 2005 of $9.39 billion (fig. 12). Of this value, $6.803 billion (82 percent) is from the sale of natural gas, with 35 percent of the natural gas value from coalbed methane (fig. 19). The value of natural gas sales estimated for 2007 represents 83 percent of the 2005 peak value of $8.155 billion. The continued decline in gas prices in Colorado (fig. 18) is the primary reason for the decline in natural gas value. Even with the constraints of limited pipeline export capacity, the value of natural gas sales in Colorado is up more than two-fold since 2000.

The estimated value of oil sales for 2007 is $1.498 billion which is up six percent from the 2006 value of $1.412 billion (fig. 21). Continued strong oil prices (fig. 15) are offsetting the decline in oil production for 2007 (fig. 20). The value of 2007 oil production represents a three-fold increase since hitting a low of $474 million in 2001, just six years ago.



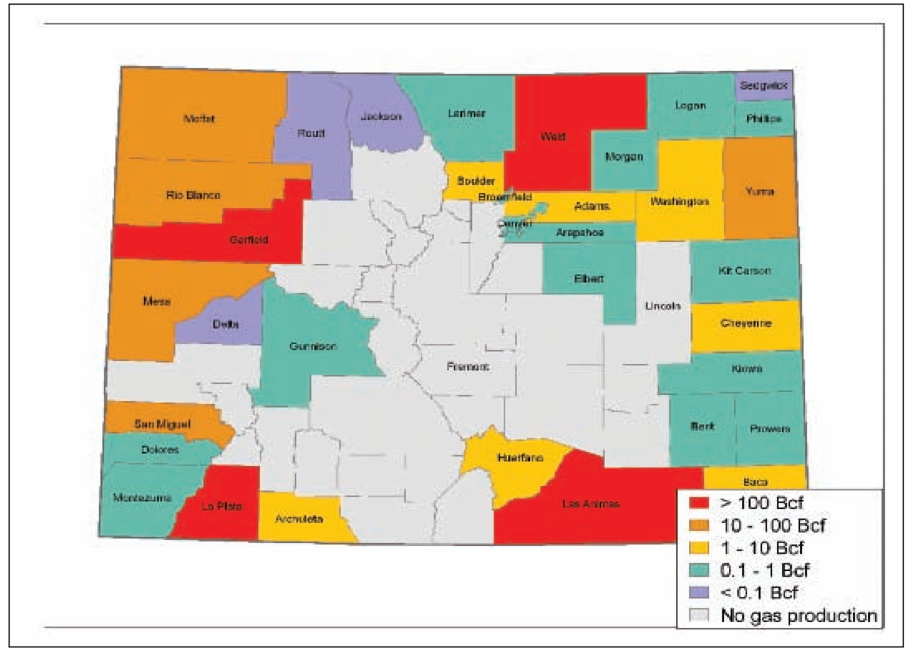
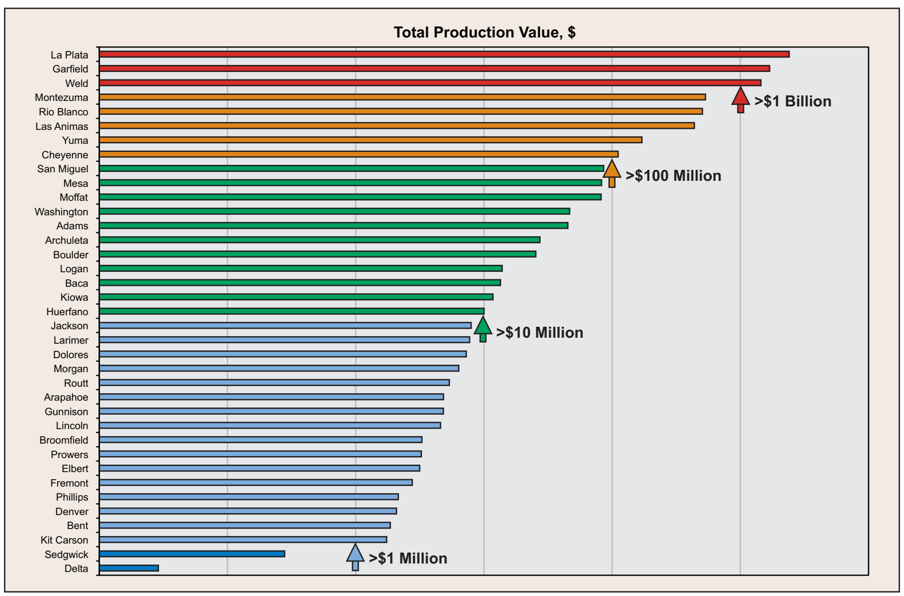
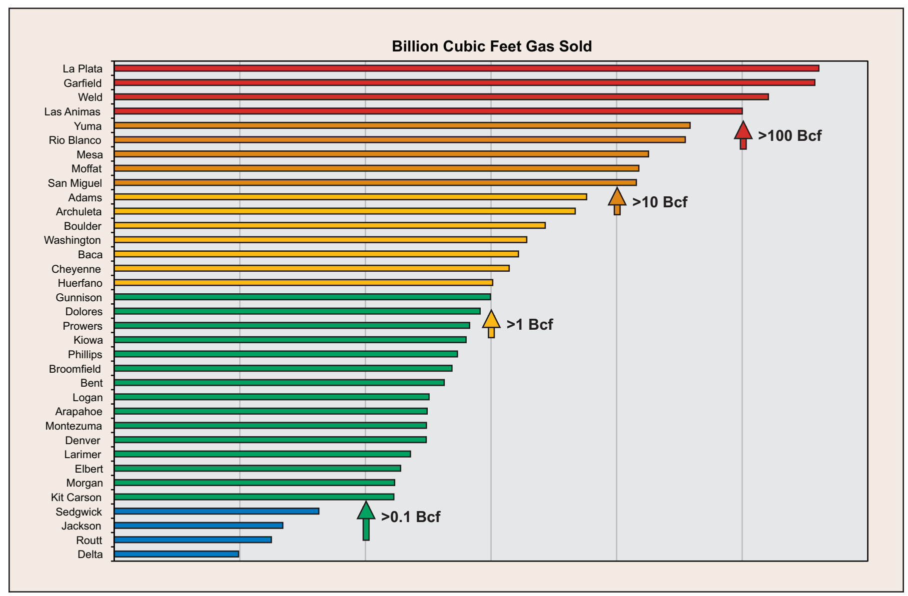


Figure 22. Colorado has eight counties in which the annual production value is estimated to exceed $100 million; in combination, they represent 93 percent of the total production value for Colorado (COGCC, 2007). Map view above; logarithmic-scaled chart below.

Figure 23. Colorado has nine counties that will produce more than 10 billion cubic feet (Bcf) of natural gas in 2007 which represents 98 percent of the total gas production for Colorado (COGCC, 2007). Map view above; logarithmic-scaled chart below.





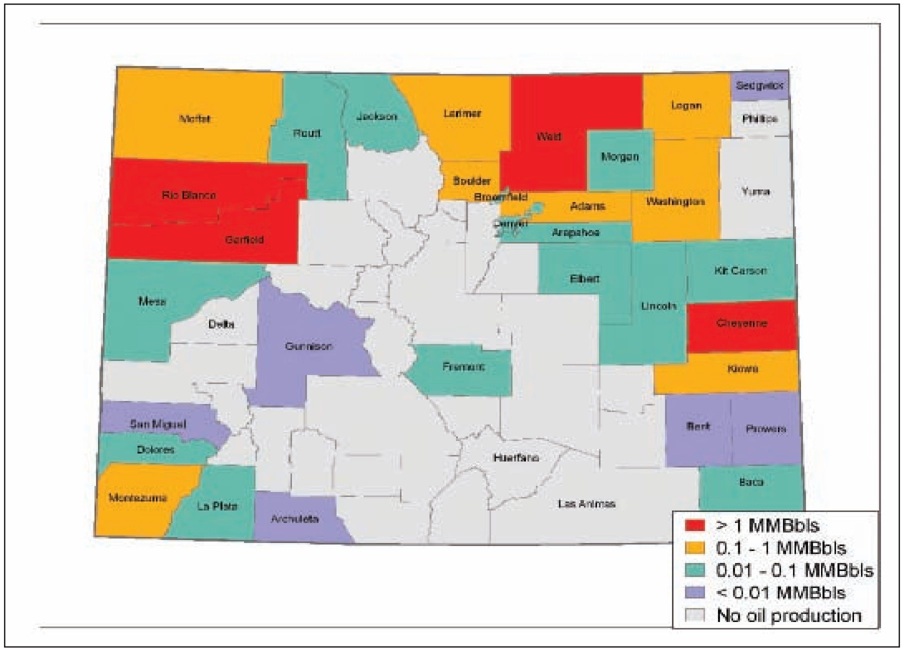
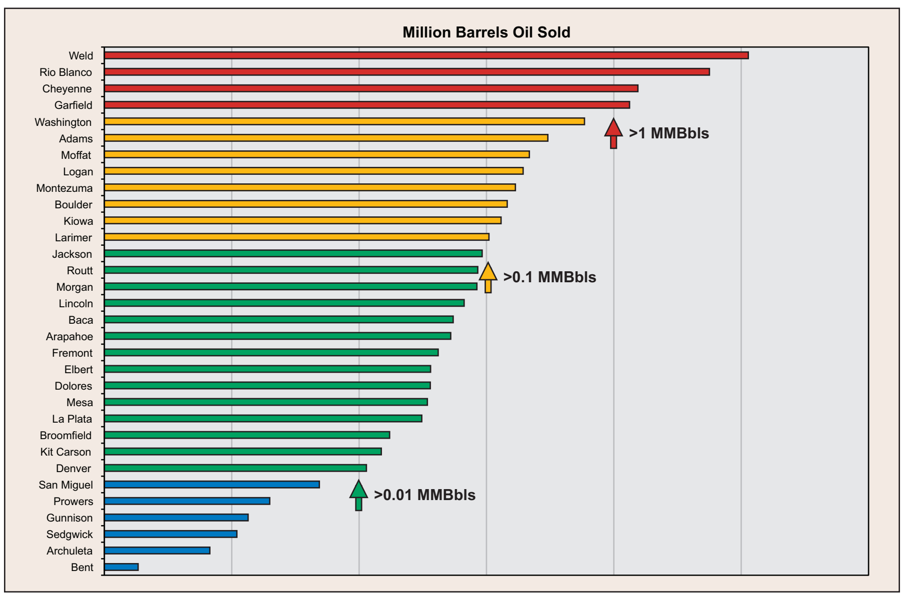


Figure 24. The four top oil producing counties in Colorado will each produce more than 1 million barrels (MMBbls) of oil in 2007 or 89 percent of the total oil production for Colorado (COGCC, 2007). Map view above; logarithmic-scaled chart below.



County Rankings

Thirty-seven (or 57 percent) of Colorado's 65 counties produce either oil or natural gas, often both. For the purpose of ranking each county's contribution to the total value of the state's production, the monthly sales volumes for each county are multiplied times the appropriate monthly oil and gas prices (fig. 14 and 17) and then summed for the year. (The sales volumes for the last half of 2007 are incomplete at the time this ranking is determined.) Based on the resulting production values computed for 2007, Colorado has three counties in which the annual production value is estimated to exceed $1 billion (La Plata, Garfield, and Weld) and five counties in which the annual production value is estimated at $100 million or more but less than $1 billion (Montezuma, Rio Blanco, Las Animas, Yuma, and Cheyenne) (fig. 22). The combined production value for these eight counties represents 93 percent of the total production value for Colorado.

A significant portion of this value results from the production of natural gas. The top ranking counties based on volume sold of natural gas in 2007 are La Plata, Garfield, Weld, and Las Animas each with sales in excess of 100 Bcf for the year; Yuma, Rio Blanco, Mesa, Moffat, and San Miguel counties each had sales of natural gas production in excess of 10 Bcf during the same period (fig. 23). These nine counties account for 98 percent of the total gas production sold in 2007. The top ranking counties based on volume sold of oil production in 2007 are Weld, Rio Blanco, Cheyenne, and Garfield with each reporting the sale of more than 1 million barrels of oil or 89 percent of the oil sold in the State of Colorado (fig. 24).

Field Rankings and Activity

The county rankings reflect the diversity in Colorado's oil and gas resource base. La Plata County is home to Ignacio–Blanco, the largest gas producing field in Colorado. Nearly 90 percent of the gas sold in La Plata County is produced from coal beds of the Late Cretaceous Fruitland Formation. Oil and gas production also occur from deeper horizons within the basin's Cretaceous sequence, including the Lewis Shale, Mesaverde Group, Mancos Shale, and Dakota Sandstone. The San Juan Basin Gas Area of Colorado and New Mexico ranked as the leading U.S. natural gas area in both production and proved reserves in 2006 (EIA, 2007b).

The Wattenberg field in the Denver Basin ranked as the 8th largest field in the U.S. both in terms of gas proved reserves and gas production in 2006 (EIA, 2007b). Wattenberg ranked 26th in oil production and 16th in oil proved reserves in 2006. Although the Wattenberg field straddles several counties within the Denver Basin, a significant portion of the field's production is located in Weld County. The western part of the basin, which is located along the eastern edge of the Front Range, is rich in both oil and gas resources. The vast majority of production comes from the Cretaceous Dakota Group's Muddy J Sandstone and the Niobrara–Codell sequence. Production also occurs from the D Sandstone and the fractured Pierre Shale. During 2007, the Wattenberg field's production averaged about 20,400 barrels of oil and 0.33 Bcf of gas each day. The liquid production is comprised of approximately 45 percent crude oil, 23 percent gas condensate, and 32 percent natural gas liquids (Wally O'Connell, Kerr-McGee, personal communication). Within the eastern portion of the Denver Basin, the relatively shallow Cretaceous Niobrara Chalk is now making a significant contribution through the production of biogenic gas—a play that is centered in Yuma County (CGS, 1999).

The Piceance Basin has recently been referred to as the "Persian Gulf of natural gas" (*Denver Post*, March 10, 2006). This remarkable center of natural gas drilling activity is located in Garfield and Rio Blanco counties and is receiving nationwide attention because of its strategically important gas resources. The Piceance Basin hosts five fields with natural gas proved reserves in the nation's "Top 100" list of fields; four of these fields are ranked in the "Top 50" (EIA, 2007b). Four of these fields are located along Interstate Highway 70 in Garfield County. Significant gas production occurs from the Paleocene—Late Cretaceous Fort Union Formation and the Late Cretaceous Mesaverde Group sandstones and coalbeds. In addition, significant oil production occurs from a thick interval spanning the Cretaceous to Pennsylvanian, including the Mancos Shale, Morrison Formation, Entrada Sandstone, the Shinarump Member of the Chinle Formation, and the Weber Sandstone. The Rangely field, which is located in the northwestern Piceance Basin, produces from the prolific Permo-Pennsylvanian Weber Sandstone and accounts for Rio Blanco County ranking second in the sale of oil production for the state. Rangely is one of the largest oil fields in the Rocky Mountains, ranking 61st in the U.S. in terms of oil proved reserves and 53rd in terms of oil production in 2006 (EIA, 2007b).

There is also intense development activity in southeastern–south central Colorado. Oil (and some associated gas) production in Cheyenne County occurs from Mississippian- and Pennsylvanian-age sandstone and limestone reservoirs along the Las Animas Arch that separates the Hugoton Embayment from the Denver Basin. The Raton Basin located in western Las Animas County is the site of aggressive coalbed methane development within the Tertiary and Late Cretaceous Raton and Vermejo Formations. The Raton Basin Gas Area of Colorado and New Mexico ranked 9th in the nation in proved gas reserves and 17th in gas production in 2006 (EIA, 2007b).

San Miguel County in the northern Paradox Basin reports the sale of more than 10 Bcf of gas produced from the Permo-Pennsylvanian Cutler and Hermosa Groups and the deeper Mississippian Leadville Limestone.

Moffat County includes both the northernmost part of the Piceance Basin and the western two-thirds of the Sand Wash Basin. Oil and gas sales are reported from numerous intervals from the Paleocene to deeper Pennsylvanian-age rocks. These include the Paleocene-Cretaceous Wasatch-Fort Union formations, Cretaceous Lance-Fox Hills-Lewis-Almond interval, Mesaverde Group sandstones, Mancos-Niobrara-Mowry shales, Dakota Group, Jurassic Morrison-Sundance-Entrada-Nugget sequence, Permo-Triassic Shinarump-Moenkopi-Phosphoria formations, Permo-Pennsylvanian Weber-Minturn formations.

Drilling Activity

The COGCC reports 7,291 applications for permit to drill (APDs) were received during 2007, representing nearly a 12.6 percent increase over the 6,474 APDs received in 2006 (fig. 25). Of those received in 2007, 129 were withdrawn and 6,586 applications were approved; 576 remained to be processed at year-end. The vast majority of the applications approved during 2007 were for drilling new wells or sidetracking existing wellbores; that is, 96 percent or 6,339 permits were approved for drilling new wells (fig. 26). The remaining 247 permits consisted of requests for deepening, recompleting, or re-entering existing wellbores.

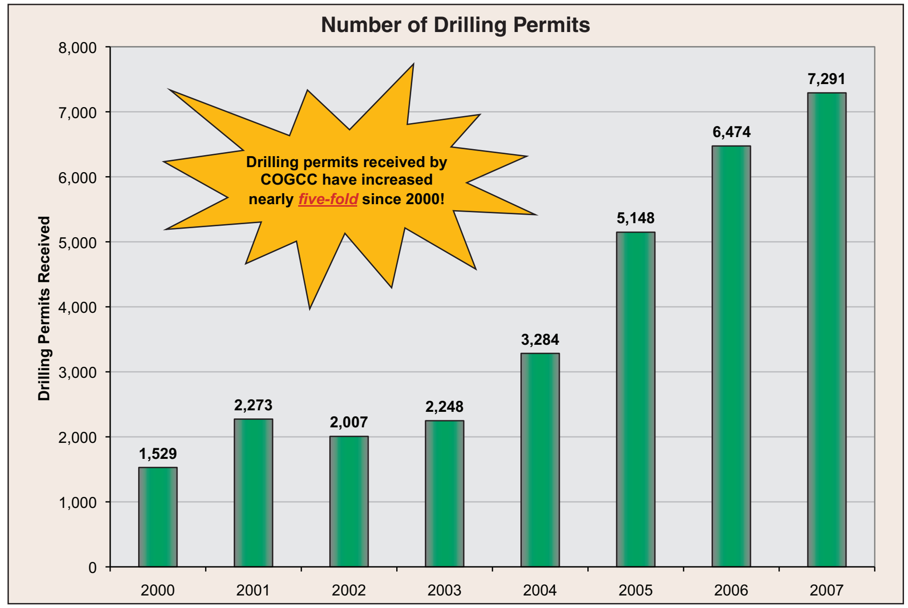


Figure 25. Drilling permits received by the COGCC since 2000 have increased nearly five-fold since 2000 (COGCC, 2007).

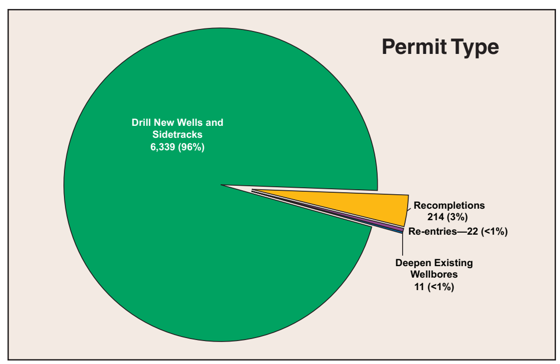


Figure 26. The vast majority of drilling permits approved during 2007 were for drilling new wells or sidetracking existing wellbores (COGCC, 2007).

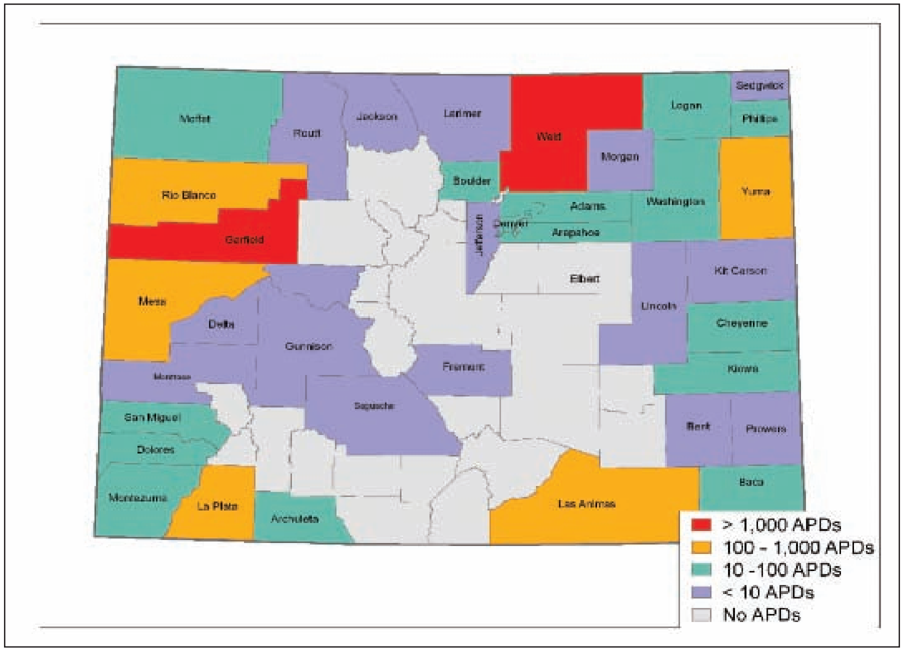
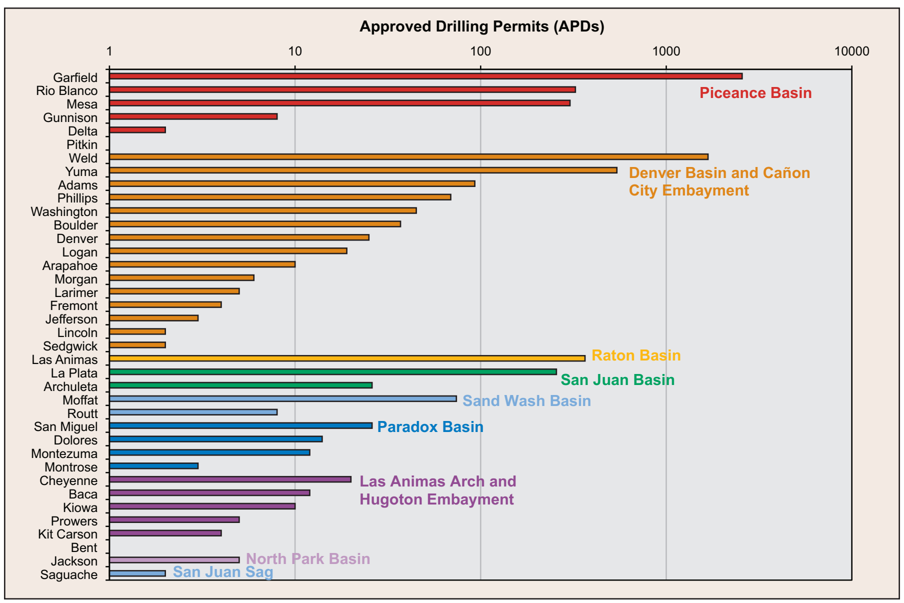


Figure 27. The two counties for which the most drilling permits were approved in 2007 were Garfield and Weld, reflecting the active development efforts taking place in the Piceance and Denver basins, respectively (COGCC, 2007). Map view above; logarithmic-scaled chart below.



The two counties for which the most drilling permits were approved in 2007 are Garfield and Weld (fig. 27), reflecting the active development efforts taking place in the Piceance and Denver basins, respectively. Of the 6,586 total applications that were approved in 2007, 87.2 percent or 5,743 were for drilling activity in the Piceance and Denver basins (fig. 28). Proposed drilling activity continued to be very strong in 2007 for Colorado's two mature coalbed methane plays with the approval of several hundred drilling permits for both the Raton and San Juan basins (365 and 282, respectively). In addition, applications were also approved for emerging resource areas such as the coalbed methane potential in the Sand Wash and North Park basins. Applications were approved for Lexam Explorations to drill two wells in Saguache County to test the gas resource potential of the Dakota Formation in the San Juan Sag.

The monthly average rotary drill rig count for Colorado was 107 during 2007, up more than 20 percent from the average of 89 for 2006 (Baker Hughes, 2008). This average represents six percent of the total 1,769 onshore rigs operating in the U.S. during 2007.

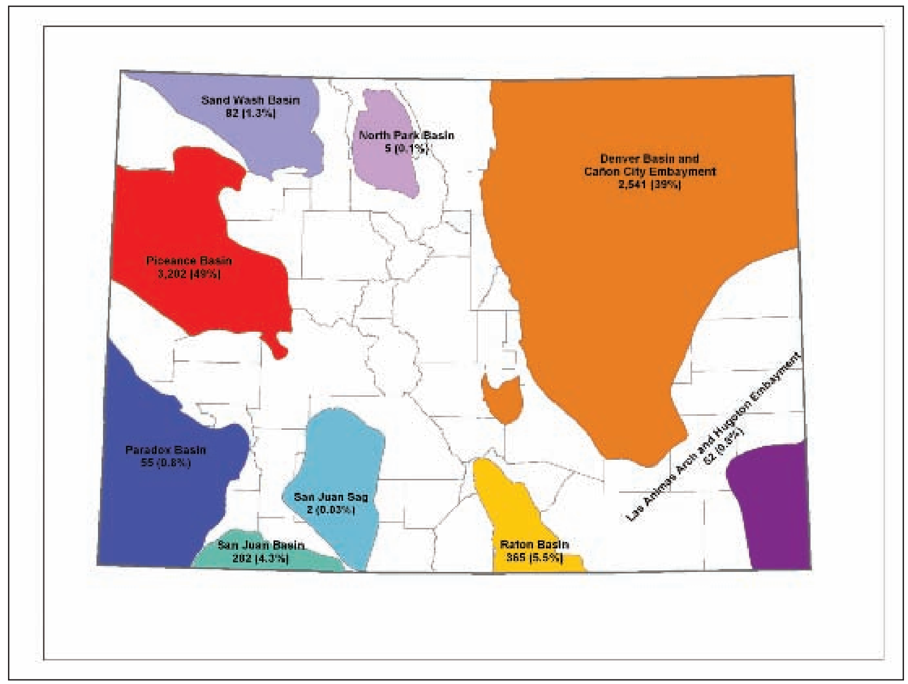


Figure 28. Of the 6,586 total applications that were approved in 2007, 87.2 percent or 5,743 were for drilling activity in the Piceance and Denver basins (COGCC, 2007).

PI/Dwights (IHS Inc.) reports 1,709 total well completions for 2007, down nearly 50 percent from the total of 3,347 reported for 2006. Five operators accounted for 57 percent of all well completions in the 2007-drilling program, most of which focused on development drilling in the Denver and Piceance basins (fig. 29).

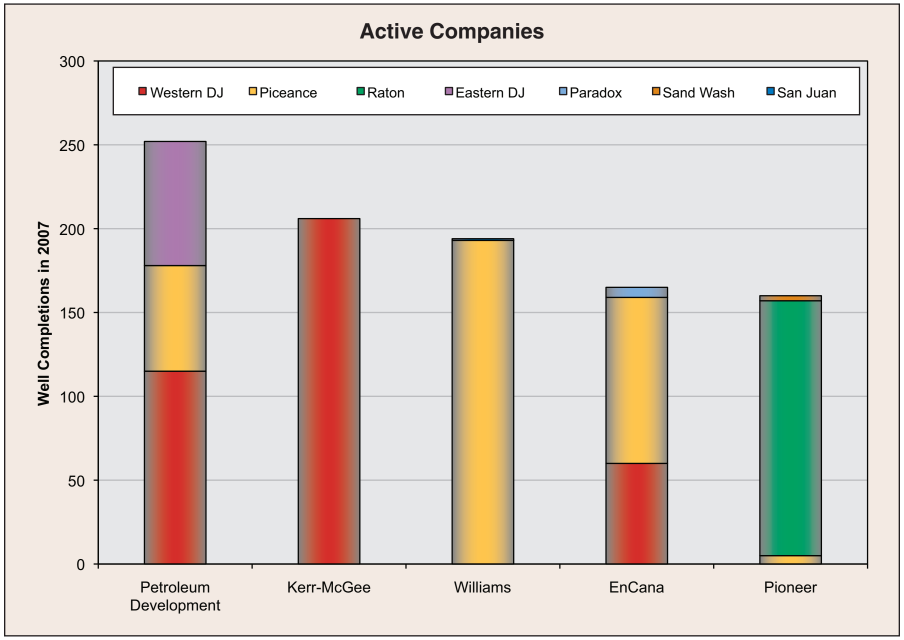


Figure 29. Five companies were responsible for 100 or more well completions in 2007 with the greatest activity occurring in the western Denver Basin and the Piceance Basin (I.H.S. Energy PI/Dwights Well Database, February 1, 2008).

Reserves

The Energy Information Administration (EIA) defines "proved reserves" as those volumes of oil and gas that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Proved reserves are either proved producing or proved non-producing. Non-producing reserves are considered by the Security and Exchange Commission to be "proved" when supported by surrounding well control and have been certified by engineering staff. Non-producing reserves may represent a substantial fraction of total proved reserves. Reserves data discussed below for crude oil, natural gas, and coalbed methane are reported by the EIA and lag by one year the production and price information available from the COGCC.

Crude Oil

Colorado had an estimated 268.3 million barrels of proved reserves of crude oil as of December 31, 2006, which represents an increase of 7.2 percent or 18.1 million barrels from the end of 2006 (fig. 30; EIA, 2007b). Acquisitions and field extensions added 87 million barrels which more than offset estimated production of 23.9 million barrels and other downward adjustments of 45 million barrels, resulting in net reserves additions of crude oil in Colorado. In contrast, crude oil proved reserves fell nationally by four percent, decreasing from 21,757 million barrels for 2005 to 20,972 million barrels for 2006 (EIA, 2007b). The principal factors contributing to the national decline were lower than average net revisions and adjustments and fewer total discoveries.

Colorado's increase in crude oil proved reserves resulted primarily from acquisitions and extensions to existing oil fields; no new field discoveries or new reservoir discoveries in old fields were reported for 2006 (EIA, 2007b). There was some adjustment to previously reported reserves which is common as infill wells are drilled, well performance is analyzed, new technology is applied, or economic conditions change. The largest upward move in oil reserves is related to the continued development efforts in the Greater Wattenberg Area of the Denver Basin.

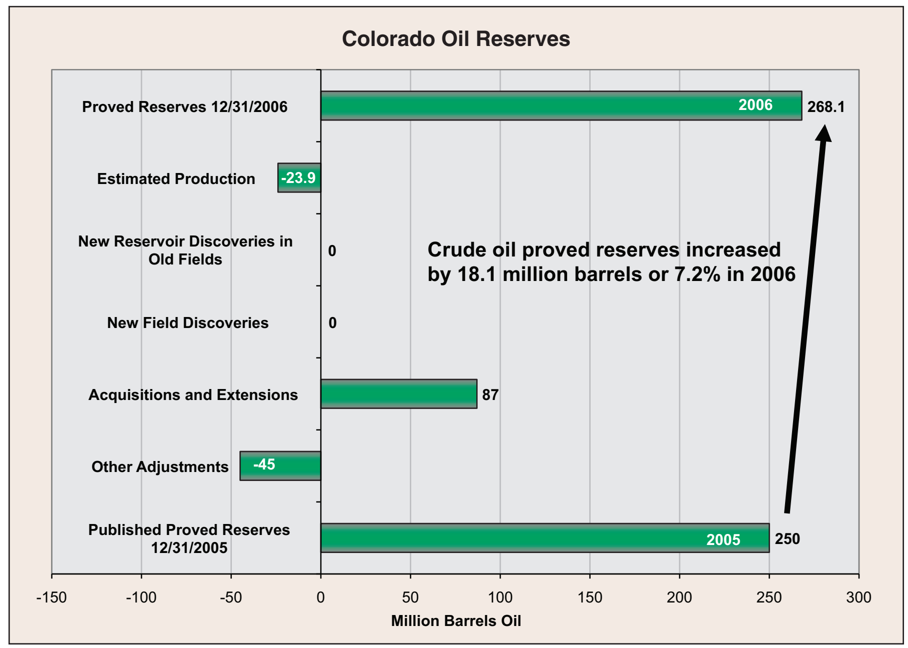


Figure 30. Colorado crude oil proved reserves increased from 250 million barrels in 2005 to 268.1 million barrels in 2006, representing a 7.2 percent gain (EIA, 2007b).

Not all proved reserves of crude oil reported in 2006 were producing. Colorado reported 102 million barrels of proved crude oil reserves in non-producing status, 37.8 percent more than the 74 million barrels reported in 2005 (EIA, 2007b; EIA, 2006). In addition, Colorado reported 40 million barrels of proved lease condensate reserves in non-producing status, 11.1 percent less than the 36 million barrels reported in 2005. Non-producing reserves are those awaiting well workovers, the drilling of extensions or additional development wells, installation of production or pipeline facilities, and depletion of other zones or reservoirs before recompletions in reservoirs not currently open to production.

The top 100 oil fields account for over two-thirds of U.S. crude oil proved reserves. The EIA (2007) ranked the top 100 oil fields based on reserves reported for 2006. Colorado has two fields in the top 100—Wattenberg and Rangely. The Wattenberg field, discovered in 1970 in the Denver Basin, ranked as the 16th largest oil field in the nation based on liquids proved reserves (liquids includes both crude oil and lease condensate). The Rangely field, discovered in 1902 in the Piceance Basin, ranked as the 61st largest oil field based on liquids proved reserves.

Natural Gas

The EIA defines "dry" natural gas as the actual or calculated volumes of natural gas that remain after: (1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation), and (2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable.

Proved reserves of U.S. natural gas increased by three percent in 2006, bringing the national total to 211 Tcf, the highest level since 1976 (EIA, 2007b). Seven areas account for 81 percent of the nation's dry natural gas proved reserves; among this list is Colorado with eight percent of total U.S. gas reserves (table 2). The EIA (2007) reports that Colorado dry natural gas proved reserves increased by 0.365 Tcf during 2006 which represents a two percent increase from the 16.596 Tcf reported for 2005 (fig. 31).

Table 2. Ranking of top U.S. gas reserve areas for 2007.

Gas Reserves by State/Area	Percent of U.S. Gas Reserves	Proved Gas Reserves, Tcf
Texas	29	61.8
Wyoming	11	23.5
New Mexico	8	17.9
Oklahoma	8	17.5
Colorado	8	17.1
Gulf of Mexico Federal Offshore	7	14.5
Louisiana	5	10.5
Alaska	5	10.2
Area Total	**81**	**173.0**

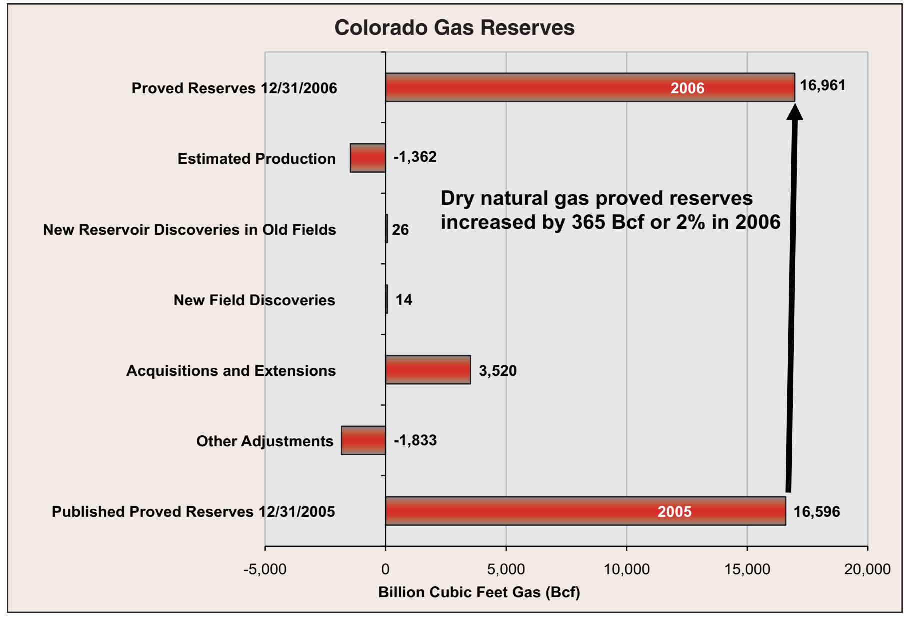


Figure 31. Colorado dry natural gas proved reserves increased from 16.6 Tcf in 2005 to an estimated 17.0 Tcf in 2006, representing a two percent gain (EIA, 2007b).

Total discoveries are those reserves attributable to field extensions, new field discoveries, and new reservoir discoveries in old fields; they result from drilling exploratory wells. Colorado was one of the seven areas in the nation that reported total discoveries of dry natural gas exceeding 1 Tcf in 2006. Ranking fourth largest, Colorado reported 2,020 Bcf in total discoveries in 2006 or 8.7 percent of the U.S. total of 23,342 Bcf (EIA, 2007b). (Texas, Wyoming, and Oklahoma ranked in first, second, and third, respectively.) The largest component of total discoveries in 2006 was extensions of existing gas fields. Nationally, extensions were 21,778 Bcf, three percent more than 2005 and 61 percent more than the prior 10-year average. Again, Colorado ranked fourth largest with nine percent of the total U.S. extensions in 2006 (EIA, 2007b).

Colorado reported 6.7 Tcf of total proved gas reserves in non-producing status in 2006, 34 percent more than the 5.0 Tcf reported in 2005 (EIA, 2007b; EIA, 2006). These "behind pipe" reserves consisted of 5.8 Tcf of non-associated gas and 0.9 Tcf of associated-dissolved gas. Non-associated natural gas is that which is not in contact with significant quantities of crude oil in the reservoir. Associated-dissolved natural gas is the combined volume of natural gas, which occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved).

Parts of eight of the nation's largest 100 gas fields are in Colorado—San Juan Basin Gas Area, the Wattenberg field in the Denver Basin, Raton Basin Gas Area, and the Grand Valley, Parachute, Mamm Creek, Rulison, and Piceance Creek fields in the Piceance Basin (EIA, 2007b; table 3). Two of these—the San Juan and Raton Basin Gas Areas are shared with New Mexico. Of these gas-rich areas, the San Juan Basin Gas Area, Wattenberg field, and the Raton Basin Gas Area rank in the top 10 in the U.S. Most notably, the Ignacio Blanco/Blanco gas fields of the San Juan Basin Gas Area in Colorado and New Mexico represent the largest proved gas reserves for the entire nation and also have the highest combined gas production of 1.4 Tcf estimated for 2006.

Table 3. Colorado gas fields ranked in top 100 U.S. by proved gas reserves and gas production in 2006.

Colorado Gas Fields	Location	Discovery	Reserves Rank	Production Rank	Production Volume, Bcf
San Juan Basin Gas Area	CO & NM	1927	1	1	1,380.8
Wattenberg	CO	1970	8	8	176.0
Raton Basin Gas Area	CO & NM	1989	9	17	109.6
Grand Valley	CO	1985	22	24	88.3
Parachute	CO	1985	25	28	81.8
Mamm Creek	CO	1959	27	19	95.1
Rulison	CO	1958	28	34	65.4
Piceance Creek	CO	1930	52	>100	13.5

Coalbed Methane

Nationally, proved reserves of coalbed methane decreased 1.5 percent from 19.9 Tcf in 2005 to 19.6 Tcf in 2006 (EIA, 2007b). These reserves are included in the natural gas reserves discussed in the previous section. Coalbed methane accounted for nine percent of all 2006 dry natural gas reserves in the U.S. Six states (Colorado, New Mexico, Wyoming, Alabama, Virginia, and Utah) account for 93 percent of the U.S. coalbed methane proved reserves. ***Colorado ranks first in the nation for coalbed methane proved reserves with 32.3 percent of the U.S. total.*** Colorado reported 6.3 Tcf in coalbed methane reserves in 2006, down 6.3 percent from the 6.8 Tcf reported in 2005. New Mexico and Utah also reported declines in their proved coalbed natural gas reserves in 2006.

U.S. coalbed methane production increased two percent in 2006 to 1,758 Bcf and accounted for nine percent of the U.S. dry gas production (EIA, 2007b). Colorado coalbed methane production was 483 Bcf in 2006, representing a 1.6 percent decrease from the 491 Bcf reported for 2005 (COGCC, 2007). New Mexico produced about seven percent more coalbed methane in 2006 than Colorado (EIA, 2006).

Natural Gas Distribution

As the growth in natural gas supply shifts to new sources, the Rocky Mountains are emerging as one of the nation's key regions. Natural gas reserves in the Rocky Mountain States of Colorado, Utah, and Wyoming account for nearly 22 percent of the total natural gas reserves in the U.S., and are mostly located in unconventional tight gas or coalbed reservoirs. Recent natural gas spot market volatility in the Rocky Mountain region has been the result of increased production while consumption and pipeline export capacity have remained limited (EIA, 2007a).

Natural gas production in Colorado, Utah, and Wyoming has increased from an average of 5.49 Bcf per day (Bcf/d) in 2000 to 8.61 Bcf/d in 2006. Total natural gas volumes delivered to consumers in these three states are much less than the volumes produced, totaling 0.61 Tcf (average 1.66 Bcf/d) in 2006 which was only slightly above the level of deliveries in 2001 (EIA, 2007a). Pipeline capacity that exports natural gas flows from Colorado, Utah, and Wyoming was 8.49 Bcf/d in 2006. Efforts to increase the pipeline infrastructure in the Rocky Mountain States are expected to add roughly 1.5 Bcf/d of capacity to transport natural gas from the region by the end of 2008.

The Kern River Gas Transmission Company pipeline was placed in service in May 2003 and is currently the only major interstate natural gas system that begins in the Rockies and transports natural gas to western markets (fig. 32). Terminating in southern California, the Kern River system runs a distance of 1,680 miles and has a capacity of 1.8 Bcf/d (EIA, 2007a).

Natural gas can also be exported from the Rocky Mountain Region through interconnections with interstate pipelines that pass through the region. Most of these interconnections are located in the eastern parts of Nebraska, Kansas, and Missouri. Before 2004, the Trailblazer Pipeline Company provided the primary link from natural gas production facilities in Colorado and Wyoming to the Midwest Region (fig. 32). With 0.95 Bcf/d of capacity, the Trailblazer system transports natural gas to eastern Nebraska from northeastern Colorado's Cheyenne Hub. In 2004, the Cheyenne Plains Gas Pipeline Company added another major pipeline with significant flows from the Rocky Mountains to the east (Cheyenne, WY, to Greensburg, KS) (fig. 32). The first phase of the Cheyenne Plains project included 0.56 Bcf/d of new pipeline capacity, while the second phase added 0.17 Bcf/d to the system in 2005 to boost total transportation capacity to 0.73 Bcf/d. There have been no major additions to the interstate natural gas pipeline system in the Rockies since 2004.

Colorado Interstate Gas (CIG), a wholly owned pipeline company of El Paso, is a major transporter of natural gas in the Rocky Mountain region. The CIG pipeline system is connected to nearly every major supply basin in the Rocky Mountains as well as production areas in the Texas Panhandle, western Oklahoma, western Kansas, and Wyoming. CIG's system is the primary pipeline that

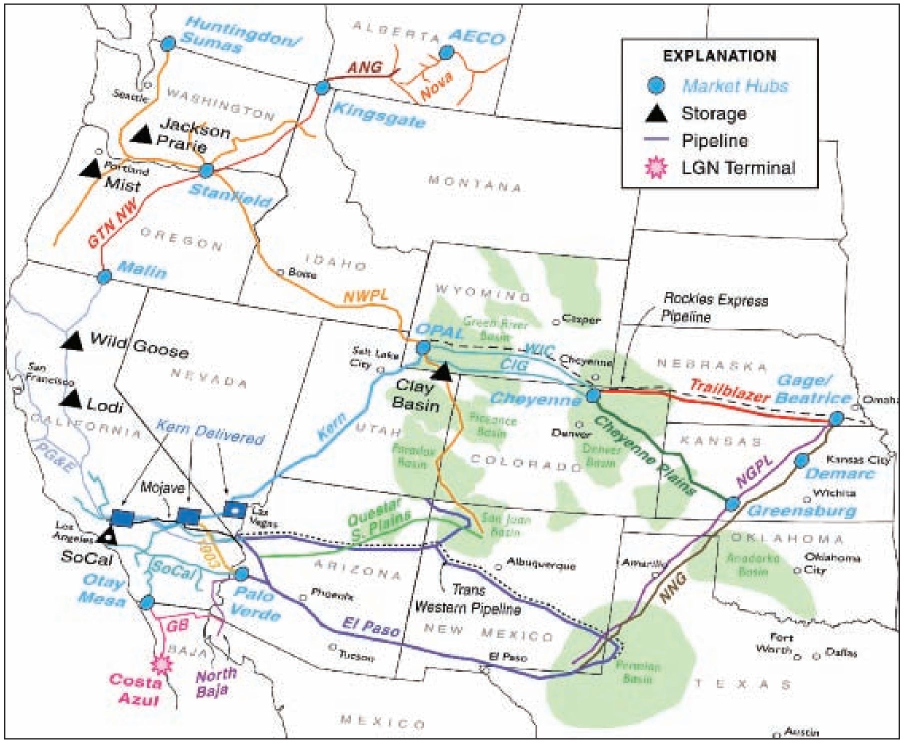


Figure 32. The interconnected pipeline grid for transporting natural gas out of Colorado and the Rocky Mountain basins is near the maximum capacity (modified after Harpole, 2007).

transports natural gas in eastern Colorado. CIG's connection to the Opal Hub in southwestern Wyoming moves Colorado natural gas to the Kern River pipeline system and western markets (fig. 32). CIG is also connected to the Cheyenne Hub in northeastern Colorado, where Colorado natural gas is transported to eastern markets via the Trailblazer and Cheyenne Plains pipeline systems.

Williams' Northwest Pipeline (NWPL) system is a primary artery for the transmission of natural gas to the Pacific Northwest and Intermountain Region. The pipeline is a 3,900-mile bi-directional transmission system crossing the states of Washington, Oregon, Idaho, Wyoming, Utah, and Colorado. Northwest's bi-directional system provides access to British Columbia, Alberta, Rocky Mountain, and San Juan Basin gas supplies. The NWPL system is one of the primary pipelines that transport natural gas out of western Colorado. As with CIG, NWPL's connection to the Opal Hub also moves Colorado natural gas to the Kern River pipeline system. In addition, NWPL has multiple connections to market hubs in the northwestern U.S.

Table 4. Natural gas pipeline capacity leaving Colorado for as of the end of 2006.

Pipeline	State From	State To	Capacity as of end of 2006 (MMcf/d)	Average Utilization in 2005 (%)
Colorado Interstate Gas*	CO	KS	294	16.7
Colorado Interstate Gas*	CO	KS	140	22.9
Cheyenne Plains Pipeline	CO	KS	730	65.6
KM Interstate Gas Co.	CO	KS	20	54.3
Southern Star Central Gas PL Co.	CO	KS	216	78.9
Total CO to KS	**CO**	**KS**	**1,230**	**60.3**
KM Interstate Gas Co.*	CO	NE	5	62.0
KM Interstate Gas Co.	CO	NE	5	62.0
KM Interstate Gas Co.	CO	NE	30	62.0
KM Interstate Gas Co.	CO	NE	255	62.0
KM Interstate Gas Co.	CO	NE	182	62.0
Trailblazer Pipeline Co.	CO	NE	945	89.1
Total CO to NE	**CO**	**NE**	**1,422**	**80.0**
El Paso Nat Gas Co.	CO	NM	790	88.4
Raton Gas Transmissions Co.	CO	NM	10	34.4
TransColorado Gas Trans Co	.CO	NM	692	73.6
Transwestern Pipeline Co.	CO	NM	705	73.1
Total CO to NM	**CO**	**NM**	**2,197**	**78.6**
Colorado Interstate Gas*	CO	OK	381	100
Total CO to OK	**CO**	**OK**	**381**	**100**
Total Pipeline Capacity Leaving Colorado			**5,225**	**76.3**

*Indicates bi-directional flow capacity. MMcf/d = Million cubic feet of gas per day. Source: EIA, 2007a.

El Paso Natural Gas (EPNG), a wholly owned pipeline company of El Paso, anchors the western end of El Paso's pipeline system, transporting natural gas from prolific basins in New Mexico, Colorado, Texas, and Oklahoma to growing markets in California, the southwestern U.S., and northern Mexico. The EPNG pipeline system is one of the primary transporters of natural gas out of southwestern Colorado.

Questar Corporation operates several pipelines that transport natural gas out of gas-rich basins in western Colorado. Questar Pipeline moves natural gas from the Sand Wash and Piceance basins in northwestern Colorado to connections with the Kern River pipeline system. In addition, Questar Southern Trails Pipeline transports natural gas from the Paradox and San Juan basins in southwestern Colorado to markets in southern California.

TransColorado Gas Transmission Co. is owned by Kinder Morgan Energy Partners, LP. The TransColorado natural gas pipeline system is 300 miles long and extends from the Greasewood area pipeline interconnects in Rio Blanco County, Colorado, to a point of interconnection with El Paso Natural Gas, TransWestern Pipeline, and Questar Southern Trails interstate pipelines at the Blanco Hub located in San Juan County, New Mexico.

The natural gas pipeline capacity leaving Colorado was 5.225 Bcf/d as of the end of 2006 (table 4). This represents 61.5 percent of the total export capacity for the Rocky Mountain Region; Utah has 2.409 Bcf/d or 28.4 percent of the total and Wyoming has 0.858 Bcf/d or 10.1 percent (EIA, 2007a). As of the end of 2006, 58 percent of Colorado's natural gas was transported east into Kansas, Nebraska, and Oklahoma, and the remaining 42 percent is transported south into New Mexico. Three-quarters of the state's pipeline capacity was fully utilized in 2005 (table 4).

Significant efforts are currently underway to expand pipeline capacity from Colorado and the other Rocky Mountain producing states eastward. When completed, the planned Rockies Express (REX) pipeline system will be able to carry up to 1.5 Bcf/d of natural gas from Rio Blanco County, Colorado, to Audrain County, Missouri (fig. 33). From there, the REX will gain an additional 0.3 Bcf/d of capacity, bringing the total to 1.8 Bcf/d. From its point of origin in Colorado to its point of termination in Monroe County, Ohio, the REX will cover a distance of 1,678 miles (EIA, 2007a).

A 136-mile section of the REX pipeline system that extends northward from the Meeker Hub located at the northern end of the TransColorado Gas Transmission Company's system in Rio Blanco County, Colorado to the Wamsutter Hub in Sweetwater County, Wyoming was completed and went into service February 24, 2006. An additional, 191-mile section of pipeline eastward to the Cheyenne Hub in Weld County, Colorado was completed and went into service February 14, 2007.

Interim service with capacity of about 1.4 Bcf/d began January 12, 2008 on approximately 500 miles of REX-West from the Cheyenne Hub in Weld County, Colorado, to the ANR Pipeline Company's delivery point in Brown County, Kansas (fig. 33). This section also includes delivery points to Kinder Morgan Interstate Gas Transmission, Northern Natural Gas Company, and Natural Gas Pipeline Company of America (fig. 32).

The remaining 213-mile section of REX-West will continue eastward to Audrain County, Missouri, and has a projected in-service date of mid-2008, at which time capacity will increase to about 1.5 Bcf/d. Weather conditions have hampered the progress of final construction activities on the REX-West system to the Panhandle Eastern Pipeline Company (PEPL) interconnect in Audrain County, Missouri (fig. 33). When completed, REX-West will be a 713-mile, 42-inch diameter pipeline with deliveries available on the pipeline system to interconnects with Kinder Morgan Interstate Gas Transmission, Northern Natural Gas Company, Natural Gas Pipeline Company of America, ANR and Panhandle Eastern Pipeline Company.

The final 638-mile section of the pipeline system, referred to as REX-East, will extend from Audrain County, Missouri, further east to the Clarington Hub in Ohio (fig. 33). This section is not scheduled to be in service until mid-2009.

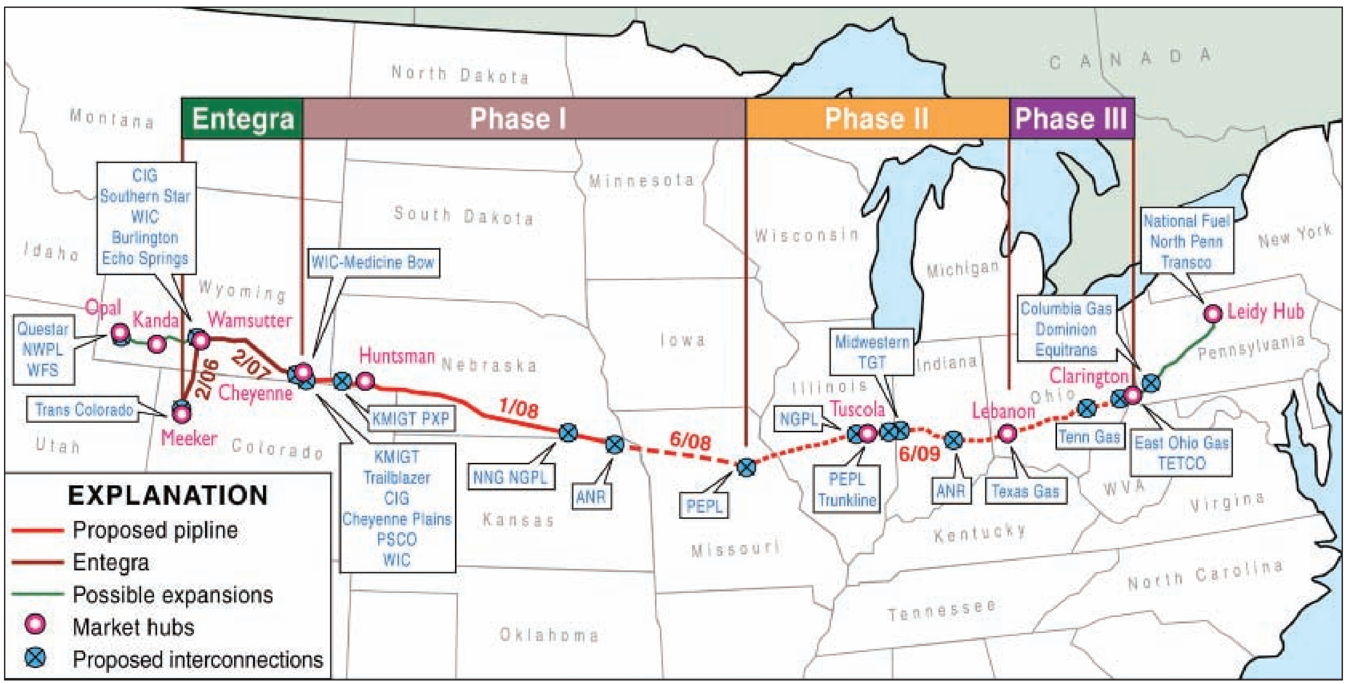


Figure 33. The proposed route and development phases for the Rockies Express pipeline system will transport Colorado natural gas to Midwestern and Eastern markets (modified after Harpole, 2007).

In addition to the REX, several other projects are being planned and constructed in the Rockies. Most recently, Questar Pipeline and Enterprise Products Partners announced plans to construct a new 7-mile, 30-inch hub pipeline to transport 2.5 Bcf/d of natural gas from the Piceance Basin to Enterprise's natural gas processing facility near Meeker, Colorado (White River Hub, 2008). If completed, the White River Hub will provide interconnections to at least six other pipelines: Questar Pipeline, REX, TransColorado Gas Transmission, Wyoming Interstate Company, Colorado Interstate Gas, and Northwest Pipeline. The project investors expect the White River Hub to be operational by the fall of 2008.

Crude Oil Refining

Suncor Energy Inc. acquired Valero Energy's refinery in Commerce City in mid-2005. The 30,000 barrel per day (bpd) Valero refinery is located adjacent to Suncor's existing refinery, which was acquired in 2003. Since acquisition, Suncor has fully integrated the two operations, providing a combined refining capacity of approximately 90,000 barrels per day, which represents about 0.5 percent of the U.S. total (EIA, 2007b).

Suncor's Commerce City, Colorado, refinery—the largest refinery in the Rocky Mountain region—provides a vital link between Suncor's large-scale oil sands resource base in Canada and the growing energy market in the U.S. The refinery is located about six miles northeast of downtown Denver and employs about 360 of the more than 500 people employed in Suncor's U.S. operations (Suncor, 2006). It supplies about 35 percent of Colorado's gasoline through the Conoco Phillips network and diesel fuel demand and is a major supplier of jet fuel to the Denver International Airport. The refinery is also the largest supplier of paving-grade asphalt in Colorado.

To further integrate Suncor's oil sands products into the U.S. marketplace, Suncor completed a US$445 million refinery upgrade in June 2006 that is designed to produce refined products which meet the newly regulated emission levels for low sulphur diesel fuel (Suncor, 2006). (The Environmental Protection Agency has mandated that all refineries reduce the sulfur content in diesel fuel to less than 15 parts per million.) In addition to the modifications to meet clean fuels regulations, the upgrades also improve the refinery's environmental performance, and enable Suncor to integrate a broader range of crude oil products, including sour crude oil from the company's Canadian oil sands production. The upgrade also included an increase in the refinery's ability to process bitumen used in asphalt production.

Over the two years of the Commerce City refinery upgrade (named Project Odyssey), the project employed a peak construction workforce of approximately 1,300 people. About 75 percent of the total project budget was spent purchasing goods and services from Colorado-based businesses. Project Odyssey consumed 2,150 tons of steel, 740,000 feet of electrical cables, and 170,000 feet of pipes. According to the Metro Denver Economic Development Corporation, the project brought more than $1 billion of economic activity to the area.

The Rocky Mountain and Centennial pipeline systems between Guernsey, Wyoming, and Denver, Colorado, connect Suncor's crude oil production with the Commerce City refining facility and the Rocky Mountain market. Suncor owns 100 percent of the 200-mile Rocky Mountain pipeline system and 68 percent of the 87-mile Centennial pipeline system (Suncor, 2006). These pipelines, operated by Suncor staff in Cheyenne, Wyoming, connect the refining operations to the larger North American pipeline network.

Roan Plateau Natural Gas Development

The Roan Plateau Planning Area (RPPA) is a significant natural gas resource for both Colorado and the nation. Approximately 53,800 acres of unleased lands are accessible using directional drilling technology (BLM, 2008). An estimated nine trillion cubic feet of recoverable natural gas underlies the federal lands in the Roan area. Federal revenue from oil and natural gas royalties and lease sales are expected to generate between $857 million and $1.13 billion over the next 20 years. The State of Colorado would receive an estimated $428 to $565 million as the state's share of federal royalties and federal leases (BLM, 2008). Leasing is currently planned for 2008.

The proposed Resource Management Plan Amendment for the RPPA is the culmination of a seven-year process that began in 2000 and has involved collaboration among many federal, state, and local governmental agencies as well as members of the general public. BLM's second and final Record of Decision requires innovative environmental protection measures, which would permit natural gas and oil development while protecting other resource values. Although there currently are discussions in Congress that may modify this plan, some of these measures include:

- No ground disturbance would be permitted on 52 percent of federal acreage, with other access restrictions on an additional 42 percent.
- Clustered development and directional drilling of multiple wells from common pads would be conducted. The density of well pads would be approximately four per square mile. Typical distance between well pads would be approximately 0.5 mile. Few new roads would be required.
- Development would proceed in a planned, phased manner on top of the Plateau, so that only one of six geographic areas would experience drilling at any one time. Drilling would be restricted to the tops of ridges to protect sensitive valley bottoms, trout habitat, and scenic waterfalls.
- The plan mandates that a maximum of one percent of lands on top of the Plateau could be in an unreclaimed state at any one time. Operators would be required to reclaim lands before more permits were issued.

Oil Shale

It is neither oil nor shale, but Colorado has the richest deposits of oil shale in the world (fig. 34). Oil shale is actually a rock, marlstone, containing kerogen, an organic material that is a precursor to oil. When this type of kerogen is buried about a mile and a half deep in the earth, the increased heat and pressure converts the kerogen to oil. Colorado's oil shale was never buried deeply enough in nature to convert the kerogen to oil, so companies have attempted to artificially convert the kerogen to oil for more than a century. Many previous methods involved mining the rock and heating it in large furnaces, or retorts. Today, oil companies are attempting to heat the rock in place and bring the converted oil to the surface with normal oil pumps.

In 2005, the BLM awarded five Research, Demonstration and Development (RDD) projects to three oil companies in Colorado. As of the end of 2007, none of these companies had applications pending before the Department of Natural Resources' Division of Reclamation Mining and Safety. During the last round of efforts at commercially producing oil shale in Colorado, the full permitting process took 42 months. Since then, new federal and local regulations have come into existence which may require further time for the permitting process to be completed. So, it is highly unlikely that any of the RDD companies will be starting the demonstration phase of their project prior to 2010.

Also in 2005, Congress directed BLM to prepare a Programmatic Environmental Impact Statement (PEIS) covering Colorado, Wyoming, and Utah; in preparation for commercial leasing of oil shale rights. BLM completed a draft of the PEIS in December of 2007, and released it for a period of public comment which ended in April.

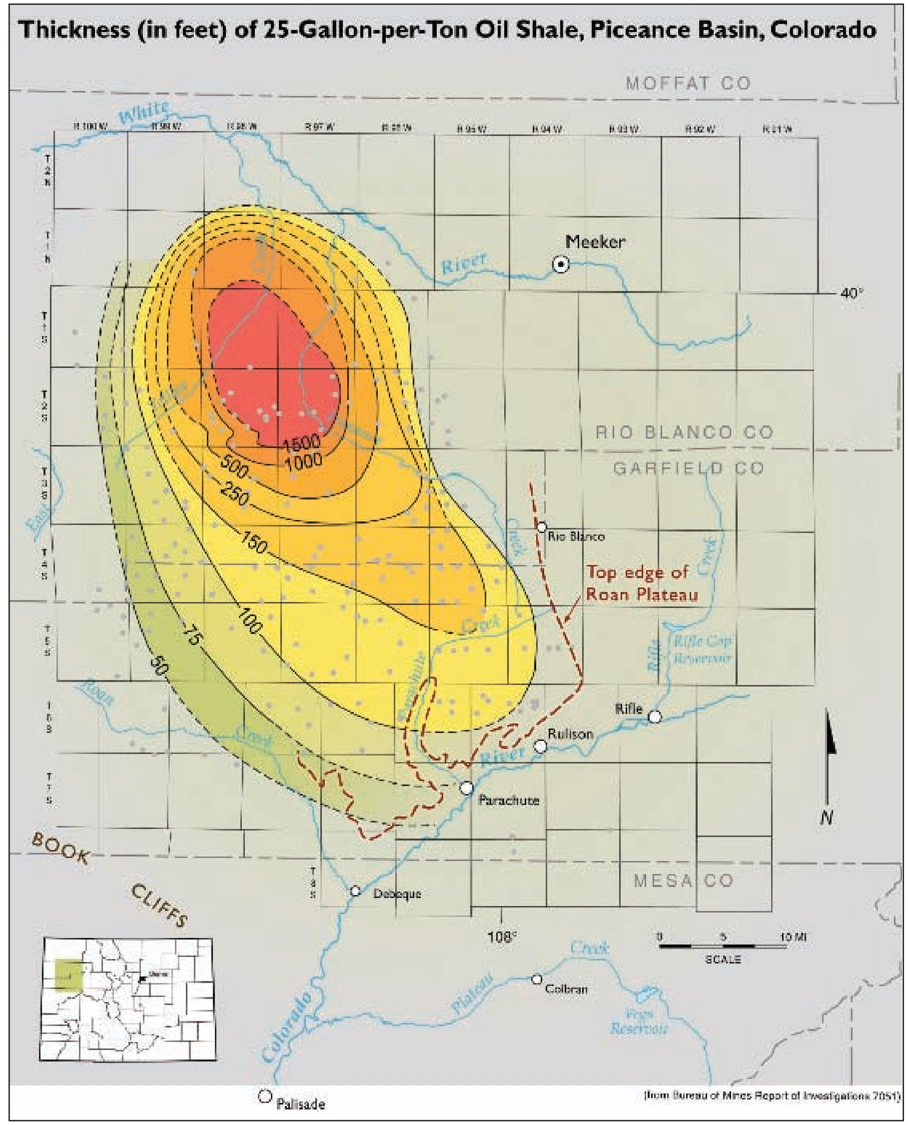


Figure 34. Thickness Map of Oil Shale: The red area contains more than 1,500 vertical feet of oil shale layers that average more than 25 gallons per ton. This is the richest oil shale resource in the world.

Carbon Dioxide

Colorado will produce an estimated 383 Bcf of naturally-occurring carbon dioxide (CO_2) in 2007, an increase of 2.4 percent from the 374 Bcf produced in 2006 (fig. 35). The total value of this production is estimated at $541 million for 2007 based on the average prices shown in table 5 and would represent more than a two-fold increase from the $262 million for 2006 (COGCC, 2007).

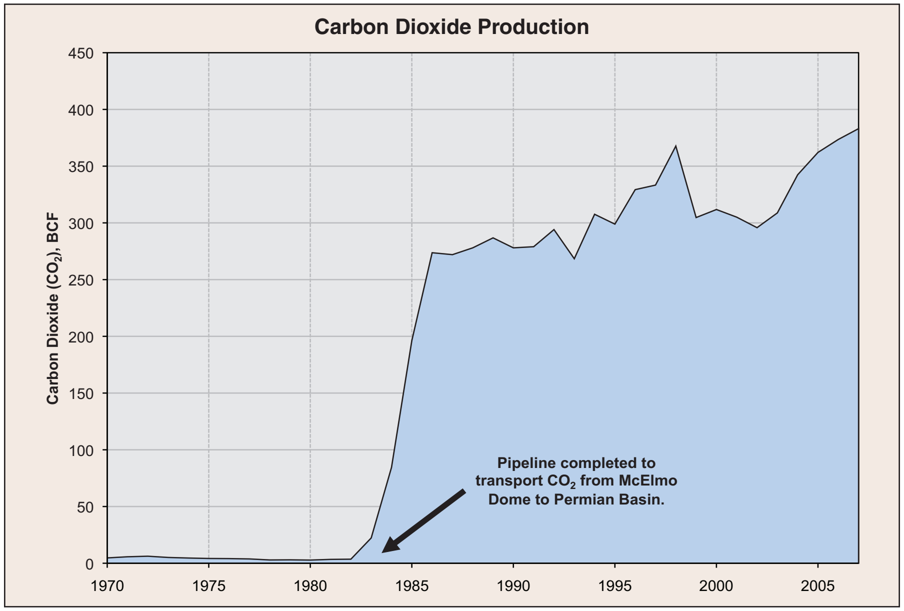


Figure 35. Carbon dioxide production continues to increase with the expansion of enhanced oil recovery projects in the Permian Basin of West Texas (COGCC, 2007).

Table 5. Volume of CO_2 Production Sold by County and Value for 2007.

County	Source	Price, $/Mcf(1)	Billion Cubic Feet Sold(2)	Value in Million $(3)
Montezuma	McElmo Dome	$1.47	354.91	$521.72
Huerfano	Sheep Mountain	$0.28	19.30	$5.40
Jackson	McCallum	$2.70	0.72	$1.94
Total			**374.92**	**$529.06**

[1] Price is based on third quarter reporting to COCGG. [2] Production volumes for 2007 are incomplete. [3] Value is determined based on known production volumes (COGCC, 2007).

Montezuma County sold 354.91 Bcf or 95 percent of the CO_2 production reported for 2007. The Mississippian Leadville Limestone at the McElmo Dome field (fig. 36) supplies CO_2 for enhanced oil recovery applications in the Permian Basin. Dike Mountain and Sheep Mountain fields in the northwestern part of the Raton Basin in Huerfano County produced 5.1 percent of the state's reported CO_2. As with the CO_2 produced from McElmo Dome, Raton Basin CO_2 is supplied to the Permian Basin of West Texas.

McCallum and McCallum South fields in the northeast part of the North Park Basin in Jackson County contributed about 0.2 percent of the state's total carbon dioxide production in 2007. North Park CO_2 is used in welding gases, the manufacture of dry ice, and the food and beverage industry.

Helium

The estimated value of Grade-A helium (99.995 percent pure or greater) extracted nationwide during 2007 by private industry was about $525 million (USGS, 2008). There were 21 privately-owned helium extraction plants operating in the U.S. in 2006—12 in Kansas, five in Texas, and one each in Colorado, New Mexico, Utah, and Wyoming. Colorado's Ladder Creek Plant is located in Cheyenne Wells, Cheyenne County (fig. 36), and is operated by DCP NGL Services, a wholly-owned subsidiary of DCP Midstream, LLC. The Ladder Creek plant was formerly owned and operated by Duke Energy Field Services, which is now DCP Midstream. The Ladder Creek plant produced 78,612.36 Mcf of helium in 2007 (Roz Elliott, Director of Public Affairs, DCP Midstream, personal communications, March 26, 2008).

All natural gas processed for helium recovery originates from gas fields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming. About 98 percent of the nation's helium reserves are contained in the Hugoton field in Oklahoma, Kansas, and Texas; the Panoma field in Kansas; the Keyes field in Oklahoma; the Panhandle West and Cliffside fields in Texas; and the Riley Ridge area in Wyoming (USGS, 2008). Most plants extract helium from natural gas using a cryogenic process; that is, helium is separated from natural gas by liquefying the product at about minus 458 degrees Fahrenheit. (Helium results from the decay of the natural elements uranium and thorium. As these elements decay, some of the helium is trapped along with natural gas deposits.) Estimated 2007 domestic consumption of 2.5 Bcf was used for cryogenic applications (28 percent); for pressurizing and purging (26 percent); for welding cover gas (20 percent); for controlled atmospheres (13 percent); leak detection (4 percent); breathing mixtures (2 percent); and other uses (7 percent).

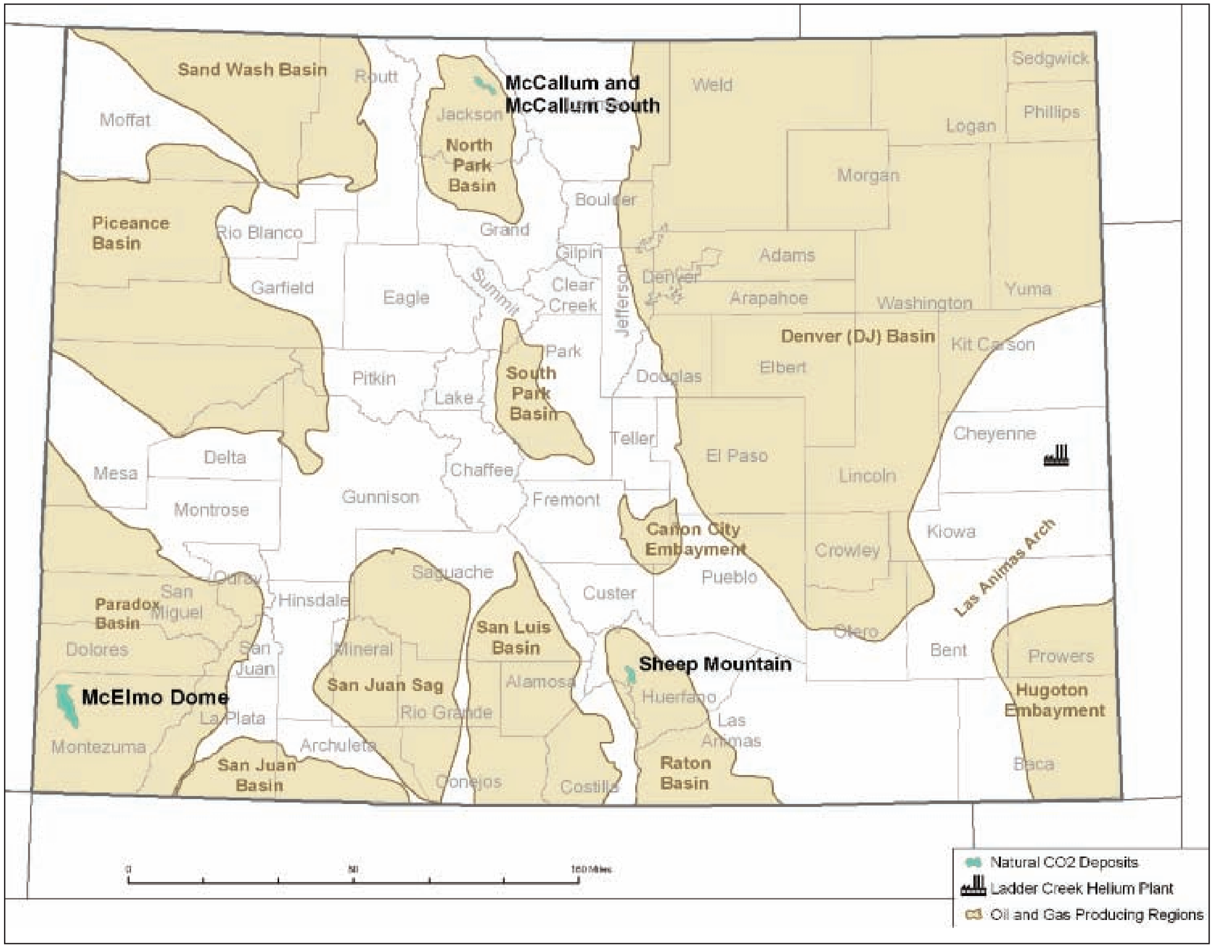


Figure 36. Naturally occurring carbon dioxide deposits occur at four locations in Colorado; the largest deposit is that at McElmo Dome. The Ladder Creek Plant in Cheyenne County is the only helium processing plant in Colorado.

Table 6. U.S. helium production and consumption for 2003–2007[1].

	2003	2004	2005	2006	2007 (est.)
Helium extracted from natural gas[2]	3.1	3.0	2.7	2.8	2.8
Withdrawn from storage[3]	1.2	1.6	2.0	2.0	2.1
Grade-A helium sales	4.3	4.6	4.7	4.8	4.9
Imports for consumption	-	-	-	-	-
Exports[4]	1.5	1.6	1.8	2.1	2.4
Consumption, apparent[4]	2.8	3.0	2.9	2.7	2.5

[1] Billion cubic feet as measured at 14.7 psia and 70 degrees Fahrenheit; [2] Both Grade-A and crude helium; [3] Extracted from natural gas in prior years; [4] Grade-A helium.Source: USGS, 2008.

The U.S. government price for helium was $58.75 per Mcf in 2007; a price which is mandated by the Helium Privatization Act of 1996 (Public Law 104-273). The estimated price range for private industry's Grade-A gaseous helium was about $90 to $105 per Mcf, with some producers posting surcharges to this price (USGS, 2008). These prices represent increases of 10 to 40 percent for 2007. These increases were implemented in response to high capacity utilization, rising raw material, energy and distribution costs, and to support reinvestment in cylinders, production, and distribution equipment.

Although helium consumption in the U.S. has declined since 2004, the nation's helium exports have continued to increase with growth in worldwide demand (table 6). U.S. exports have risen from 1.5 Bcf in 2003 to an estimated 2.4 Bcf in 2007, a 60 percent increase since 2003. In contrast, U.S. consumption has declined from 3.0 Bcf in 2004 to an estimated 2.5 Bcf in 2007, representing a decrease of 16.7 percent since 2004.

In 2003, BLM estimated U.S. helium resources at 177 Bcf and reserves at 146 Bcf. U.S. helium reserves are being depleted and there is no substitute for helium in cryogenic applications if temperatures below minus 429 degrees Fahrenheit are required. Argon can be substituted for helium in welding, and hydrogen can be substituted for helium in some lighter-than-air applications in which the flammable nature of hydrogen is not objectionable. Hydrogen is also being investigated as a substitute for helium in deep-sea diving applications below 1,000 feet.

COAL

Introduction

Coal is a combustible black or brown rock containing carbonaceous material that is prolific in Colorado. This sedimentary rock is composed mostly of carbon, volatile hydrocarbons, and trace elements. Coal forms from the compaction of lithified plant remains in peat swamps millions of years old. Ancient plant matter stored energy as successive layers of rock covered the swamps. This energy is unlocked when we burn coal to run the generators at coal-fired power plants for our everyday electrical needs.

Coal provides the fuel to generate about 68 percent of Colorado's electricity. It provides the 'base load' fuel source for today's electrical needs. A growing economy usually needs more energy, and coal is the most plentiful fossil fuel available. At current growth and consumption rates the supply of Colorado's mineable coal may last over 250 years. However, if world energy demand grows by 60 percent over the next 22 years then fossil fuel consumption will increase in demand, and coal supplies could be depleted faster.

2007 Colorado Coal Production

The Colorado coal industry rebounded from a slight dip in production during 2005 and 2006. Total coal production from the 11 coal mines last year exceeded 36.1 million short tons, making 2007 the third best coal production year on record. Most of the coal is produced in northwest Colorado near Craig and west-central Colorado east of Delta (fig. 37). Colorado ranks seventh for coal production nationally. Currently the Colorado coal mines are producing at a rate of over 100,000 short tons per day. The Colorado coal industry is producing a valuable economic commodity. Using an average sales price of $29.75 per ton the value of Colorado's coal production in 2007 was $1.075 billion, a new annual record.

County Coal Production Statistics

Coal was produced in eight Colorado counties in 2007. For the second year in a row Delta County was the state's top coal producing county (**table 7**), with over 10.3 million tons. The large mining district in Delta and Gunnison counties is called the North Fork Valley, or Somerset Coal Field. Bowie Resources and Oxbow Mining each have large underground mines in Delta County; the Bowie #3 Mine and the Elk Creek Mine, respectively. Following Delta County were Routt and Moffat counties with 8.3 and 8.1 million short tons, respectively.

Delta County employed the most coal miners with 572, as of December 2007. The North Fork Valley is Colorado's most concentrated coal mining area. The three mines in the North Fork Valley are Bowie, Elk Creek, and West Elk. Together these three mines produced nearly 17.2 million short tons of coal in 2007. All of these mines produce coal from either the Paonia or Bowie Shale Formations of the Mesaverde Group.

Table 7. Colorado coal production by county, type of production, and employment as of December 2007. All coal production is reported in short tons. 'Miners employed' only includes coal miners and does not count the total workforce at the mines. Source: Division of Reclamation, Mining, and Safety (DRMS) individual mine records, 2008.

County	2007 Production Total	Underground Production	Surface Production	Miners Employed	Mine Name	Surface/ Underground Mines
Delta	**10,304,233**	10,304,233	—	572	Bowie, Elk Creek	0/2
Garfield	**247,120**	247,120	—	22	McClane Canyon	0/1
Gunnison	**6,893,096**	6,893,096	—	357	West Elk	0/1
La Plata	**470,171**	470,171	—	88	King Coal, King II	0/2
Moffat	**8,099,473**	—	8,099,473	417	Trapper, Colowyo	2/0
Montrose	**406,279**	—	406,279	23	New Horizon	1/0
Rio Blanco	**1,424,019**	1,424,019	—	135	Deserado	0/1
Routt	**8,290,894**	8,290,894	—	455	Foidel Creek	0/1
TOTALS	**36,135,285**	**27,629,533**	**8,505,752**	**2,069**		**3/8**

Nearly half of Colorado's coal production comes from four large mines in northwest Colorado. The four mines there are Twentymile (also known as the Foidel Creek Mine) Mine in Routt County, Deserado Mine in Rio Blanco County, and the two large surface mines Colowyo and Trapper Mine in Moffat County. All of these mines produce coal from the prolific Williams Fork Formation. Moffat County has the most surface coal mine extraction in Colorado.

As of December 2007 the number of coal miners employed in Colorado has increased to 2,069, the highest employment figure since 1988 (fig. 38), but still far below the record of 4,380 miners employed in 1979, the most since 1960. The industry is providing many high-paying jobs to rural Colorado. But not many young people are going into mining and the workforce is aging. In the coal mines today it is important that the aging coal work force train younger workers to keep the skilled technical knowledge up to date.

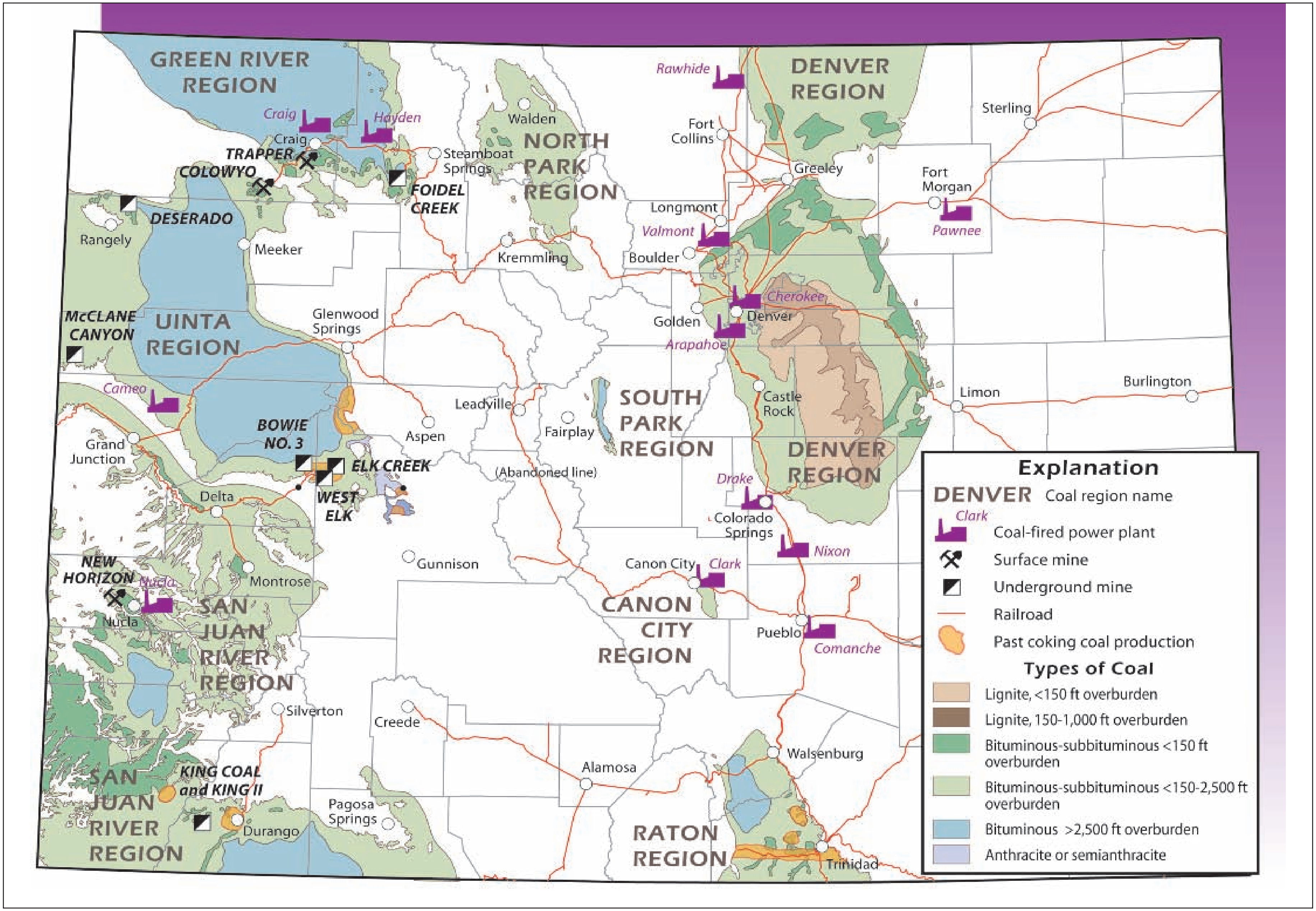


Figure 37. Locations of coal mines, power plants, railroads, and coal-bearing regions in Colorado, 2007. The colored areas denote the large coal mining regions in Colorado with only the active coal mines located. The coal regions are color-coded by coal quality and depth characteristics.

Underground Mining Activity

The eight underground mines produced 27,629,533 short tons of coal in 2007 (table 8). In January 2007 Bowie Mine #3 produced 535,608 short tons of coal, a new monthly production record for the mine. Bowie also produced 5,480,571 short tons, an annual record. About 5.27 million tons of coal came from the longwall operation in the #3 Mine and about 213,000 tons from room and pillar coal retreating from the #2 Mine. In December 2007 Bowie sealed the #2 Mine. Bowie also has a modern preparation plant onsite to handle higher ash and sulfur coal from the B seam. The coal from the D-coal seam in the #2 Mine is combined with the coal from the B-coal seam in the #3 Mine on a conveyor before the preparation plant. Together this coal produces a 12,200 Btu coal product for steam coal plants in the south-central U.S. The #3 Mine produces coal from a 10–14 ft thick split of the B-seam.

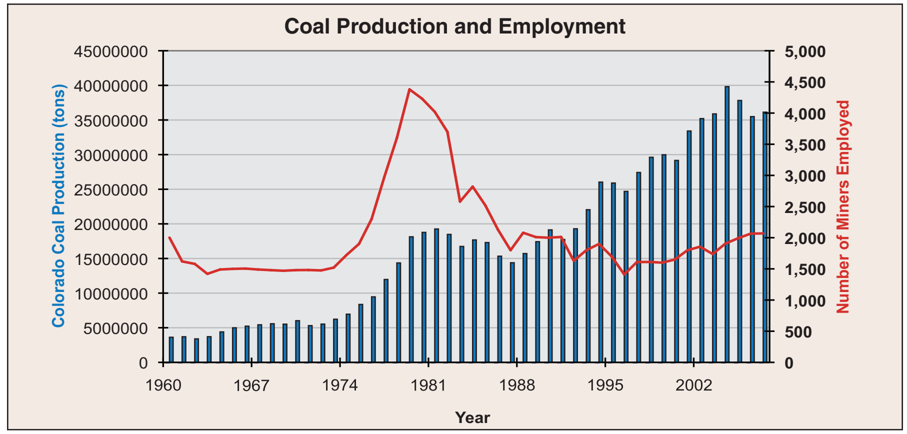


Figure 38. Coal production and employment of miners in Colorado, 1960–2007. It takes fewer miners to operate longwall machinery today than it did with continuous mining equipment in 1960. The number of coal miners dropped significantly after its peak in 1979 when conventional mining operated at twice the number of mines in Colorado. Today coal production has doubled since 1979 with the help of technology. Today's large surface mine equipment and the underground longwall operations have increased productivity substantially.

Table 8. Colorado coal mine statistics, 2007. The table shows current geologic information; location, production, and number of miners employed for each coal mine currently active in Colorado. See Figure 37 for mine locations.

County	Parent Company	Operator	Mine Names	Coal Region	Coal Field	Twp., Rng.	Geologic Formation	Producing Bed Names	Seam Thickness	Depth of Cover	BTU (sampled by CGS Nov 2007)	Mine Type	Mining Method	2007 Prod. (tons)	Dec 2007 Miners	Shipment Method
Delta	Colorado Energy Investments, LLC; Sentient Coal Resources, LLC	Bowie Resources Ltd.	Bowie #3	Uinta	Somerset	13S, 91W	Mesaverde	lower B	11.5 ft	1,400 ft	12,224	U	Longwall, continuous	5,480,571	268	Rail
Delta	Oxbow Carbon and Minerals Holdings, Inc.	Oxbow Mining, LLC	Elk Creek	Uinta	Somerset	13S, 90W	Mesaverde	D2	D=6-19 ft. D2 seam minable is 14 ft.	2,000 ft	12,850	U	Longwall, continuous	4,823,662	304	Rail
Gunnison	Arch Coal Inc.	Mountain Coal Company, Inc.	West Elk	Uinta	Somerset	13S, 90W	Mesaverde	B1-B2, E	B1 = 3.1 ft; B2 = 8–11 ft; E = 11 ft	B1-B2: 1200–2300 ft; E 400 ft	12,891	U	Longwall, continuous	6,893,096	357	Rail
La Plata	GCC Energy	National King Coal, LLC	King Coal	San Juan River	Durango	35N, 11W	Upper Menefee	Upper Bed	6 ft	300 ft	13,532	U	Continuous	462,736	81	Truck
La Plata	GCC Energy	National King Coal, LLC	King II Mine	San Juan River	Durango	35N, 11W	Upper Menefee	Upper Bed	7 ft	30 ft	12,665	U	Continuous	7,434	7	Truck
Garfield	Rhino Energy, Llc	McClane Canyon Mining, LLC	McClane Canyon	Uinta	Book Cliffs	7S, 102W	Mesaverde	Upper Cameo, Lower Cameo	Upper Cameo= 5–9 ft; Lower Cameo= 8–10 ft	350 ft	10,391	U	Continuous	247,120	22	Truck
Moffat	Rio Tinto	Colowyo Coal Company, L.P.	Colowyo	Uinta	Danforth Hills	3N-4N, 93W	Williams Fork-Fairfield Coal Group	A-F,X,Y	52.2 ft total; Y=4 ft, X=10.7 ft, A=2 ft, B=6.8 ft, C=6.4 ft, D=10.1 ft, E=6.8 ft, F=5.4 ft	30–120 ft	10,670	S	Dragline, Shovels, Dozers	5,621,924	263	Rail
Moffat	PacifiCorp/Tri-State G&T/Salt River	Trapper Mining, Inc.	Trapper	Green River	Yampa	6N, 90W-91W	Williams Fork-Upper Coal Group	H, I, K, L, M, Q	H=6 ft, I=5 ft, K=4 ft, L=4 ft, M=6 ft, Q=10 ft	60–100 ft	9,554	S	Dragline, Shovels, Hyd. Excav.	2,477,549	154	Truck
Montrose	Tri-State G&T Assoc.	Western Fuels Colorado, LLC	New Horizon	San Juan River	Nucla-Naturita	46N, 15W-16W	Dakota	1, 2	Kd Upper= 0.80–1.5 ft; Kd Lower= 5.0–7.5 ft	47 ft	10,868	S	Shovels, dozers	406,279	23	Truck
Rio Blanco	Deseret Generation & Transmission	Blue Mountain Energy, Inc.	Deserado	Uinta	Lower White River	2N-3N, 101W	Williams Fork	B Seam	B= 7–16 ft., D= 6–8 ft.	500 ft	10,000	U	Longwall, continuous	1,424,019	135	Rail
Routt	Peabody Energy	Twentymile Coal Co.	Twentymile (Foidel Creek)	Green River	Yampa	5N, 86W	Williams Fork-Middle Coal Group	Wadge	8.5–9.5 ft	1,100 ft	11,115	U	Longwall, continuous	8,290,894	455	Rail, Truck
Mine Type abbreviations: U—underground mine, S—surface mine							**Shaded items indicate new annual production record.**						**Totals**	**36,135,284**	**2,069**	--

Twentymile Mine—Routt County

Peabody Energy's Twentymile Mine (also known as the Foidel Creek Mine) in Routt County produced 8.29 million tons in 2007. Twentymile was again the highest producing coal mine in the state for the eleventh year in a row. In 2007 the company constructed a new preparation plant onsite. Since 1983 the 11-ft-thick Wadge seam coal quality has been compliant to ship straight from the facility with minimal washing. Only coal near the seam top and bottom edges has needed to be washed. Now a modern continuous sampling coal monitor will use a by-pass operation to send coal through the preparation plant. This plant will help the mine with steam coal sales, as coal-fired power plants demand more stringent coal quality parameters. Peabody hopes to mine 10 million tons with their new longwall and preparation plant in 2007.

King Coal Mine—La Plata County

The King Coal Mine in La Plata County had some major changes in 2007. The parent company, National King Coal, was sold and the mine changed its operations name to GCC Energy. This is a subsidiary of its best customer, Grupo Cementos de Chihuahua, from Mexico. GCC is phasing out the old King Coal Mine, which has operated for 72 years continuously. GCC is creating a new mine just across the valley called King II. It features new surface facilities that the old mine lacked such as automated coal conveyor feeders and loaders. The new mine will operate in the same coal seam, which outcrops on the north side of Hay Gulch. Currently they are producing a minor amount of coal during portal construction (fig. 39). The new portal only has 30 ft of overburden but coal quality from exploration drilling indicates high quality partially metallurgical coal ranging from 12,600 to 13,500 Btu. GCC hopes to have the new mine fully operational by the end of 2008. The high Btu coal is sold to cement manufacturers in New Mexico, Arizona, and Mexico. Much of the coal mined at King Coal is hauled by truck to rail lines in Gallup, New Mexico and to cement plants in Tijeras, New Mexico.

Deserado Mine—Rio Blanco County

Coal production for 2007 at the Deserado Mine in Rio Blanco County near Rangely was down due to a mine fire in August. Blue Mountain Energy, the mine operator, along with MSHA, successfully contained the fire without incident. Nitrogen pumped into the affected area suppressed the fire. Some equipment was damaged but no injuries resulted. The mine was not fully operational since then. The longwall is now in the 7-to 16-foot thick B-seam at a depth of over 500 feet. In-place reserves will keep Deserado mining in its current development plan through 2026.

Figure 39. Construction activities at the new King II Mine, La Plata County. Shown are the main entry and ventilation systems. The coal bed is 6 to 7 ft thick, as shown in the cut slope face.

McClane Canyon Mine—Garfield County

Rhino Energy, operator of the McClane Canyon Mine in Garfield County near Loma, announced plans to build a 15-mile rail spur from Mack to the proposed Red Cliff Mine location. This mine is located on the existing McClane permit near the southeast corner along the Book Cliffs. The Red Cliff project will mine the same Cameo coal beds as the McClane Canyon Mine. There is no scheduled timetable for the new mine to open. Currently the mine hauls 300,000 tons of coal annually via truck to the Cameo Power Plant in Palisade, Colorado. The future of this operation is unknown at this time with the recent announcement of Xcel Energy's decision to close the Cameo Plant by 2011.

Elk Creek Mine—Delta County

Oxbow Mining Company's Elk Creek Mine continued to operate at about 4.8 million tons per year. The mine's longwall is currently operating in the Delta County part of the permit. The Elk Creek overcame head-gate troubles on the longwall early in the year in the fractured B-seam. Elk Creek mines the 11 to 14-ft thick D2 seam with about 2,000 ft of overburden. The mine separates out high ash coal manually. Elk Creek has enough coal to mine at its existing location until 2017 (projected life-of-mine).

West Elk Mine—Gunnison County

Arch Coal's West Elk Mine on the east end of the North Fork Valley had its second best production year on record in 2007 by producing over 6.8 million tons of coal. This mine produces coal from the 10–11-foot thick E-seam, and the 9.5 ft thick B2 seam. These seams are 400 and 1,350 ft deep, respectively. The mine is developing the E seam while phasing out the B seam in 2008. The new mine plan represents a change from operating in the North Fork Valley to now mining coal in the southern part of the lease in the Minnesota Reservoir quadrangle. West Elk produces a low-sulfur, and high-Btu bituminous coal (between 12,800 and 13,300 Btu heat value).

Longwall Operations

A longwall coal miner is an automated machine with a long, rotating cutting head that travels the length of a coal block over 1,000 ft long cutting into a coal face up to 3 ft at a time (fig.40). The rotating head cuts the coal, which then falls directly onto a conveyor belt that carries the coal up to the surface. As the longwall advances, the ground subsides behind the shields that hold up the rock over the working space. Longwall machinery is important to Colorado because of its safety and productivity records. Longwall technology is an important reason why Colorado's coal production from its thick coal beds has doubled since 1982.

The 2007 U.S. Longwall Census from *CoalAge* reports five active longwall's operating in Colorado (table 9). There are over 53 longwalls operating at coal mines in the U.S. The average panel length in Colorado mines is now over 9,000 feet long. The biggest shearer and set of shields is the new Deutsche Bergbau Technik (DBT) longwall at Peabody Energy's Foidel Creek Mine in Routt County. According to *CoalAge*, the EL3000 shearer has 2,970 horsepower and the supports have a yield of 1,328 tons—the shields are the nation's largest. The mine now has the most robust face for longwalls in the state.

Arch Coal/Mountain Coal's West Elk Mine in Gunnison County has announced that the mine will replace their longwall operation with new equipment in 2008. The previous longwall was used in the mine since 1991.

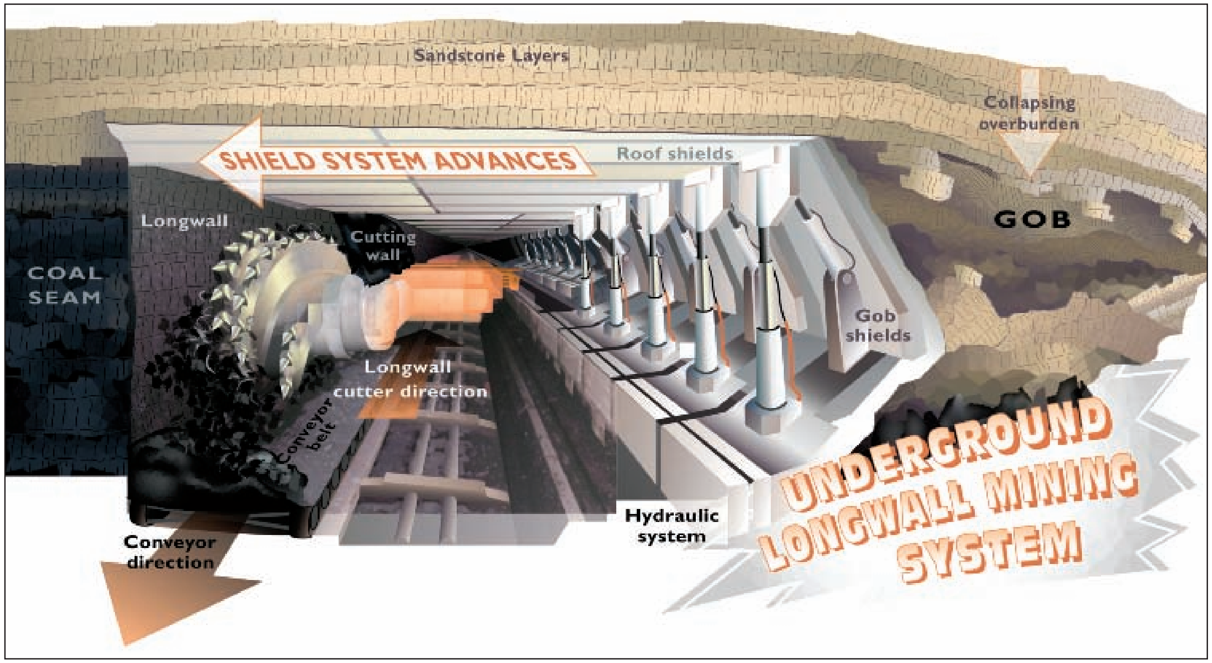


Figure 40. Diagram of underground longwall operating system. Figure shows how a longwall system moves in an underground coal bed.

Table 9. Longwall statistics from Colorado's underground coal mines in 2007. There are five longwalls operating at the eight underground mines in Colorado. (Source: *CoalAge* magazine, Feb. 2007). Ft = feet, in=inches.

Company Name (Mine)	Seam	Seam height. (in)	Cutting Ht. (in.)	Panel Width (ft)	Panel Length (ft)	Overburden (ft)	Depth of Cut (in)	Shearer/ horsepower
Bowie Resources (Bowie Mine #3)	B	144–240	108–132	845	7,000	1100–1,700	36	BI EL2000 DDR 2,000
Blue Mountain Energy (Deserado Mine)	B	84–168	132	800	11,000	400–900	32	Joy 4LS-5 DDR 1,030
Oxbow Mining (Elk Creek Mine)	D	108–180	132	805	6,800	500–2,000	30	Joy 7LS-3A DDR 1,720
Peabody Energy (Foidel Creek)	Wadge	108	108	1,000	12,000–15,000	1,400–1,650	39.4	BI EL3000 DDR 2,970
Arch-Mt Coal Co (West Elk)	B	276	144	950	4,000–7,000	600–1,800	40	Joy 6LS-2 DDR 1,720

Surface Mining Activity

Colorado only has three surface coal mines: Rio Tinto's Colowyo Mine, Trapper Mining's Trapper Mine, both in Moffat County, and Western Fuels' New Horizon Mine in Montrose County. These three mines produced a total of 8.5 million short tons, or 24 percent of the state's total coal production.

Trapper Mine—Moffat County

Trapper Mine produced its own all-time monthly production record in October 2007 by producing 286,480 short tons. They also broke their all-time annual production record in 30 years of operation with 2,477,549 short tons produced in 2007. Trapper Mine was operating with two draglines in the Z-Pit to maximize production after losing access to a landslide in the eastern pit areas. Trapper continues to produce coal from the Upper Williams Fork Formation coals to supply the nearby Craig Power Plant.

Colowyo Mine—Moffat County

Rio Tinto Energy America's Colowyo Mine in Moffat County is the state's largest surface coal mine. Colowyo has operated continuously for over 30 years in this location. They began excavating to uncover the coal reserves in the South Taylor Pit in 2007. It is a truck shovel pit operation now developing the box cut into the last remaining 10-ft-thick X seam on the property. The South Taylor Pit mine plan calls for excavating six major seams and bed splits between the B to G coal beds of the Williams Fork Formation. The G8 coal bed is the bottom-most seam in the pit, and is up to 20 ft in thickness. The 40 million ton reserve in the South Taylor Pit is expected to last up to 10 years. The West Pit is still operating through 2011 with a dragline. The other two draglines operate on reclamation projects.

In 2007 Rio Tinto shipped Colowyo coal to the Craig and Valmont Power Plants. Minor tests were shipped to the Cherokee and Martin Drake plants and the Coors Brewery as well. Out of state sales for Colowyo coal went to Arizona, Texas, Arkansas, and Iowa. Most of their coal is for steam electric power but one plant in Texas generates steam for chemical processing. The Rio Tinto parent company is divesting assets from coal mining in the U.S. with Colowyo and the Wyoming Powder River mines currently for sale in 2008.

New Horizon Mine—Montrose County

The New Horizon Mine in Montrose County near Nucla supplies the Tri-State Generation and Transmission's Nucla Power Plant. In 2007 Western Fuels began a new exploration program to extend the life of the mine because the existing pit has reached its western limits. The new pit will be northwest of the current operation in the same coal beds. The Dakota coals are higher ash and sulfur than the typical Mesaverde and Williams Fork coal mined in other parts of Colorado. The Nucla Plant can handle up to 30 percent ash at its Flue-Gas Desulfurization operation, the most modern, environmentally compliant plant in the state (fig. 41).

Figure 41. Detailed view of the lower Dakota coal bed at the New Horizon Mine surface highwall. Note tonstein or ash beds interbedded within the coal unit near hammer. These ash beds are usually cleaned out during coal washing in preparation plants or at the power plant environmental controls.

Historic Coal Mine Production

Over 1,741 Colorado coal mines have produced nearly 1.34 billion tons of coal since 1864 (fig. 42). Most of the historic coal has been produced in the Uinta Coal Region (37 percent of the state total), and the Green River Coal Region (26.8 percent) which are both actively mined today. In terms of depletion 2.28 billion tons of coal have been mined or sterilized in Colorado through December 31, 2007 (using an average recovery factor of 58 percent). In 2007, nearly 24.5 million tons of coal were mined in the Uinta Coal Region from six mines. The largest coal mines in Colorado history are active today. The Twentymile Mine has been the largest underground coal mine in Colorado history, with cumulative coal production of over 121 million short tons since 1983. The Colowyo Mine is the largest surface mine and the largest coal producer ever in Colorado history, with over 130 million tons mined since 1977.

Colorado coal has been mined continuously for over 144 years. In that time, technological progress has made underground coal mining much safer and more efficient.

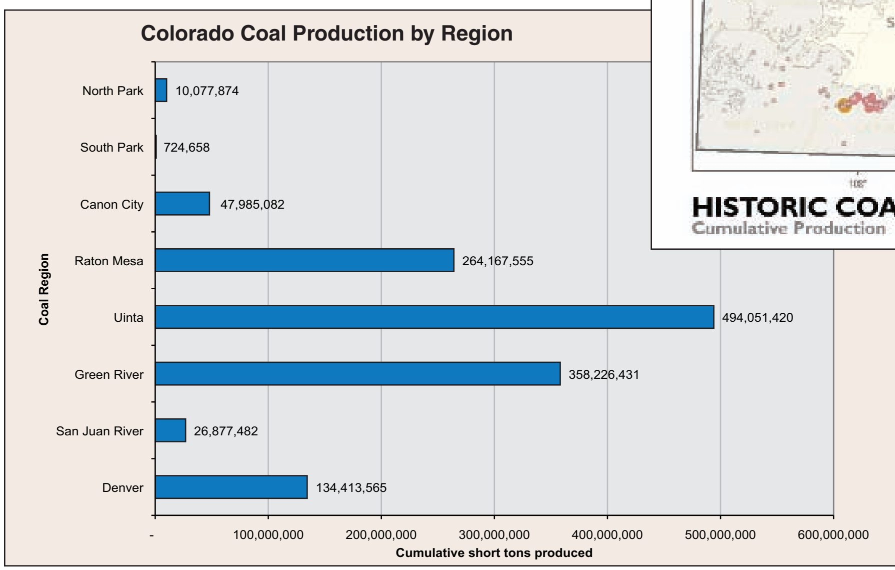


Figure 42. Historic Colorado coal production by coal regions. The total coal production for all coal mines in Colorado as of January 1, 2008 is 1.336 billion short tons. Total coal production in the Uinta and Green River areas surpassed the Raton Mesa area in 1999, and has continued at a rapid pace in those areas.

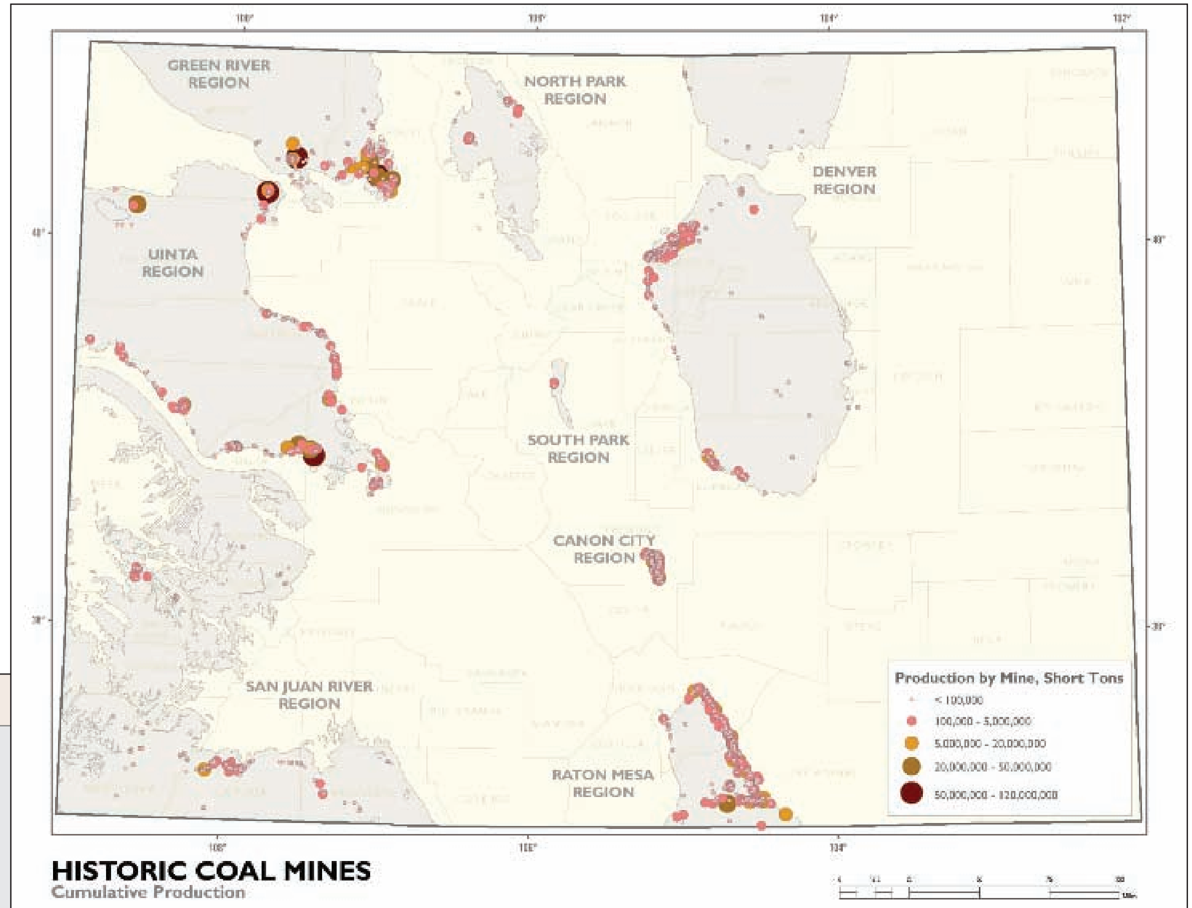


Figure 43. Historic coal production map of Colorado. Each circle represents a significant bench mark in coal production. Raton Mesa, Green River, and Uinta and Denver coal regions have the largest coal mines. Coal mines are located around the margins of the basins because coal is buried deeper toward the center of the basins. Although coal exists throughout the basins, it cannot be mined by either surface or underground methods with current technology.

Originally it was hand dug, and hauled out by mules. Then pick and dynamite mining took over, and then was replaced in the 20th Century with conventional miner types of room and pillar mining. By the 1980s the technology expanded greatly with the advent of the longwall mining system, which can mine coal at a far superior rate. Consequently, since longwall mining took over, more coal has been mined than ever before. In the last ten years over 342 million short tons of coal have been mined in Colorado. This represents over 25 percent of all the coal ever mined. In terms of accident reduction, the number of accidents is greatly reduced over that time as well.

Historic records indicate that the Twentymile Mine has produced more coal by underground methods than any other mine in Colorado (fig. 43). As of Jan 1, 2008, Twentymile has produced a cumulative 121.66 million short tons of coal since it became an underground mine in 1983. This is 34 percent of all the coal ever produced in the Colorado portion of the Green River Coal Region, and 9.1 percent of all the coal ever produced in Colorado by any means.

Exploration Activity

Coal exploration continued to be active in Colorado in 2007. Rule 2.02 of the Colorado mining statutes requires any person intending to conduct coal exploration to remove more than 250 tons to file a notice of intent to explore with the Colorado Division of Reclamation, Mining, and Safety (DRMS). Most of the exploration has been at active coal mines looking to expand their lease holdings by drilling in new development areas, but some new targets coal areas have also been explored.

Seven coal exploration permits were filed in 2007 with the DRMS. Western Fuels filed two permits to explore for new coal reserves in their Third Park and Second Park areas adjacent to the New Horizon Mine in Montrose County. Thick Dakota coals in this area northwest of the current operation could be the future development direction for the mine. Arch Coal, owners of the West Elk Mine, continued to drill on a two-year exploration program in the Book Cliffs coal field north of Fruita. The Grand Valley Book Cliffs exploration program is near the historic coal mining area in Stove Canyon. The Mt. Garfield Formation coal zones such as the Anchor, Palisade, and Cameo coal beds have been mined in this area previously.

In northwest Colorado, Colorado Coal Resources, a subsidiary of Peabody Energy, was exploring at the Cow Camp Underground prospect in Routt County. Twentymile Mine applied for a permit to drill the Wolf Creek Seam below the existing mine. The Wolf Creek seam is 130 feet beneath the Wadge seam, which is currently being mined. This would be the logical mining choice for the Twentymile Mine to follow after completion of the Wadge seam in their long term mining plan.

The Colorado Division of Wildlife recently issued a coal lease to mine under the Bosque Del Oso State Wildlife Area to the New Elk Coal Company in Las Animas County. This action is in anticipation of the company receiving a DRMS revision to their existing permit and workings to mine south of the existing New Elk Mine operation. New Elk Coal, along with the Goodland Energy Center, may want to use coal to fire an ethanol plant in Kansas. Reclamation and re-activation work at the New Elk Mine (formerly the Allen Mine) facilities continue while the issue of re-opening the mine is permitted. The New Elk Coal Company owns the property and in early 2008 is de-watering the old mine workings in an attempt to re-open the remaining economic parts of the mine. They want to extract additional reserves from the Allen, Apache, or Maxwell seams in the Raton Formation.

A proposed decision to approve the permit was initiated by DRMS recently for the new Northfield coal mine. This new mine is located south of Canon City near the Brookside subdivision in Canon City. The mine is proposed to be between 300 and 800 feet deep in a four- to six-foot-thick coal bed called the Ocean Wave seam of the Vermejo Formation. Northfield Partners, LLC. Holcim and GCC are both potential customers of this raw coal product. Northfield plans to mine up to 400,000 tons per year for cement plant purposes. The reserve life at that rate is projected to run for 15 years. This seam has not been mined before because of its thin four-foot-thickness. The underground mining will be conventional mining methods.

The Colorado Coal Marketplace

Coal Prices

National spot prices for coal sales have increased substantially in early 2008 (table 10). The spot price according to the Department of Energy's Energy Information Administration (EIA) for Uinta Basin coal is $40 per ton as of March 2007 (Colorado's Uinta Basin coal is similarly characterized as 11,700 British Thermal Units (Btu) and 0.8 percent sulfur dioxide). This is a significant increase from $27 per ton as late as January15, 2008.

Table 10. Spot coal prices comparing five major coal producing regions in the U.S. Weekly spot prices reported to DOE EIA indicate 20 percent price increases in all U.S. coal markets. Colorado coal sales resemble those under the Uinta Basin column heading. The cost to mine a ton of coal in the Western U.S. is still much less expensive than Eastern or Midwestern U.S. coal. All values in dollars per sort ton sold.

Week Ended	Central Appalachia 12,500 Btu, 1.2 SO_2	Northern Appalachia 13,000 Btu, <3.0 SO_2	Illinois Basin 11,800 Btu, 5.0 SO_2	Powder River Basin 8,800 Btu, 0.8 SO_2	Uinta Basin 11,700 Btu, 0.8 SO_2
18-Jan-08	$59.90	$63.00	$34.00	$12.30	$27.00
15-Feb-08	$66.95	$70.00	$46.80	$13.10	$33.00
14-Mar-08	$84.30	$80.00	$52.00	$14.05	$40.00

Coal prices for federal mineral leases in Colorado continued to climb in 2007. The Mineral Management Service (MMS) reports that coal sales over the past five years have continued to rise. Table 11 shows that the federal mineral lease values, the price paid to the federal government for coal leases have increased 53 percent in the last five years in Colorado. Using the average price of $29.75 per ton and not including spot price sales, the value of Colorado's coal production in 2007 was $1.075 billion. After years of decreasing coal prices, the notion of coal as an inexpensive fuel source may have passed.

Table 11. Federal mineral lease values for the average ton of coal sold on federal land in Colorado, 2003–2007. The sales price for the majority of Colorado coal sales has increased 53 percent in the last five years. Source: Colorado Department of Local Affairs.

Year	Avg Price per ton sold
2003	$19.43/ton
2004	$19.86/ton
2005	$24.37/ton
2006	$28.19/ton
2007	$29.75/ton

The price of sales coal on the spot market for Colorado coal was $37 per ton for the first half of 2007, then around $27 per ton for the second half of the year. In early 2008, however, the prices have increased substantially. Spurred on by a price-spike in China, the spot market price for Uinta Basin bituminous coal is now over $40 per ton as of March 1, 2008. Coal produced on Federal coal leased land is about 2/3 of all the coal produced in Colorado. The federal coal royalties average about $51 million annually.

Distribution

The main transportation method for coal in the West is by rail. Both the Union Pacific (UP) and the Burlington Northern/Santa Fe (BNSF) railroads transport coal through Colorado. The UP moves coal out of western Colorado through the Moffat Tunnel to customers in the Midwest and along the Front Range. BNSF transports Wyoming coal to the Rawhide Power Plant north of Ft. Collins, and to power plants along the Front Range, and through Denver, Colorado Springs, and Pueblo to customers in Texas and the southeast U.S.

Some of the coal mines are mine-mouth facilities (fig. 44). New Horizon Mine is captive to the Nucla Power Plant and Deserado Mine supplies coal just for the Bonanza Power Plant in Utah. Trapper Mine is captive to the Craig Power Plant, and McClane Canyon only sells coal to the Cameo Power Station. Coal is hauled via truck at each of these mines, with the exception of Deserado which has an electric train and conveyor system. The conveyor is 3 miles long while the train is 34 miles long to the power plant.

More than 77 percent of all rail shipments originating in Colorado are coal products. Over 51 percent of the rail shipments terminating in Colorado are coal, by far the single most important rail commodity in the state. Coal rail freight growth is expected to increase nationally and the Colorado railroad infrastructure, while currently supplying mines that are under producing, is inadequate for future growth. The constraint in the existing rail infrastructure in Colorado is a limiting factor for coal production in the state. In 2007, over 17 million tons of coal moved from the Somerset Coal Field to the Front Range and further east. Stockpiles at the three North Fork mines were eased by slowdowns at the mines, but in early 2007 stockpiles began increasing again. This is directly related to the number of coal trains that can move in and out of the one-way valley on the UP Railway. In 2007, over 29 million tons of coal were transported through the Moffat Tunnel between Winter Park and Denver.

Another location for rail congestion is between Denver and Colorado Springs. The Palmer Divide slows rail traffic and both the BNSF and the UP share tracks along this corridor. Most of the existing rail traffic there are coal trains passing through Denver from Wyoming's Powder River Basin. The trains must slow their speed through Denver to 10 mph, so the railroad companies, Colorado Department of Transportation, and local governments are now looking into re-routing freight lines around the populated Front Range metropolitan areas.

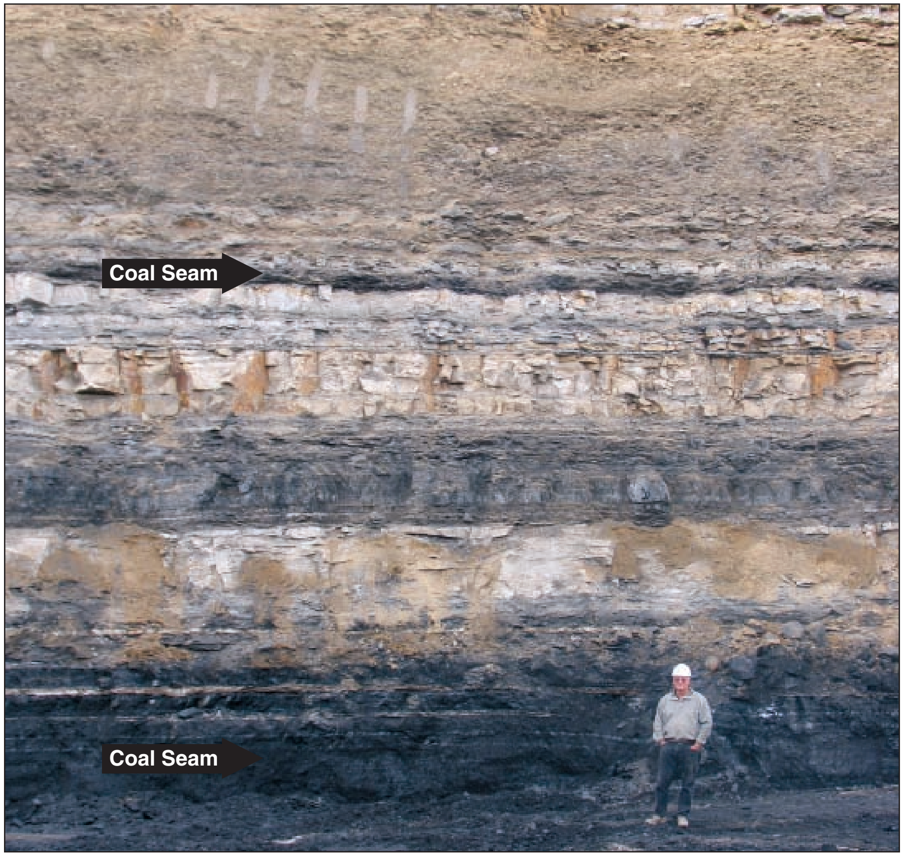


Figure 44. Highwall at the New Horizon Coal Mine, Montrose County, Colorado. This mine supplies coal to the Nucla Power Plant. It is the only coal mined from the Dakota Sandstone in Colorado. Black rock bands show the 8 inch upper coal seam and the 5 ft lower coal seam, with sandstone and carbonaceous shale beds between them. Ross Gubka for scale.

Table 12. Distribution of coal produced in Colorado. Coal was shipped to electric utilities, industrial plants, and commercial or residential customers in 27 different states in 2006. Source: Energy Information Administration.

State of Destination	Electric Utilities	Industrial Plants	Residential/ Commercial	Total	Percentage of Total Distribution	Change from 2005	Transportation
Alabama	470	-	-	470		Decrease	Rail
Arizona	1,118	127	-	1,245		Decrease	Rail, Truck
Arkansas	605	8	-	613		Increase	Rail
California	142	-	-	142		Increase	Rail
Colorado (in-state)	12,000	343	65	12,408	35.0%	Decrease	Rail, truck
Delaware	349					New	
Florida	219	-	-	219		Decrease	Rail
Georgia	354		-	354		Decrease	Rail
Illinois	874	30	-	904		Increase	Rail
Indiana	109	44		153		New	
Iowa	122	241	-	363		Increase	Rail
Kentucky	2,339	-	-	2,339		Decrease	Rail, River
Massachusetts	505	-	-	505		Decrease	Tidewater piers, Rail
Michigan	659	236	-	895		Increase	Rail, Great Lakes, River, Truck
Minnesota		49		49		Increase	Rail
Mississippi	1,290	-	-	1,290		Decrease	Rail
Missouri	46	52	-	98		Decrease	Rail
Nebraska	-	125	5	130		Decrease	Rail
Nevada	463	-	-	463		Increase	Rail
New Mexico	-	76	-	76		Decrease	Truck
Ohio	430	-	-	430		Decrease	Rail, River
Oklahoma	32	104	-	136		Increase	Rail
Tennessee	3,714	-	-	3,714		Decrease	Rail
Texas	2,052	1,535	-	3,587		Increase	Rail, truck
Utah	1,723	1	-	1,724		Decrease	Rail
Virginia	161			161		Increase	Rail
Wisconsin	1,109	327	-	1,436		Decrease	Rail, Great Lakes, Truck
Wyoming	-	115	-	115		Decrease	Truck
Domestic distribution to other states	**18,885**	**3,070**	**5**	**21,960**	**61.9%**	**down**	
Total Domestic (including Colorado)	**30,885**	**3,413**	**70**	**34,368**	**96.8%**	**down**	
Foreign Exports	**-**	**1,122**	**0**	**1,122**	**3.2%**	**up**	**estimated**
Total Domestic (including Colo) and Foreign Export	**30,885**	**4,535**	**70**	**35,490**	**100.0%**	**down**	

All figures in thousands of short tons. Note: EIA total reflects coal transportation inventories, 2006. Represents most current published data.

As an exporter of compliance coal, Colorado is one of the most important coal suppliers for the nation (table 12). Colorado coal is used in 27 other states and is sold as far away as Massachusetts and Florida. Most of Colorado's produced coal is shipped to states in the East where it is blended with high-sulfur Appalachian and Illinois Basin coals to reduce air pollution at minimally-compliant power plants. The leading Colorado coal exports to other states (EIA, 2006 most recent data) were to Tennessee, Kentucky, Texas, Utah, Mississippi, and Wisconsin. In addition to coal shipped for use in power plants, over 3.1 million tons of coal are shipped to industrial plants in Texas, Michigan, Arkansas, and Iowa for cement manufacturing and other industrial uses. Of the Colorado coal consumers in the Western U.S., electric utilities and industrial plants in Arizona, Nevada, and New Mexico accounted for about 2 million tons in coal sales. Around 2 million tons per year are shipped to Utah's Bonanza Power Plant via the 34-mile private railway from the Deserado Mine.

Consumption

Coal is consumed at coal-fired power plants, commercial industries, and manufacturing plants throughout the state. Power plants use the coal to generate steam power for electricity generation. Manufacturing sites include nonmetallic mineral products companies and primary metal manufacturing companies that use coal for various purposes. According to EIA, a total of 20.059 million tons of coal were consumed in Colorado in 2006 (table 13). This is a 3.2 percent increase in consumption over 2005. Of this total, 19.707 million tons were consumed at power plants, which is 98.2 percent of Colorado's total coal consumption.

Table 13. Colorado coal consumption by type of use 2006. W = withheld to avoid disclosure of individual company data (Source: Energy Information Administration, preliminary 2008 publication, 2006 is most recent data).

2005 (million short tons)				2006 (million short tons)				% Change
Electric Power	Other Industrial	Residential and Commercial	2005 Total	Electric Power	Other Industrial	Residential and Commercial	2006 Total	
19,013	W	W	19,445	19,707	W	W	20,059	+3.2

Xcel Energy owns or operates seven coal-fired power plants in Colorado and is the largest consumer of coal in the state. The Craig Power Station, owned and operated by Tri-State Generation and Transmission and several other partners, consumed over 5 million tons of coal in 2007, generating over 11 million Megawatt-hours (Mw-h) of electricity. The Craig Station receives coal shipments from two Moffat County mines, Trapper and Colowyo mines.

The Martin Drake Power Plant in El Paso County is operated by the Colorado Springs Utilities. This plant consumed over 1 million tons of coal in 2007 and generated over 2 million megawatt-hours of electricity, both very high figures. The downtown Colorado Springs power plant consumes Colorado coal from the Foidel Creek Mine.

Table 14. Electric generation and fuel consumption at coal-fired power plants in Colorado, 2007. Refer to Fig. 37 for utility locations on map. PRB = Powder River Basin, Wyoming. Mw = Megawatts, MCF = thousand cubic feet, BBLS = Barrels (Source: Data from utility company annual reports).

Power Plant	Utility	Nameplate Rating (Mw)	2006 Gross Electric Generation (Mw-h)	2007 Gross Electric Generation (Mw-h)	2007 Fuel Consumption				Origin of Coal
					Coal (tons)	Gas (MCF)	Wood (tons)	Fuel Oil (BBLS)	
W.N. Clark	Aquila Inc.	38	279,693	240,136	141,754	0	806.5	0	99% Foidel Creek, 1% PRB coal
Martin Drake	Colorado Springs Utilities	273	1,964,478	2,097,326	1,025,742	113,972	0	0	82% Foidel Creek, 18% Wyoming PRB
Nixon	Colorado Springs Utilities	225	1,737,182	1,620,963	887,504	0	0	4,292	Wyoming PRB
Rawhide	Platte River Power Auth.	270	2,159,230	2,555,481	1,296,251	1,192,259	0	2,025	Wyoming PRB
Craig	Tri-State G & T Assn./Platte River Power/Salt River Project/Xcel/PacifiCorp	1,274	10,764,000	11,062,115	5,087,883	64,860	0	3,501	51% Colowyo, 47% Trapper, 2% Foidel Creek
Nucla	Tri-State G & T Assn.	100	825,326	776,710	397,660	35,634	0	9,285 (propane)	New Horizon
Arapahoe	Xcel Energy	144	958,440	1,081,079	652,040	2,918,726	0	0	Wyoming PRB
Cameo	Xcel Energy	66	378,614	447,264	269,306	107,324	0	0	McClane Canyon
Cherokee	Xcel Energy	710	4,782,833	5,195,752	2,088,085	2,841,194	0	0	80% Foidel Creek, 16% Bowie, 3% Colowyo, 1% Elk Creek
Comanche	Xcel Energy	700	4,877,932	4,888,369	2,758,175	359,467	0	0	Wyoming PRB
Pawnee	Xcel Energy	547	3,765,345	3,998,554	2,351,368	253,528	0	0	Wyoming PRB
Valmont	Xcel Energy	166	1,266,696	1,418,780	542,520	579,277	0	0	51% Foidel Creek, 25% Colowyo, 20% Bowie, 2% West Elk, 2% Elk Creek
Hayden	Xcel Energy/Pacificorp/Salt River Project	447	3,805,345	3,902,405	1,735,265	25,675	0	0	Foidel Creek
State Totals		**--**	**37,565,114**	**39,284,934**	**19,233,552**	**8,491,916**	**807**	**19,103**	**--**

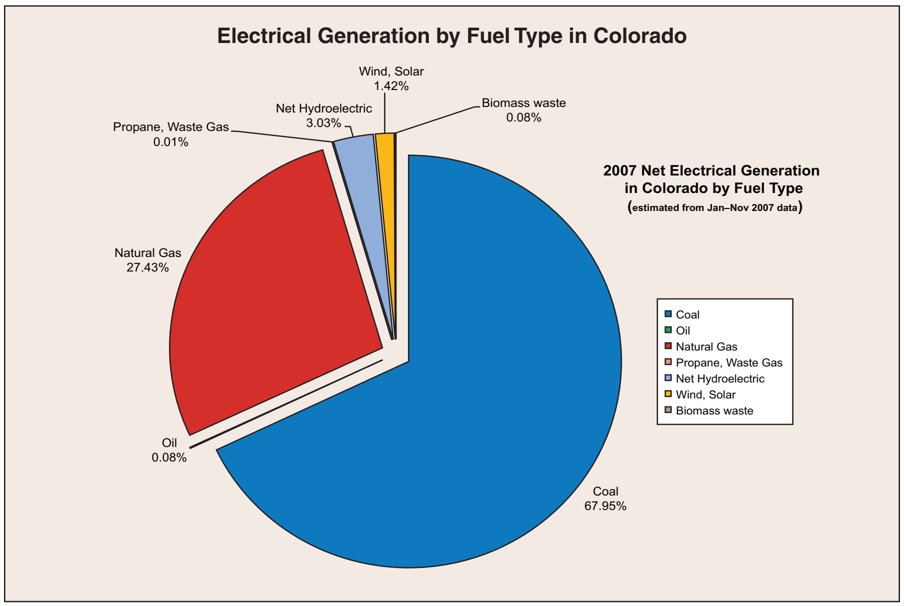


Figure 45. Net Electrical Generation by fuel type in Colorado, 2007. Chart shows that most of the electricity generated in Colorado is from coal. In recent years the coal portion has decreased in favor of natural gas. Data for Colorado from Jan. through Nov. 2007. Source DOE-EIA.

The 13 Colorado coal-fired plants generated nearly 37.6 million Megawatt-hours (Mw-h) of gross electric power in 2007. Gross electric generation is the product of megawatts of power generated times the number of hours in a year (8,760). Some of these plants also use natural gas or fuel oil as generator start-up fuel after regular scheduled maintenance.

The majority of Colorado's electric generation comes from coal (fig. 45). In 2007, less than 68 percent of the electricity generated in Colorado came from coal. Natural gas, which has increased its market share of electric generation in the last decade, now represents over 27 percent of the fuel source type. Renewable energies and fuel oil make up the remaining five percent.

Tri-State Generation and Transmission's Nucla Station produced 100 megawatts of generating capacity. It is the first atmospheric circulating fluidized-bed combustion power plant in the world. It captures more than 70 percent of the sulfur dioxide emissions. The fabric-filter bag house collects more than 90 percent of all particulate matter. In 2007 the plant used nearly 400,000 tons of high ash Dakota coal from the New Horizon Mine.

In recent years about one-third of the coal produced in-state was actually consumed in Colorado. In-state power plants and industrial plants consume coal mined in Colorado, Wyoming, and to a lesser extent, Pennsylvania and Utah (table 15). Our demand is such that Colorado consumes more than half (20 million tons in 2007) as much as it produces (36 million tons), regardless of origin. Coal consumption in Colorado is mostly for electric generation, but about two percent is consumed in the manufacturing and commercial sectors. Major manufacturers using coal for boilers in Colorado include Cemex, Inc. and Holcim, Inc. for cement-manufacturing; TXI, Inc. for lightweight shale aggregates; Western Sugar for their sugar beet refining; and the Coors Brewery. GCC is building a new large-scale cement plant in Pueblo County that will consume Wyoming coal. There is no coking coal market in Colorado today, nor is any Colorado coal used at coke plants in the eastern U.S. Colorado has over 2 billion tons of coking coal resources in the Trinidad and Somerset coal fields, but none has been produced since 1995.

Table 15. Colorado coal consumption by state of origin, 2006. Coloradoans consume coal from four states: Colorado, Pennsylvania, Utah, and Wyoming. Note that in 2006 more Wyoming coal was consumed in Colorado than Colorado coal for the first time. Units in thousand short tons.

State of coal origin	Electric Generation	Industrial Plants	Residential and Commercial	Total
Colorado	10,931	343	65	11,339
Pennsylvania	2			2
Utah	0		1	1
Wyoming	11,340			11,340
State Total Consumption	22,273	343	66	22,682

Black Hills Corporation, a Colorado-based company, is partially acquiring Aquila Corporation's utility operations and properties in Colorado, Kansas, Nebraska, and Iowa. This will broaden Black Hills' regional presence and retail utility base. Great Plains Energy, the parent company of Black Hills Corp, will now own the W.N. Clark coal-fired power plant in Canon City.

Employment, Safety and Productivity

The employment of coal miners from 2006 to 2007 increased only slightly from 2,065 to 2,069 miners. The Colorado Mining Association says that total number of employees at Colorado coal mines is over 2,246. Coal is the biggest component of Colorado's mining industry today. The average annual wages and benefits for Colorado coal mines is over $93,000 per year. This high paying work is in direct competition with petroleum workers on the western slope as demand for skilled workers in an aging workforce continues.

Colorado's coal miners produce more coal per man-hour than most other states. Coal mining productivity is defined as the total state coal production divided by the total direct labor hours worked by all mine employees. In 2006 (again the most recent data available from EIA), the average production per employee per miner-hour was 7.9 tons, down 7.2 percent from 2005, but still higher than the U.S. average of 6.36 tons per miner-hour. Overall coal miners in Colorado are the eighth most productive nationally. Underground miners in Colorado produced coal at a rate of 7.79 tons per miner-hour. This is the second highest rate in the nation after underground miners in New Mexico. Surface miners in Colorado produced at a rate of 8.46 tons per miner-hour, good for seventh best in the U.S.

The average number of union employees at Colorado coal mines declined sharply in recent years. Only 17 percent of the present workforce are union miners in Colorado. Most of the union miners are employed at surface coal mines.

At the 110th National Western Mining Conference in Denver this February the Colorado Mining Association and the Colorado Division of Reclamation, Mining and Safety awarded several coal companies with excellent achievement in safety and pollution prevention. The companies winning the 2007 awards included Trapper Mining, Western Fuels, Oxbow Carbon & Minerals, McClane Canyon Mining, and Rio Tinto America. Rio Tinto America's Colowyo Mine personnel won the Large Surface Coal Mine Award for innovative safety practices. Bowie Resources won the Large Underground Coal Mine Award for reducing its total incident rate in the past year, and Oxbow Carbon won the award for excellence in safety at its Terror Creek Load out. McClane Canyon and the New Horizon Mines won awards for Medium underground and surface mine safety respectively. Trapper and Colowyo Mines won the excellence in safety awards for large surface coal mines. Colowyo's nine explosives team members won a special award for working over 25 years without a lost-time injury, and 12 individual miners won an award for 30 years of safe employment.

At a time when safety is a major concern to coal miners in the U.S. it is important to recognize the much improved injury statistics with regard to safety at the nation's coal mines today. Injuries at coal mines have dropped by 66 percent in the last 16 years nationally. More than 50 percent of the U.S. coal mines operate each year without any lost time work injuries. Six Colorado mines have gone years without lost time accidents.

Coal Quality and Reserves

Four components are important in determining the desirability of a certain coal: ash, sulfur, and mercury content, as well as the heat value in Btu. These, along with transportation costs, determine the price that can be obtained for a particular coal. The amount of ash determines how much impurities such as clay particles are mixed in with the coal. The lower the ash content, the lower the waste products after burning. The amount of sulfur and mercury concentrations bound within the coal determines how much removal treatment is required to comply with Clean-Air standards. The Btu value determines how much heat can be generated from a pound of coal.

In the fall of 2007, the Colorado Geological Survey conducted a sampling program of all eleven active coal mines. The run-of-mine samples collected represent a picture in time for the type of coal sold in Colorado today. The average of 20 samples was 11,343 Btu per pound, 0.62 percent sulfur, and 11.93 percent ash. These are characterized as high Btu, low sulfur, and moderate ash coal. Coking coal was also indicated for the analyses from the King Coal Mine. Most of the coal mined in Colorado is bituminous (approximately 79 percent of the state's production); only two mines produced sub-bituminous coal (Trapper and Colowyo mines).

Colorado is second only to Illinois in bituminous coal reserves, but is by far the leader in bituminous clean air compliant coal reserves. According to EIA data, the average quality of coal received at manufacturing plants in Colorado for 2005 was 11,620 Btu, 0.51 percent sulfur, and 9.77 percent ash. Btu of Colorado coal increased from the 11,336 Btu reported for 2005.

Colorado steam coal is attractive because of its high quality for Clean Air Act compliance with power plant emission standards (table 16). The San Juan and Raton Mesa Coal Regions have the highest heat values, averaging over 12,500 Btu (fig. 46). The Denver Coal Region has the lowest sulfur coal averaging 0.3 percent. The South Park and Uinta Coal Regions have less than seven percent ash. Colorado coal produced in 2006 ranges between 0.4 and 0.8 percent sulfur, which is about two or three times lower than the average eastern bituminous coal. The average quality of coal received at electric utilities in Colorado is compliant with Clean Air Act standards.

Over 70 percent of the global recoverable coal reserves are in the U.S., Russia, China, India, and Australia (the leading coal exporting country). In the U.S., Wyoming is the largest coal-producing state supplying 1/3 of the nation's coal. Over 90 percent of the U.S. coal production goes to electricity generation, supplying about 50 percent of the country's electricity. When adjusted for inflation, the price of U.S. coal in 2005 was less than the coal price in 1949.

About 75 percent of Colorado coal leases are federally owned. Nearly 50,000 acres are currently under lease. The average recovery percentage at Colorado coal mines is 66.88 percent. EIA's Demonstrated Reserve Base (DRB) data show Colorado has 16.187 billion tons of coal; 11.18 billion tons underground mineable and 4.75 billion tons surface mineable. The estimated recoverable reserves (9.73 billion tons) are defined as that part of the DRB that can be mined using today's mining technology.

Table 16. Average quality values for mineable coal beds from all coal mines in Colorado by coal region. Ash, Btu, and Sulfur samples from the U.S. Geological Survey COALQUAL database. Mercury values are from the U.S. Geological Survey National Coal Quality Inventory at active mines collected by the CGS in 2001 (Source: CGS Information Series 58).

Analyses	Denver Region	Green River Region	North Park Region	Raton Mesa Region	San Juan Region	Uinta Region	South Park Region	Cañon City Region
Ash (percent)	11.2	9	12.4	16.1	12.7	6.8	6.4	9.8
Sulfur (percent)	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
No. Samples	727	851	53	861	720	1,732	1	684

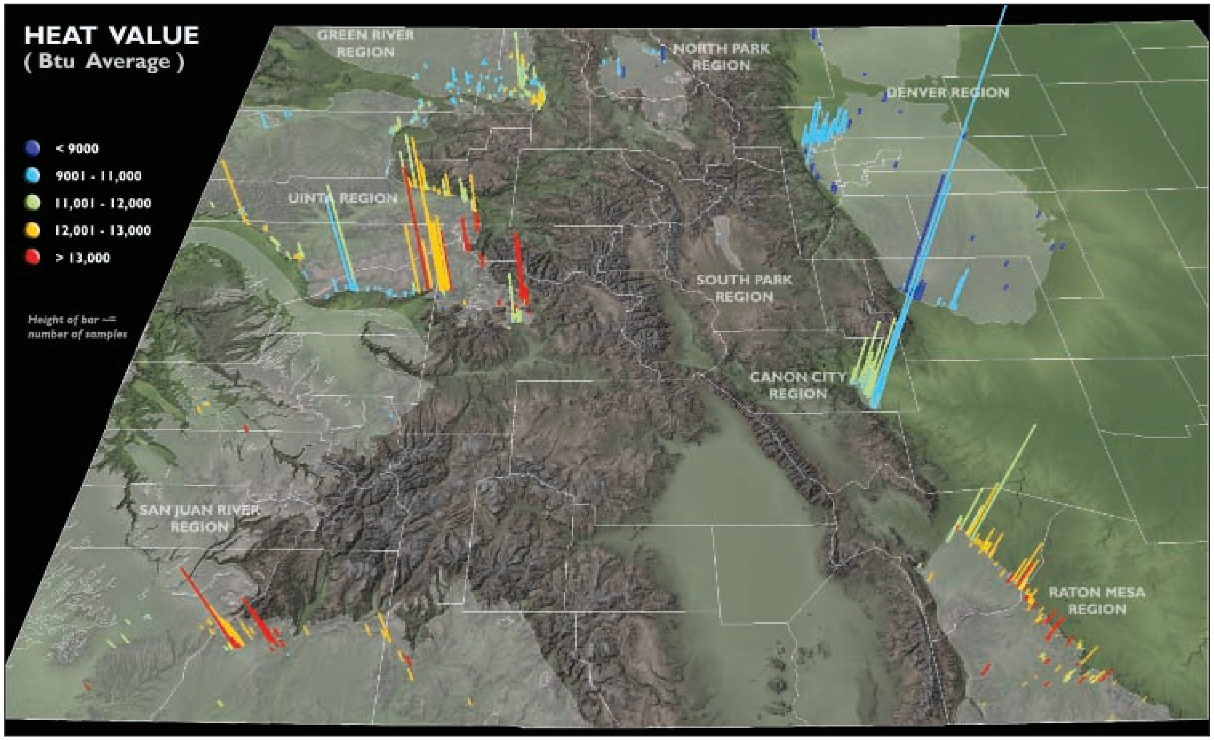


Figure 46. Heat value in terms of average Btu per mine for 1,000 historic coal mine operations in Colorado. Data suggests that the highest heat value coal comes from southern Colorado provinces that have been influenced by geothermal gradient highs in the Raton Mesa, San Juan River, and southern Uinta Coal Regions.

The World and National Coal Outlook

The U.S. produced over 1.15 billion tons of coal in 2007 while consuming about 1.11 billion tons. This was the second highest coal production year on record. The U.S. is a net exporter of coal, with over 23 million tons more exported to other countries than it received. This was nearly double the amount from 2006. The U.S. economy is tied directly to electricity use and if natural gas supplies continue to decline in the future, the only near-term solution for baseload electric generating fuel is either coal or nuclear. For now coal will remain critical to the future of electrical generation.

The environmental outlook for coal is not good. The global warming concerns over coal-fired power plants has made the future of building new power plants in doubt. Over 48 proposed coal-fired power plants have been scrapped in the last year in the U.S. due to concerns over costs and the uncertainty of climate change.

In 2007 China changed from being a net exporter to a net importer of coal. Due in large part to their large-scale building construction boom, the metallurgical grade coal sales price to China is now over $200 per ton. Chinese steel construction demand is sending coal prices to new highs, nearly doubling the price of coal around the world. In addition, late in January 2008, a severe series of winter storms pushed through China and power shortages around the country lead the government to suspend coal exports for two months. China's need for coal is rising faster than it is for other countries. Flooding at Australian Mines and overloading at their ports in the past year have dampened China's import demand. World demand for coal is also on the rise: South Africa and Japan have had to increase steam coal consumption while their traditional nuclear and gas-fired power plants have been under developed. Electricity shortages in South Africa caused the shut down of major gold mines and other industrial centers.

Clean Coal Technology

"Clean coal" is defined as coal that is chemically washed of mineral impurities and sometimes gasified and burned. Long used as a method for generating electricity, coal might also provide a faster and cheaper way to produce liquid fuels in the future. Various forms of clean coal technology include Integrated gas combined cycle (IGCC) technology, which is like a turbo charger for your coal fired power plant, and the coal to liquids (CTL) program that processes coal and wood into liquid fuels like diesel. Last year IGCC was the technology of interest, but now it seems that CTL is important in 2008, due to higher fuel prices in the U.S.

CTL technologies are now being researched intensively across America. Coal can be converted into many fuels. South Africa has the only two commercially available CTL plants in the world, and China is building one in 2008. CTL supplies 30 percent of that country's gasoline and diesel fuel. There are two methods for converting coal into liquid fuels, direct liquefaction and indirect liquefaction. The former dissolves coal in a solvent at high temperatures and pressures for further refining for fuel. The latter process gasifies coal into a 'syngas' that is condensed over a catalyst. This process, called the 'Fischer-Tropsch' process, produces high quality fuel that the South Africans have used for more than 50 years.

As the price of petroleum increases in relation to the price of coal these types of expensive and technically complicated alternatives becomes more viable. CTL is being tried commercially in Colorado also. Rentech Inc., is completing a $50 million demonstration plant in Commerce City. It will be a commercially available diesel and aviation fuel plant that converts coal and other feedstocks (such as municipal waste and wood chips) into fuel. However, the capital costs and process technologies are quite costly, but with oil over $100 per barrel the technology seems much more promising. To fund the research the U.S. Air Force has shown much interest in the technology not by funding the operations but by guaranteeing future demand for the fuel. The Air Force plans to fuel half its North American fleet with a synthetic-fuel blend by 2016. A typical CTL plant might cost $4 billion to build, require 4 million tons of coal annually, and produce 20,000 barrels of fuel per day. With current diesel fuel prices over $4 per gallon in the U.S. today the need for an alternative fuel source is in high demand. Gasoline in South Africa is equivalently $1.60 per U.S. gallon.

While environmental groups have now turned their backs on CTL because of the doubling of CO_2 production at the plants, most CTL proponents are now tagging even more expensive carbon sequestration onto them. To offset these costs, Rentech proposes to sell CO_2 as an enhanced oil recovery gas to the petroleum industry. Also, the fuel produced by Fischer-Tropsch methods can be made to burn cleanlier than the commercially available diesel fuel used today. The best advantage to CTL is the energy security: this process allows domestic coal to replace foreign oil imports. It also helps to strengthen our energy independence as well.

Introduction

After a remarkable spike in uranium prices that saw the spot price of the energy mineral reach $135 per pound in April, the price settled back to a sustained level of $75 to $85 per pound for the remainder of 2007 (Figure 47). Several factors figured into the wave of panic buying since 2006. First, there is a lot of concern about energy technologies that generate CO_2. Reliable baseload energy for generating electric power, other than fossil fuels, create a very short list. Secondly, the world's largest uranium mine—the Cigar Lake Mine in northwest Canada, was closed for an extended period (and remains closed) by successive flooding incidents. Third, a contract by which the U.S. has been dismantling Soviet-era nuclear weapons, adding the down-blended uranium into fuel stocks, is rapidly coming to a close and the Russian government is not planning to renew it.

The production of uranium in the United States and the world has not kept up with the demand and the demand is increasing. Worldwide, 439 reactors—with a combined capacity of approximately 370 Gigawatts of electricity—require 66,500 tons of uranium. In 2005, 41,600 tons were supplied by mines—less than 2/3 of the required supply. The remainder was made up by the down-blending of weapons-grade material or was removed from existing stockpiles. The stockpiles are now largely depleted.

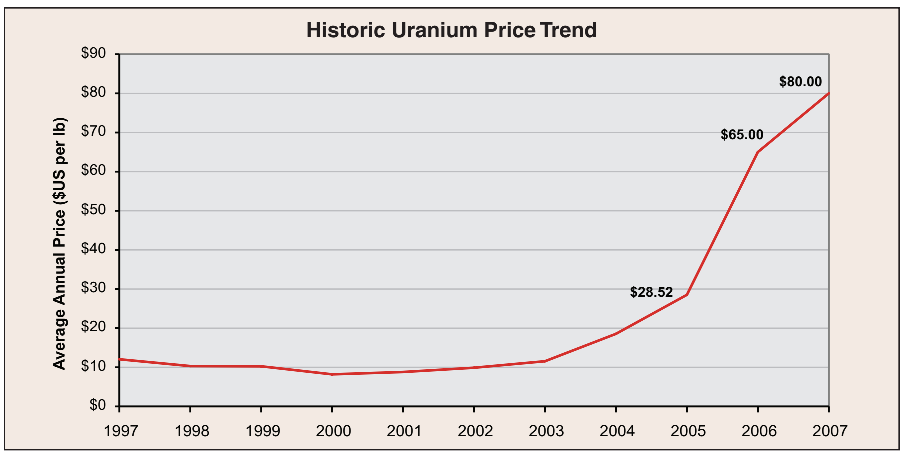


Figure 47. The price of uranium was rejuvenated in 2004 by the anticipation of a growing demand because of plans by nations around the world to build new nuclear power generating capacity, the loss of the single largest mine in the world for an indefinite period of time, and the pending end of the treaty by which Russian nuclear warheads are dismantled with their uranium content being converted to nuclear fuel rods. The price actually hit a peak of $135 per pound in the spring of 2006, but has since settled into a range between $75 and $85 per pound.

Looking at future demand, the World Nuclear Association lists an additional 222 reactors proposed around the world, 93 already planned or ordered and 34 being built. This will nearly double the demand for uranium. Nations planning to enter the group of nuclear power generators include Bangladesh, Belarus, Egypt, Indonesia, Iran, Israel, Kazakhstan, North Korea, Thailand, Turkey and Vietnam. The U.S. demand for 2008 will be approximately 19,000 tons, while the production in the U.S. was only 1700 tons in 2006, according to the World Nuclear Association. It's no secret why there has been renewed interest in Colorado's uranium resources.

Mining Uranium in Colorado

A company or an individual planning to mine uranium in a particular location in Colorado has four ways to pursue the venture, depending on who controls the mineral rights of the land where the uranium is located. The simplest situation is a deposit located on private land. The prospective miner need only obtain the rights to the land, before pursuing the required permits. A deposit on state land requires leasing of the mineral rights from the State Land Board.

Federal mineral rights for uranium can fall into one of two categories. For typical federal land with federal mineral rights, whether the surface is administered by the Bureau of Land Management or the U.S. Forest Service, the prospective miner must follow the procedures for staking a claim. Land on which a deposit has been discovered can be "staked" by any U.S. citizen by marking the corners and midpoints of the long boundaries with posts sunken into the ground or some other technique (Fig. 48), such as a rock cairn and registering the claim at the county courthouse and at the state office of the Bureau of Land Management in Wheat Ridge. Each claim can be of a maximum length of 1500 feet, maximum width of 600 feet, but there is no limit to the number of claims that can be staked. This gives the claimant the right to develop a mine on the claimed area.

Figure 48. Example of a mining claim, staked at the corner and midpoint of the long boundaries of a claim for minerals. Claims can be filed on land for which mineral rights are owned by the U.S. government, giving the claimant exclusive rights to develop the mineral resources on that plot of land.

Another category exists uniquely for uranium. The Atomic Energy Commission (AEC), predecessor to the Department of Energy, set aside special lease tracts in the Uravan mining district of southwest Colorado for uranium mining. ("Uravan" combines the two commodities uranium and vanadium, which are found together in mineable quantities in southwest Colorado.) Rights to mine these tracts in the counties of Mesa, Montrose, and San Miguel are leased through a special competitive bidding process through the Department of Energy. The leases on these tracts, not used for many years while the price of uranium was low, have reverted to the DOE and will be bid again in the spring of 2008.

These are four means by which the property can be secured for mining, but before mining can proceed, the miner must obtain permits to operate the mine. Exploration, including subsurface drilling to better define the extent of the uranium deposit (Fig. 49), is done via a permit from the Colorado Division of Reclamation, Mining and Safety. The details of the activity during this exploration period are confidential and even the identity of the company cannot be released by the state agency for concerns of competition. It should be noted, though, that most companies are themselves willing to release information on their exploration and provide it readily on their websites and through their press releases.

If the company determines that the mineralized zone is rich enough to justify mining, they must obtain permits from the Colorado Department of Public Health and Environment (CDPHE) and the Colorado Division of Reclamation, Mining and Safety (DRMS). Before those permits can be finalized, a list of other permit items must be satisfied, including county special use permits, a federal plan of operation and an environmental assessment (EA), Department of Transportation permit, air quality permit, storm water control permit, water discharge permit if applicable, a permit from the federal Mine Safety and Health Administration (MSHA), an explosives permit, and have a spill prevention control and countermeasures plan (SPCC plan) as per 40 CFR part 112; water rights and sewage disposal regulations must be satisfied.

Figure 49. The drill rig is set up to investigate a prospect in San Miguel County using a "Notice of Intent to Explore," an exploration permit issued by the Colorado Division of Reclamation, Mining and Safety. The site in the photo is one of seven active projects being investigated by Energy Fuels Resources in the Uravan District of Colorado.

2007 Activity in Colorado

The uranium industry saw a high level of activity in the state in 2007. A record number of claims were staked on federal land across the state, as companies attempted to acquire legal access to potential mineralized sites for closer investigation. A total of 10,624 claims were filed in 2007. Based on their location, the CGS estimates that more than 9300 of them (88%) were for uranium. (The claim registration does not require that the commodity of interest be listed.) Figure 50 shows the distribution of new mining claims in 2007 by county.

Many companies were able to progress beyond the claim filing stage and have been working to refurbish and reopen old, existing mines or have begun drilling program to quantify the resources present. Figure 51 and Table 17 show the location of activity across the state.

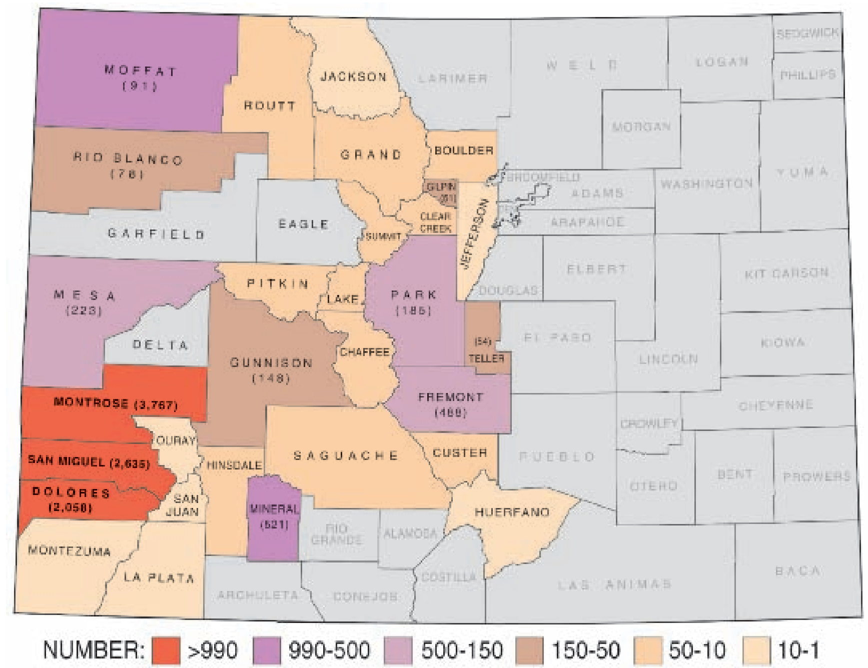
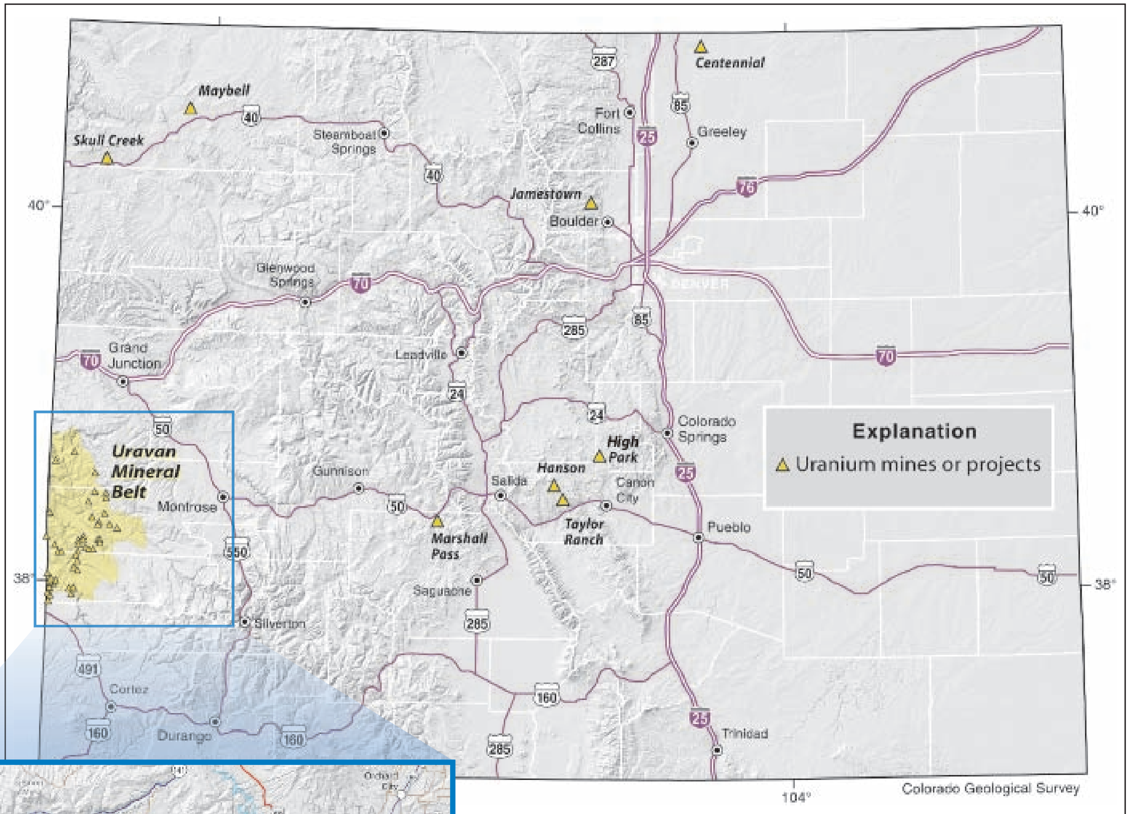


Figure 50. Distribution of mining claims filed with the U.S. Bureau of Land Management, by county. The greatest concentration is in the traditional heart of uranium mining country—the Uravan Belt of Mesa, Montrose and San Miguel Counties. A large number of claims were filed in neighboring Dolores County in 2007. Other counties with probable high totals of uranium activity include Fremont, Park, Moffat and Rio Blanco Counties.



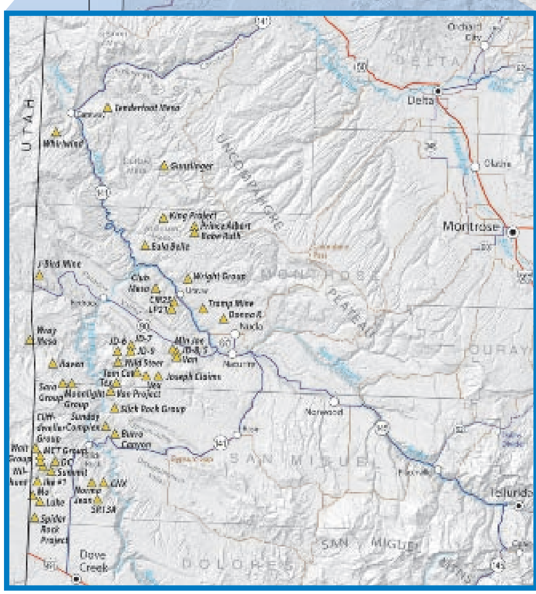


Figure 51. The double map shows uranium projects that the Colorado Geological Survey has confirmed as active in the state. The locations shown on the map correspond with the projects as listed by company on Table 17. Most of the projects are located in the Uravan District of southwest Colorado; that section of the map is enlarged to better show the names and locations of the projects. The projects represent various stages of activity. Some are currently being explored, some are being drilled, some already exist as mines and are being refurbished by the company in preparation for mining.

Table 17 (right). Active uranium projects in Colorado by project name and county. Note that the great majority of projects are located in the "Uravan" Belt (Uranium–Vanadium) of southwest Colorado, in the counties of Mesa, Montrose and San Miguel. Other companies may be in the process of exploration but CGS has been unable to identify them or the locations of their projects. Those projects marked with an asterisk (*) hold an active permit with the Colorado Division of Reclamation, Mining and Safety.

Company	Project Name	County
Anglo-Canadian	Gunslinger Claims	Mesa
	Eula Belle	Montrose
	Wild Steer	Montrose
	Tom Cat	Montrose
	Joseph Claims	Montrose
	Spider Rock	San Miguel/Dolores
Black Range	Taylor Ranch	Fremont
BlueRock Resources	J-Bird*	Montrose
	Tramp*	Montrose
	Skull Creek	Moffat
	Donna K	Montrose
Buckingham Exploration	High Park Project	Teller
Cotter Corporation	Mineral Joe Claims	Montrose
	C-LP-21 Mine*	Montrose
	JD-9 Mine*	Montrose
	CM-25 Mine*	Montrose
	JD-7 Mine*	Montrose
	JD-6 Mine*	Montrose
	SM-18 Mine*	Montrose
	LP-22A Mine	Montrose
	JD-7 Pit*	Montrose
	Wright Group*	Montrose
	JD-8 Mine*	Montrose
	Liberty Mine*	Mesa
	SR-13A Mine	San Miguel
	Ike No. 1 Mine	San Miguel
	Bachelor Mine	San Miguel
Denison Mines	Sunday Complex Mines*	San Miguel
	Van Project*	San Miguel
Energy Fuels Resources	Whirlwind Mine	San Miguel
	Tenderfoot Mesa	Mesa
	Club Mesa	Montrose
	Sara Group	Montrose
	Moonlight Group	Montrose
	Walt Group	San Miguel
Energy Metals Company	Hansen Creek Project	Fremont
Homeland Energy	VEX	Montrose
	TEX	Montrose
	CNX	San Miguel
	Slick Rock	San Miguel
	Norma Jean	San Miguel
	Big Indian	Montrose
New Horizon	Summit Project	San Miguel
	Elkhorn Project	Park
Powertech Uranium	Centennial Project	Weld
Rimrock D&E	Prince Albert Mine	Montrose
Universal Uranium	Marshall Pass	Saguache
	Jamestown	Boulder
Uranium Energy Corp.	Sandy/Babe Ruth	Montrose
	Carnotite	Montrose
	Raven	Montrose
	Triangulation	Montrose
Uranium Power Corp.	Burro Canyon Project	San Miguel

These projects represent various stages of completion, from initial identification to the point where the company is ready to bring ore out of the ground. Since 2005, however, there has been no official production of uranium from Colorado. Uranium ore from conventional underground or surface mines must be processed after it is removed from the ground by the milling process. The uranium ore commonly contains less than one percent uranium oxide and, in the Uravan area, several percent Vanadium oxide. The waste rock must be removed, with a product that contains concentrated amounts of the uranium and vanadium so it can be shipped to a refiner, where the concentrate is converted into the salable metals. This concentration process is accomplished at a uranium mill (fig. 52.)

Figure 52. Aerial photo of a uranium mill. The mill itself, where the ore is crushed and the uranium and vanadium removed, is surrounded by a piles of the waste rock, from which the commodities have been removed, and a lined pond, containing water from the operation.

Figure 53. Uranium ore arrives at the mill containing less than 1 percent uranium. Through the milling process, yellowcake is produced—a powder of consisting of approximately 90% U_3O_8., with about 0.3% of the fissionable isotope U-235. The yellowcake is then shipped to a plant where the concentration of U-235 is raised to about 4% for use in fuel rods for nuclear power plants.

The milling process begins by grinding the ore. The particles must be small enough that the uranium and vanadium can be more easily dissolved from the ore by the second step—the leaching of the ground-up ore—in large tanks. The liquid containing dissolved uranium is processed into a concentrated powder (fig. 53) of U_3O_8 called "yellowcake." The vanadium is removed through a separate process.

In 2007, there were no fully functional uranium mills in the United States. The White Mesa Mill in Blanding, Utah, was being refurbished by the new owner—Denison Mines—but was not scheduled to become completely operational for both uranium and vanadium until the end of March 2008. Because of this, Colorado miners were not extracting ore from their mines. Denison itself has been stockpiling ore at the mill so it is ready to process as soon as the mill is completely operational.

The paucity of conventional milling facilities in the U.S. is a major bottleneck in the production of uranium. There are several other mills that can be reopened, each positioned to conveniently service different uranium-producing areas of Colorado. Figure 54 shows the location of the mills and their distance from the center of the Uravan District. While the cost of transporting ore from southwest Colorado to several of these mills would be high, the Sweetwater mill in Wyoming is within reasonable distance from the Moffat County uranium districts and the Canon City mill is well situated to process ore from the Fremont and Teller County areas, as well as ore from New Mexico. The management of the Cotter Corporation has initiated steps with the Colorado Department of Public Health and Environment—the permitting agency for uranium mills—to refurbish their mill in Canon City, modernize it and reopen the operation. The opening of these mills will enable Colorado uranium miners to ship their product, and mining will probably resume at a higher rate.

The ability to produce uranium without the conventional milling process is one reason that several companies are planning to utilize the in-situ recovery (ISR) method of mining. With this technique, the miners take advantage of uranium's sensitivity to oxidation conditions by pumping oxidized water into the buried deposit, dissolving the uranium, and pumping the water back out of the ground to recover the dissolved resource. The method not only by-passes the need for traditional mills, but is much less expensive and avoids aspects of traditional mining that typically must be accounted for. There is no heavy equipment such as trucks, no digging or blasting, and hence no dust; there is no mine waste rock. Specific conditions must be found in the deposit, however, such as a permeable sandstone containing the ore with an impermeable layer both above and below to prevent the pumped water from migrating. Concern exists about the fact that the company will be working in the aquifer and these concerns must be addressed and trust must be gained before ISR projects become common in Colorado.

Figure 54. Location of conventional uranium mills and their distance from the Uravan Mining District. While the White Mesa and Shootaring Canyon Mills in Utah are best situated to mill ore from the Uravan District, the Sweetwater mill is closer to the Moffat County districts and the Canon City Mill to the potential mines in Fremont, Teller and Park Counties as well as ore from New Mexico.

Introduction

The New Energy Economy as outlined by Governor Bill Ritter in 2007 has grown significantly in its first year. Amendment 37, which requires utility companies to get 20 percent of their energy from renewable sources by 2020, has been the strongest motivator for building new renewable energy programs in Colorado the past few years. New electric transmission lines, which usually take years to permit, have been streamlined for wind energy in eastern Colorado. The New Energy Plan calls for more wind, sun, and biomass powered alternatives, as opposed to the traditional hydroelectric power. The Bill also sets the first renewable energy standard for rural electric cooperatives in Colorado. The state of Colorado is situated in a unique location for alternative energy technology, and the Governor's plan has already taken great strides toward developing this resource.

Wind Energy

Wind energy is defined by the process in which kinetic energy generated by wind is transformed into mechanical power to generate electricity. Wind power is the fastest growing source of electricity generation in the nation. For 2008, new Colorado wind power projects will bring an additional capacity of 776 megawatts of power capacity. Xcel Energy buys all of the Colorado wind-generated electricity from the high plains. Since the wind source is erratic rating power systems are referred as capacity only, and not actual generation numbers.

New design technologies make wind generated electricity more competitive with traditional electrical generation. The turbines used today are much more efficient than they were 30 years ago. Wind electricity sells for half the price of nuclear power and about the same as electricity from coal, oil, and natural gas. Although wind energy represents a small part of the total electrical generation, its power production has increased substantially in the last year. Wind generated electricity in Colorado jumped from 0.6 percent to 1.4 percent of the total electricity generated in 2007.

National Wind Power

The U.S. wind energy industry continues to exceed expectations. In 2007, over 5,244 megawatts of wind energy capacity were installed in the U.S. This increased the nation's wind power generating capacity by 45 percent in one year. Wind energy in 34 states now totals over 16, 818 MW capacity. The American Wind Energy Association estimates that over 48 billion kilowatt-hours of wind energy will be generated this year. Over 1,067 MW capacity of utility-scale wind power are now installed in Colorado, making Colorado the sixth largest wind-generating power capacity state in the nation (table 18). Since Colorado is only ranked 11th for wind potential in the US, the sixth ranking for wind development shows that our state is ahead of most states in developing their wind potential.

Table 18. Total capacity of wind generation facilities by state, through December 2007. This table shows the top six wind power generating states in terms of installed energy capacity.

State	Megawatts of Installed Wind Generation Capacity	Ranking
Texas	4,356	1
California	2,439	2
Minnesota	1,299	3
Iowa	1,273	4
Washington	1,163	5
Colorado	1,067	6

Colorado Wind Power

New wind power projects in Colorado are quite numerous (table 19). In terms of new construction, Colorado was second in the nation after Texas with new wind capacity for 2007. Most of the new wind-facility construction activity is in northeast Colorado between the small towns of Peetz (Logan County) and Grover (Weld County). Geographically this area along the Nebraska state line is an elevated high plain with a cliff edge along the southern edge where wind blows continually. This windy area also has existing electric transmission lines that can easily accommodate the new wind turbines.

In the summer of 2007 a new Peetz Table site was constructed. This massive facility with 176 turbines has 264 Megawatt (Mw) capacity rating. Each turbine has a 1.5 Mw rated GE Energy turbine. The project was developed by Florida Power & Light (FPL) and by Invenergy. FPL is also the owner. The new Peetz Table facility was the largest wind farm built in the nation in 2007. In addition to this plant, three more projects were built in the fall of 2007. These were an additional Peetz Table project of 91 turbines with 136.5 Mw capacity rating, built by the same developers. Then a project at Cedar Creek near Grover in Weld County was also constructed. This 79.5 Mw plant was developed by Babcock & Brown partnering with BP America. In 2008, another Cedar Creek project, called Cedar Creek II, will be built. It will be a 221 Mw facility using smaller 1 Mw turbines. This will be the largest wind farm in terms of the number of turbines constructed at one facility.

Figure 55. Cedar Creek Wind Energy Farm, Weld County. This wind farm has over 270 turbines generating 300 Mw capacity electricity when the wind is blowing, which is most of the time in northeastern Weld County.

The Vestas Wind Systems Company opened its new turbine manufacturing plant in Windsor, Larimer County, in March 2008. The new plant employs 600 personnel to build the wind turbine blades for its wind systems. Vestas is the world's largest wind-energy manufacturer. The factory hopes to produce 1,800 blades annually for regional wind farms. The blades are 148 feet long and 10 to 11 feet in an aerodynamic width. The location is ideal for research and development as most of Colorado's new wind farm installations are located in northeastern Colorado along the Wyoming and Nebraska border. Vestas likes Colorado because of its strong winds, research potential with the National Renewable Energy Laboratory in Golden, and the pro-renewable political environment at the State level. The market technology is ever changing with more efficient and stronger blade designs.

The Colorado state land board operates the State Trust Lands in Colorado. They have a wind energy development leasing program for five existing wind energy leases with a total of 9,258 acres. Ponnequin, Logan, Florida Power and Light's Peetz table, Cedar Creek, and the Waunetta Wind Farms are all part of this program with. Approximately $200,000 revenue is generated annually from this program. There are nine pending wind energy state lease applications for an additional 12,400 acres of wind turbines in 2008.

Table 19. Wind energy developments and proposed projects in Colorado. Mw = Megawatts (Source: American Wind Energy Association).

Project	Owner	Date Online	Mw Capacity	Power Purchaser	No. Units	Turbine Type
Ponnequin EIU 1	K/S Ponnequin Windsource & Energy Resources	1999	5.1	Xcel Energy	7	NEG Micon
Ponnequin Xcel 2	Xcel Energy	1999	16.5	Xcel Energy	22	NEG Micon
Ponnequin EIU 3	New Century	2001	9.9	Xcel Energy	15	Vestas
Peetz Wind Farm	New Century	2001	29.7	Xcel Energy	33	NEG Micon
Colorado Green, Lamar (Prowers Co)	Xcel/GE Wind Corp.	2003	162	Xcel Energy	108	GE Wind 1.5 Mw
Prowers Co (Lamar)	Arkansas River Power Authority	2004	1.5	Arkansas River Power Authority	1	GE Wind 1.5 Mw
Baca Co (Springfield)	Arkansas River Power Authority	2004	1.5	Arkansas River Power Authority	1	GE Wind 1.5 Mw
Prowers Co (Lamar)	Lamar Utilities Board	2004	4.5	Lamar Utilities Board	3	GE Wind 1.5 Mw
Aurora Wal Mart	Bergey Windpower	2005	0.05	WalMart	1	Bergey Windpower 50 kW
Spring Canyon (near Peetz)	Invenergy Wind, Llc	2006	60	Xcel Energy	40	GE Wind 1.5 Mw
New Installations in 2007						
Twin Buttes	PPM Energy	2007	75	Xcel Energy	50	GE Wind 1.5 Mw
Peetz Table	Florida Power & Light (FPL) Energy/Invenergy	2007	264	Xcel Energy	176	GE Wind 1.5 Mw
Logan (east of Peetz Table)	FPL	2007	136.5	Xcel Energy	91	GE Wind 1.5 Mw
Cedar Creek (near Grover)	Babcock & Brown/BP America	2007	79.5	Xcel Energy	53	GE Wind 1.5 Mw
Cedar Creek (near Grover)	Babcock & Brown/BP America	2007	221	Xcel Energy	221	GE Wind 1.0 Mw
Proposed Installations for 2008–2009						
Northern Colorado Wind Project (near Spring Canyon)	FPL	2008?	200	Xcel Energy	133	GE Wind 1.5 Mw
Cedar Creek (Phase II)	BP	2009?				
Cedar Point (Elbert, Lincoln cos)	Renewable Energy Systems	2008–2009?	300			
Waunetta (Yuma Co)	Iberdrola Renewable Energy	2009?	102		8	
Crossing Trails (Kit Carson, Cheyenne Cos)	Horizon Wind					
Akron (Washington Co)						
Maxwell Ranch (Larimer Co)	Colorado State University		250			

In terms of small-scale projects in 2007 the Colorado Senate passed House Bill 1087 that creates a grant program for schools. This will help schools to install wind turbines and develop an educational clean energy curriculum. Education will also receive more funding from House Bill 1145 which is called renewable resource development on Public Lands. This bill enables the state land board to lease lands for renewable energy, and the funds from the lease will go toward K–12 education.

Hydroelectric Power

Electricity generated by hydropower converts kinetic energy in falling water into power. Colorado's mountainous terrain has great potential for hydroelectric power and has maintained a substantial amount of hydroelectric power generation. In 2007 3.3 percent of our total electrical output came from 48 hydroelectric generating stations. Aspen, Telluride, Durango, Ouray, Nederland and other mountain towns supply much of their power from several nearby hydroelectric stations (figure 56). The Colorado-Big Thompson Project brings large volumes of western slope water via tunnels under the Continental Divide to the Front Range. Along the way hydroelectric power is generated at several substations.

Most hydroelectric dams were built before 1960 when coal and natural gas-fired power plants were largely inefficient. Since that time dams have become relatively less efficient and environmentally controversial. The largest dams were built around 1960 as bigger also meant more efficient and also met the growing demands of urban electrical consumption. Hydropower is the world's largest renewable source of electricity supplying about 15 percent of global electricity. About 10 percent of the U.S. electricity comes from hydropower, and in Colorado it is about four percent. The worldwide capacity for hydropower on dams is potentially four times greater than what has already been constructed.

This energy is clean and renewable, but dams have a significant impact on river ecosystems. The environmental impacts of dam construction have overshadowed hydroelectric power over the last 30 years. Hence this energy source is renewable but is not considered a major player in Colorado's New Energy Economy.

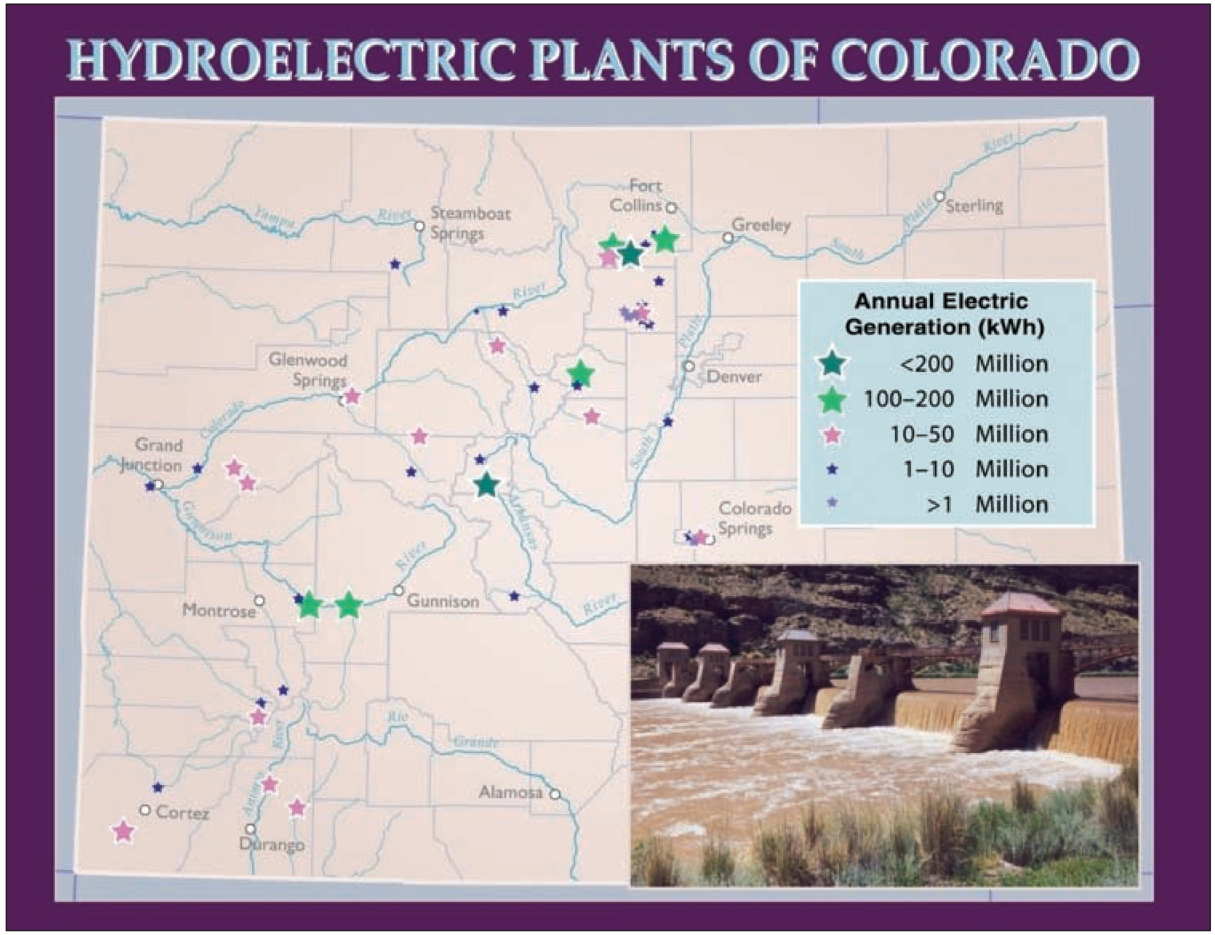


Figure 56. Hydroelectric plants in Colorado sorted by electric generation. Larger hydropower plants located with large green stars. Inset photograph of the Cameo hydroelectric facility on the Colorado River east of Grand Junction.

Solar Energy

The Governor's Energy Office estimates that Colorado could potentially produce as much as 83 million megawatt-hours per years from solar technology. Solar energy provides heat for buildings and water storage, and it can generate electricity. The National Renewable Energy Laboratory (NREL) in Golden provides solar research in two main areas of concentration: solar thermal and photovoltaic (PV) research. Their solar thermal program looks to analyzing cost and improving performance for new solar systems and developing parabolic trough technology for solar electric generation. Their photovoltaic research is based on materials research, developing new PV cells, and assisting the PV industry with manufacturing of better PV materials and products. The National Center for Photovoltaics is located at NREL, which works on increasing the efficiency of PV systems. New research and designs on PV systems globally have seen a doubling of capacity of large-scale photovoltaic plants constructed in the last few years.

The Alamosa Photovoltaic Solar Plant was constructed in the San Luis Valley in 2007. This solar center is the second largest photovoltaic facility in the nation. Owned by Sun Edison, LLC, the 8.2 Mw power capacity plant may potentially produce up to 17,000 Mw-hour of power annually. Located near Center, Alamosa County, the plant is the first of its kind in Colorado. Ranked as the 16th largest PV solar plant in the world, the power generated from the plant will be purchased by Xcel Energy. The plant was recently activated after only 9 months of construction. It is the largest solar PV plant to support substation loads for a major public utility in the U.S. Sun Edison contracted with Xcel Energy to supply them with electricity over the next 20 years. This plant is unique in that it has three distinctive solar technologies employed: single axis tracking, fixed-mount, and dual axis tracking arrays with PV concentrator technology. The photovoltaic panels were manufactured in China and the concentrating panels were manufactured in Germany.

Another significant solar project installation in 2008 is the SunEdison solar park at the Denver Federal Center in Lakewood, Jefferson County. This six-acre facility adjacent to 6th Avenue will generate one Mw of power. It will augment the peak demand of electricity at the Federal Center by ten percent. SunEdison built the photovoltaic plant with a grant from the U.S. General Services Administration.

Biomass, Ethanol, Biofuels

Biomass technology is a renewable way to use organic matter to generate heat, power, or be converted into processed fuels or chemicals. The Colorado Renewable Energy Society states that Colorado has a fair biomass potential. They say that 5.2 billion kilowatt hours (kWh) of electricity could be generated using renewable biomass fuels in Colorado. Wood is the most commonly used biomass fuel. Urban and mill residues such as wood from construction sites, right of way trimmings, and discarded wood products and crates and mulch are common biomass recycle fuels. Dead wood such as the timber available in Colorado's beleaguered pine-bark-beetle-kill areas would be great sources for biomass fuel. Agricultural biomass includes organic crop-harvest mulch such as corn husks, wheat straw, and orchard trimmings. While these materials are not plentiful in Colorado there is still a small but potentially growing market.

Recently ConocoPhillips purchased the 432-acre former StorageTek corporate campus in Louisville. They plan to use the facility to become the state's largest research facility for biofuels made from crops and non-petroleum feedstocks. The company plans to develop liquid fuels made from renewable sources. It is scheduled to open in 2012. ConocoPhillips has an alternative fuels annual research budget of $160 million, researching mostly biofuels and biodiesel projects such as converting animal fats into diesel, ethanol from corn, and re-using agricultural waste products and other organic resources. ConocoPhillips also researches ways to convert coal and petroleum coke to hydrogen fuel, and may also use the new facility to research oil shale production. Governor Ritter hopes that biomass, including use of beetle-killed tree burning, will help the new energy economy in Colorado. There are over 50 E85 fueling stations in Colorado, up from only 14 one year ago. Current biodiesel production comes from soybeans and recycled restaurant cooking oils.

Ethanol consumption has its share of critics as well. Corn is the nation's largest agricultural crop and is used for animal feed, food supplies for humans, and other food byproducts. Ethanol production in 2001 was seven percent of the total U.S. crop. Today it is rapidly increasing as 114 ethanol bio-refineries have sprung up throughout the Midwest. In 2007, the price of corn has risen due to this new demand for corn products. Ethanol has some environmental challenges ahead because it produces twice the greenhouse gas emissions as the gasoline it replaces. Ethanol plants also consume large volumes of water.

Economically, farmers sell more corn to ethanol plants now to produce biofuels. The American Feed Industry Association says that "Consumers will see another major increase in food prices this summer due to rapidly increasing animal feed costs, a result of competition for corn and oilseeds between livestock and poultry feeding and alternative fuels production."

Geothermal Energy

Heat from within the earth may be tapped for energy use. Heat flow is defined as the amount of heat energy moving from inside the earth to its surface. This heat flows to the near surface especially along fractures and faults. Hot springs are surface expressions of high heat flow areas leaking up to the surface. Colorado has 59 hot spring sites located primarily in the mountains and plateaus of the western slope.

There are at least three distinct modes of use for geothermal energy:

1. Direct Use—Hot water from springs or wells is used for swimming pools (such as at Glenwood Springs and Ouray), heating buildings (Pagosa Springs), greenhouse agriculture (Mt. Princeton Hot Springs), and aquaculture (such as alligator ranching in Mosca).
2. Electrical Power Generation—High temperature water from the earth is used to turn electricity-generating turbines. If the water is hot enough to turn into steam at the surface, then the steam directly drives the turbines. Water that is not hot enough to drive the turbines directly can sometimes heat a secondary liquid that boils at lower temperatures. This secondary gas then drives the turbines.

3. Geothermal Heat Pumps—Also known as "geoexchange" or "ground-source heat pumps," this is probably the most under-appreciated renewable energy in the world. This system does not require high heat flow as do the first two types of geothermal energy uses. Rather, it uses the nearly constant earth temperature at shallow depths (~55°F) as a source of heat for heating and a heat sink for cooling. The system circulates water into the ground and back into a building as a supplement to both heating and cooling units. Energy savings are typically around 30 to 40 percent. Delta-Montrose Rural Electric Cooperative is a leader in the use of this technology.

In 2007, there was new and renewed interest in geothermal exploration for electrical generation. Areas in Colorado that are prime for new exploration include the Rico Dome structure in southwestern Colorado, Mount Princeton Hot Springs, and the San Luis Valley. These exploration targets represent potential sites with high heat flow. There currently are no geothermal electrical power generating facilities in Colorado.

On October 10, 2007, the Colorado Public Utilities Commission hosted an informational meeting on the prospects of geothermal energy development. Their focus was on the nature and extent of Colorado geothermal resources, electricity generation, and direct use applications. The regulatory and leasing aspects for geothermal production were also evaluated. The Colorado Geological Survey has recently used re-calculations of temperature and heat flow data to compile statewide heat flow and geothermal gradient databases. This continuing project will also focus on high temperatures observed in drill-stem tests and bottom hole temperatures in existing or abandoned petroleum wells throughout the state. These wells, when no longer active, represent infrastructure that can potentially be used to tap resident geothermal energy at depth.

Direct-use consumers are increasing in numbers as expensive fossil fuel prices make geothermal alternatives more attractive. Residential heating customers are increasingly turning to direct-use geothermal heat pump applications. Commercial direct-use geothermal applications vary from heating an alligator farm in Alamosa County to heating a greenhouse in Chaffee County. In Pagosa Springs and in Steamboat Springs heating of public buildings has been in operation for decades. This type of direct geothermal energy use has potential for expansion throughout the state. The Geo-Heat Center at the Oregon Institute of Technology identified 15 communities in Colorado that are within five miles of a geothermal resource with a temperatures of 122°F or more, making them good candidates for community district heating or other geothermal applications. The State Land Board lists one geothermal lease application in 2008.

New projects utilizing renewable energy in Colorado include a housing subdivision in Arvada called GEOS Mixed-Use Development Project. The company plans to build Colorado's first sustainable, integrated community maximizing renewable energy technologies in its infrastructure. They would like to be the first fossil fuel free community in the U.S. This will be attained through wind energy, solar energy, and a heat recovery ventilation system using a district ground source heat pump. This 300-home community will be self-sufficient for most energy consumption using a combination of energy efficient building materials and renewable energy. Heat pump technology is an excellent renewable source available to all Colorado homeowners.

Introduction

Overview of 2007

Nonfuel mineral production includes metals, industrial minerals and construction materials such as sand, gravel and aggregate. The Colorado Geological Survey (CGS) estimates that the total value of nonfuel minerals produced in Colorado in 2007 was $1.932 billion (figure 57), compared to the final revised 2006 value of $1.762 billion. Of that 2007 total, $1.298 billion is from metal mining. These estimates have been compiled from information obtained by CGS from mine operators, news articles, corporate press releases, annual reports of public companies and from preliminary estimates released by the U.S. Geological Survey (USGS) Minerals Information Team. The 2007 production value for all non-fuel minerals represents a 10 percent increase from 2006. Colorado ranks 11th among the states in nonfuel mineral value, up from 12th position in 2006.

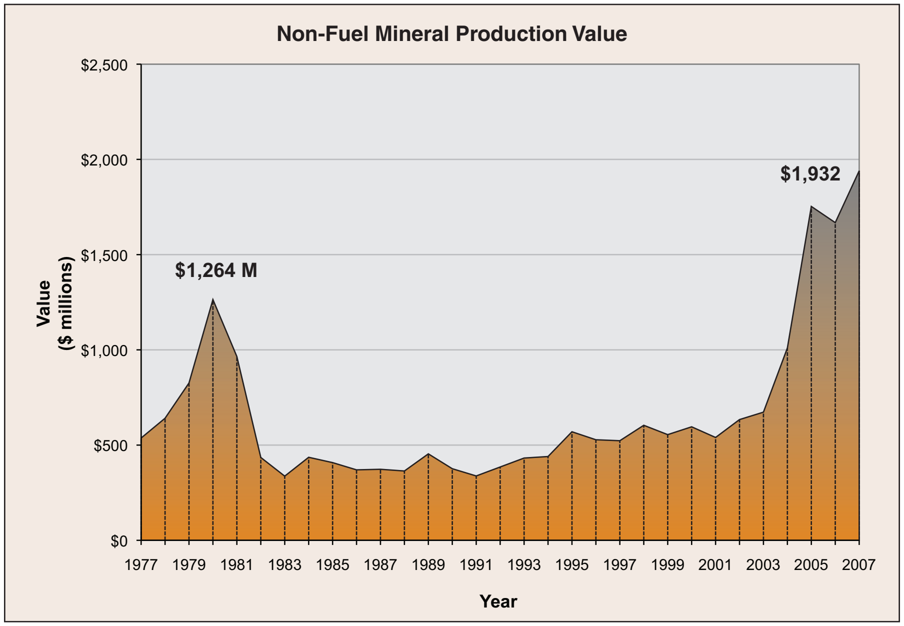


Figure 57. Colorado non-fuel mineral production value, 1977 to 2007 (estimated). Non-Fuel minerals produced in Colorado in 2007 are molybdenum, gold, silver and industrial minerals. The numbers are based on preliminary data for the 2007 calendar year. The production value of Colorado minerals was up 16 percent from 2006, due largely to stronger molybdenum prices.

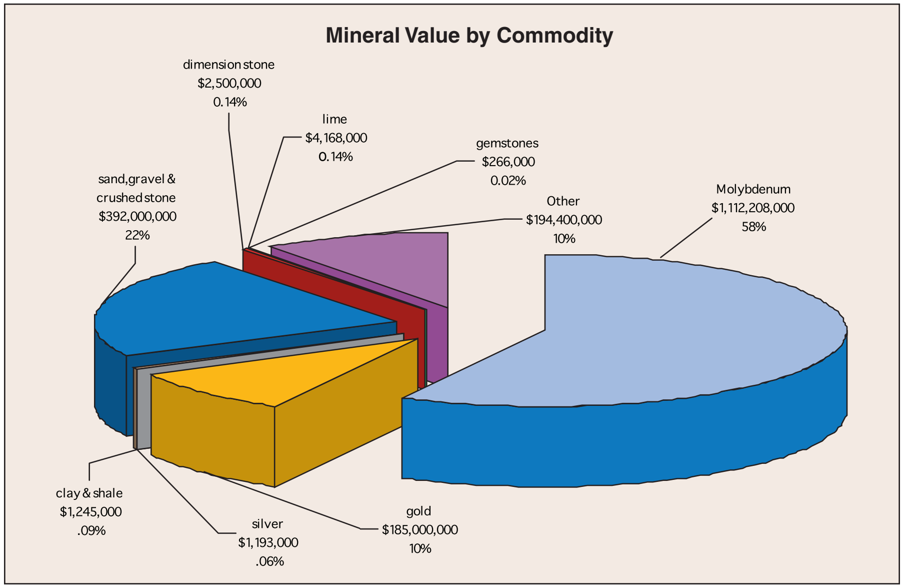


Figure 58. Estimated production value of non-fuel minerals in Colorado, 2007. "Other"includes cement, soda ash, sodium bicarbonate, gypsum, and bentonite. Molybdenum was once again the bulk of Colorado's production, with construction materials sand, gravel and crushed stone second, and gold third.

Gold reached a high of $860 per ounce in 2007, with an average price of about $700 per ounce for the year. This trend continues the gold price rise that started at $260/ounce in March of 2001. The molybdenum market has been driven primarily by expansion of the steel industry in developing nations (mainly China). Molybdenum traded in a range from $25 to $35 per pound in 2007, a substantial increase from the $2-range in the early years of the millennium.

Demand remained strong for mineral commodities in 2007, especially metals such as gold, silver, and molybdenum. Increased demand leads to rising prices which in turn led to increased exploration activity. According to the Metals Economics Group, an organization that tracks trends in the mining industry, exploration expenditures reached record levels in 2007 for gold, base metals, molybdenum, mineral sands and and base metals (copper, nickel, zinc.) Years of stagnant and declining metals prices caused exploration efforts to languish. The global economic growth, coupled with the depleted stockpiles of mineral commodities, have generated demand conditions that will take some time to correct.

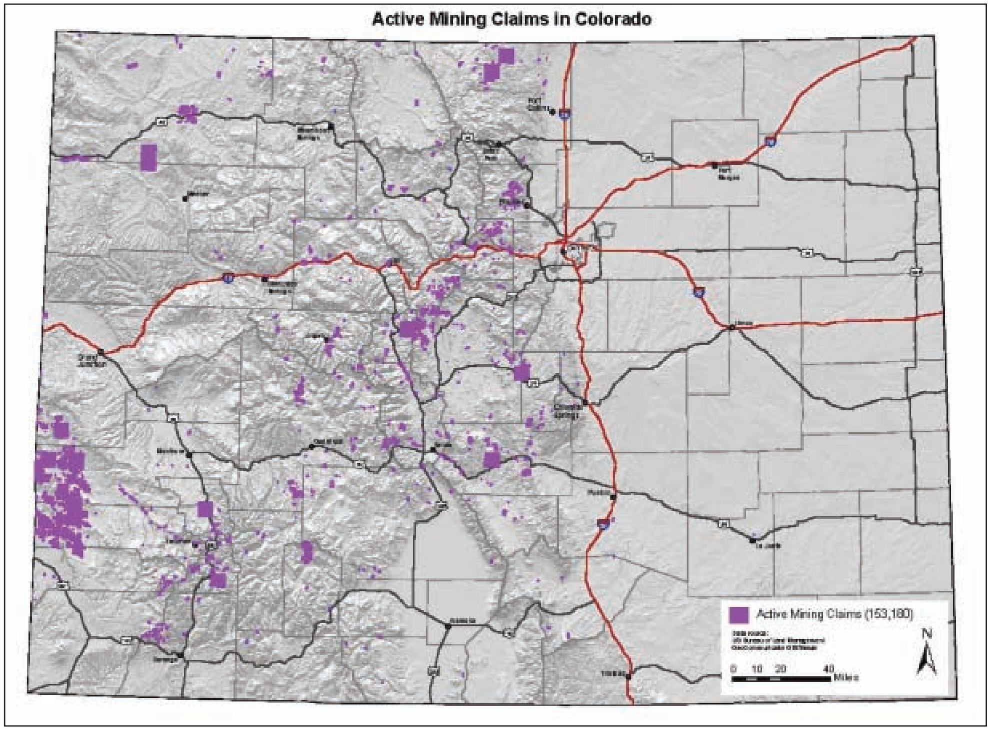


Figure 59. The total active mining claims on Federal mineral lands as of December 2007. The identity of the mineral being sought is not specified. Many of these claims may be overlapping or could be disputed because more than one claimant has staked the same area. The map simply shows the areas in which the claimant has paid the annual fee to retain an active claim. It also does not include exploration located on private or state lands. Source: U.S. Bureau of Land Management.

One indicator of increased exploration activity in Colorado is the number of mining claims filed on federal lands in Colorado. A mining claim provides exclusive rights to the filer to develop the parcel for minerals. The number of new claims filed increased from 4317 in 2005 to 5693 in 2006. In 2007, an additional 10,628 claims were filed, representing another large increase for that one year. While the claimant is not required to specify the commodity target at each claim, the distribution of claims indicates that the great majority of these claims were filed for uranium, based on the counties in which they were filed. Figure 59 displays the new claims filed in 2007 by county.

Metals Mining

Molybdenum

Colorado was the leading molybdenum-producing state in the U.S. in 2007. The production from the Henderson Mine near Empire in Clear Creek County was approximately 39.8 million pounds. This total represents 28 percent of U.S. production again in 2007, the same as 2006, fully 9 percent of worldwide molybdenum production. The United States is a net exporter of molybdenum, a unique situation for our nation with metals. The price of molybdenum rose from $8 per pound in 2003 to historical highs of more than $30 per pound in 2005, reaching a peak of $40 per pound in 2005. The price achieved an average of $26.81 per pound in 2007, yielding a value of production in Colorado for 2007 of $1,067,038,000. The 2007 price is still very high compared to the 20-year average of $5.60 per pound. The high price has moved molybdenum to the position as the largest sector of the Colorado mining industry in terms of production value. Figure 61 shows molybdenum production in Colorado and the average price per pound of molybdic oxide from 1970 through 2007.

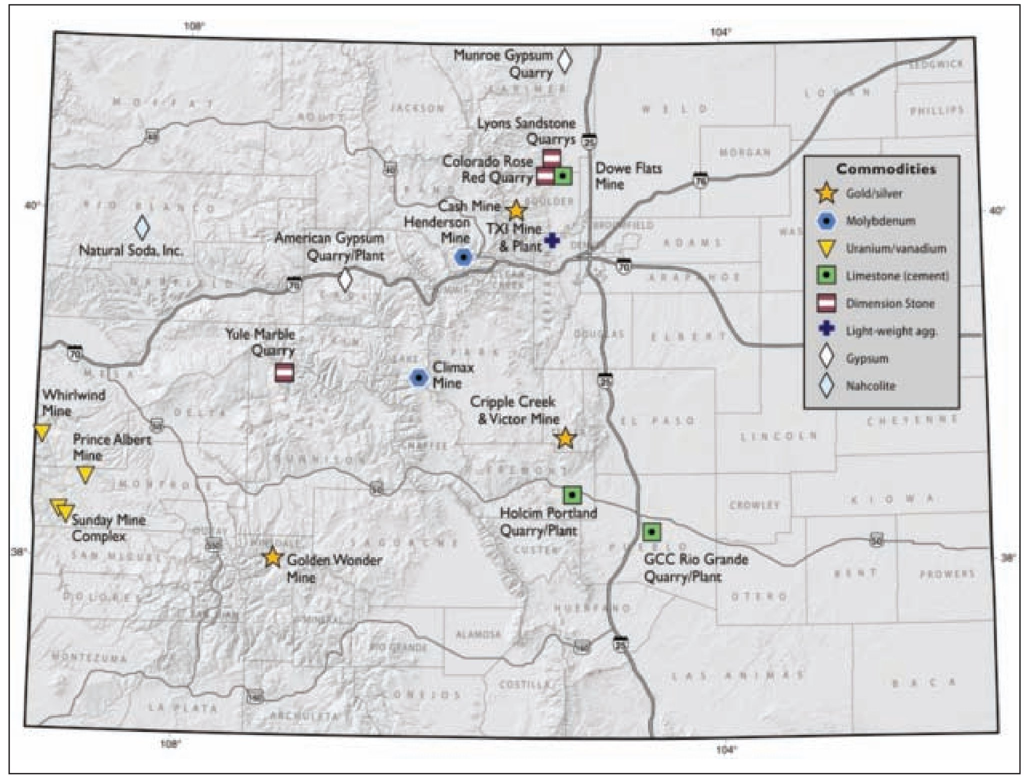


Figure 60. Map showing locations of significant metal and industrial mineral mines in Colorado in 2006. Clay and aggregate mines are not shown. Small sand and gravel quarries are located across the state, generally near metropolitan areas and along transportation corridors. For most mineral commodities, the mines are "where you find it," as the old miners always said.

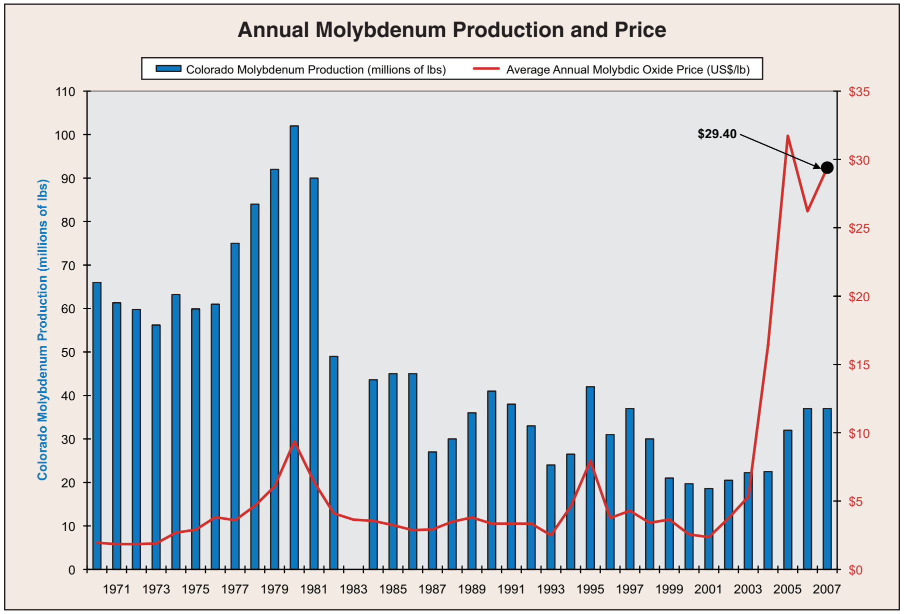


Figure 61. Molybdenum production in Colorado and average annual molybdenum price from 1970 to 2007. Data for recent years based on prices quoted in Platts Metals Week as reported by the U.S. Geological Survey Minerals Information Team. Molydenum production was just about level from 2006 to 2007 while the average price of molybdenum increased.

Fig. 62. Some important uses of molybdenum include nuclear power and desalination plants, oil and gas drilling and pipelines. Demand for molybdenum in the steel industry has been increasing worldwide and the United States is in the enviable position of being a net exporter of the commodity, with exports helping our balance of trade with China. Colorado has several rich deposits of this irreplaceable metal.

Uses of molybdenum

The uses of molybdenum are many and varied, and it is particularly valuable in today's energy economy (figure 62). As an alloying agent, molybdenum provides hardness and durability to steel, especially at high temperatures, and imparts corrosion resistance, particularly to salt corrosion. Those characteristics make molybdenum important (and irreplaceable) as an alloying component in many steel formulations. In the oil and gas sector, molybdenum steel is a key ingredient in the new double-hulled oil tankers replacing aging fleets worldwide; molybdenum steel is necessary as companies around the world replace tens of thousands of miles of oil and gas pipelines; it is an essential catalyst in petroleum refining; the hardness of molybdenum steel has always made it essential in the drill steel for oil and gas drilling rigs. For coal power generation, molybdenum is necessary for the scrubbers that remove sulfur-rich contaminants from stack emissions. In the nuclear industry, molybdenum steel is used in nuclear reactor vessels and its resistance to salt corrosion makes it invaluable for the miles of coolant tubing in each nuclear power plant and desalination facility. The metal is used in electrodes for glass furnaces, in rocket engine components, liquid metal heat exchangers, in the superstructure of large buildings, and as a heat-resistant lubricant for machining.

The uses in newly developed materials is expanding annually, as its physical and chemical characteristics of softness, ductility, very high melting point, and corrosion resistance are impossible to replace.

Henderson Mine, Clear Creek County

The Henderson Mine lies in the Front Range just west of Empire (figure 63). The mine is the largest primary producer of molybdenum in North America. The underground block-cave mine is owned by Climax Molybdenum Company, acquired by Freeport-McMoRan Copper and Gold, Inc. on March 19, 2007. Nearly 40 million pounds of molybdenum metal in 2007 was produced from 9.7 million tons of ore.

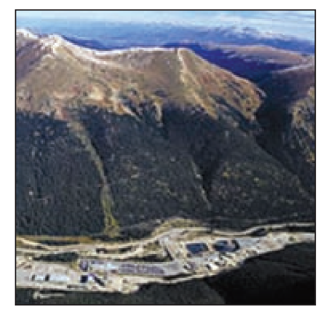


Figure 63. View of the Henderson Mine. The mine is located near Empire. The company has operated since 1976, producing over a billion dollars worth of molybdenum in 2007. (Photo by Freeport McMoran)

Ore from the Henderson Mine is transported to the mill in Grand County by a conveyer belt through a 10.5-mile-long tunnel beneath the Continental Divide (Figure 64). The sulfide concentrator at the Henderson mill is capable of treating 32,000 tons of ore per day. The mine ships most of its high-purity, chemical grade molybdenum concentrate to Fort Madison, Iowa, for further processing. Henderson has mined more than 205 million tons of ore and produced over 932 million pounds of molybdenum. Reserves are estimated at more than 150 million tons of ore containing over 500 million pounds of recoverable molybdenum.

Figure 64. Ore is transferred beneath the continental divide to the mill in Grand County by means of a 15-mile long conveyer system. Once processed at the mill, the molybdenum-rich material, referred to as "concentrate," is then transferred to the Freeport-McMoran plant in Fort Madison, Iowa, for refining into forms of molybdenum for sale. (Photo by Conveyer Service Corp.)

Climax Mine, Lake and Summit Counties

The biggest news in the world of molybdenum in 2007 was the announcement that the Climax Mine, also owned by Freeport-McMoRan, would take steps to reopen and resume production. Climax, located on the Continental Divide at Fremont Pass between Leadville and Copper Mountain (fig. 65) was the first major molybdenum mine in the U.S. The mine has been on care-and-maintenance status since 1995, but the recent high price of molybdenum and the recognition of a large reserve of molybdenum resources at the mine has induced the company to plan an investment of more than $500 million to completely refurbish and rebuild the facilities for reopening. Production is scheduled to begin again in 2010. A recent pre-feasibility study showed that the mine could produce 20 to 30 million pounds of molybdenum annually and employ 300 workers. Current estimates are that the Climax deposit contains 156 million tons of ore grading at 0.19 percent molybdenum, containing more than 500 million pounds of recoverable molybdenum. Estimates of additional reserves indicate more than 570 million tons of ore at 0.16 percent grade. The old facilities are being demolished and will be replaced with new buildings, including a mill to process 30,000 tons per day of ore. The target production for the Climax Mine would be 24 million pounds of molybdenum per year.

Figure 65. The Climax molybdenum mine and mill is located at Fremont Pass, Lake and Summit Counties. The first molybdenum mine in the U.S., the Climax Mine will reopen after a complete rebuild of facilities with an investment of $500 million by Freeport McMoRan. (Photo by Vince Matthews, CGS)

Other Colorado Molybdenum Deposits

Colorado has not just these two world-class molybdenum producers; at least two additional major deposits are known. The Lucky Jack deposit in Gunnison County was formerly known as the Mount Emmons deposit. Owned by U.S. Energy Corporation, the Lucky Jack was discovered beneath the Keystone Mine, a silver-lead-zinc mine that was operated until the 1970s. Core drilling has identified more than 220 million tons of ore grading at 0.366% MoS_2, making this a true world-class deposit. The company is in the process of preparing permit applications and operations plans to continue development of the project.

The other large deposit is located at the old mining town of Rico in Dolores County. Drilling by The Anaconda Company in the early 1980s identified a resource of 273 million pounds of molybdenum. At the present time, the CGS found no plans to develop the deposit.

One of the first principles a young geologist learns about ore deposits is that, when exploring for economic deposits, one always "looks for elephants in elephant country." There's no question that Colorado is elephant country for large molybdenum deposits and that fact has not been lost on explorationists. Molybdenum, usually in the form of the mineral molybdenite (MoS_2) has been found in many places around Colorado and as long as molybdenum is an important commodity for international trade and national security, geologists will seek it out in this state (Figure 66).

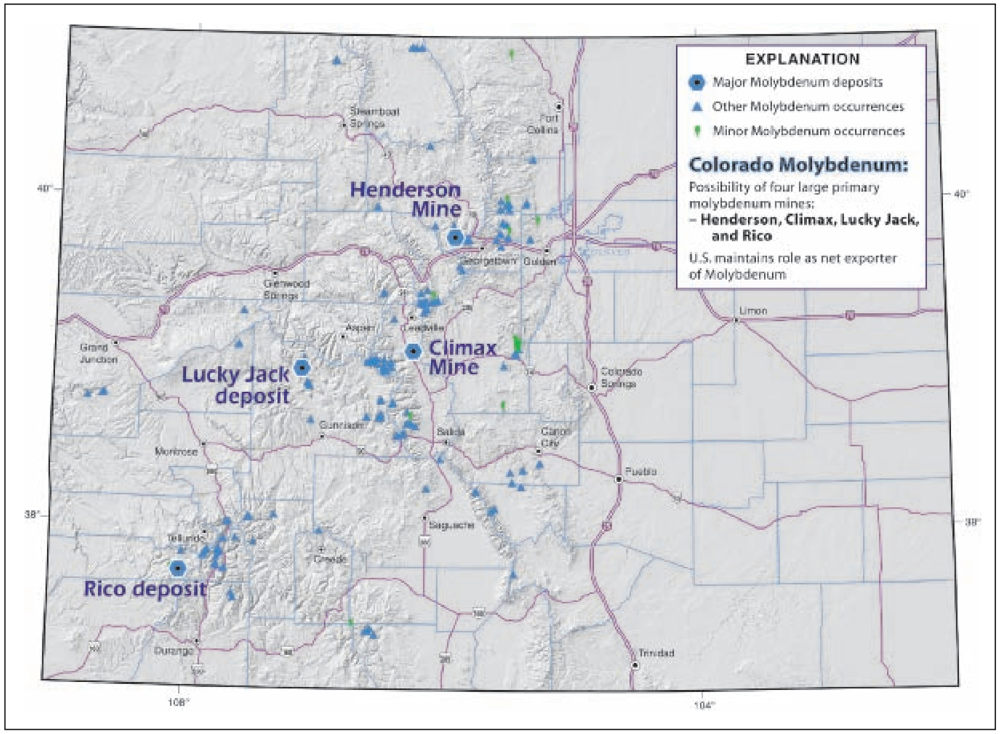


Figure 66. Molybdenite—the major ore mineral of molybdenum—has been identified in numerous locations around Colorado. This map shows more than 300 occurrences that can be referenced; not many of these occurrences contain a sufficient resource to support a mine, if any, but they provide ample exploration targets for companies seeking to augment the US's supply of this vital commodity. (Source Minerals Resource Data System, U.S. Geological Survey)

Gold

According to the most recent statistics available, Colorado is the 4th leading gold-producing state behind Nevada, Utah, and Alaska. Total Colorado gold production for 2007 is estimated at 281,820 ounces, representing a seven percent decrease from the 2006 production figures, for a net value of $184 million. The estimated production comes from two mines—the Cripple Creek and Victor (CC&V) gold mine in Teller County and the Cash Mine in Boulder County. Additional small amounts of gold were probably produced from small placer (gravel) or lode mines that do not publicly disclose production figures. Figure 67 shows Colorado gold production along with the average annual gold price from 1968 to 2007. In October of 2007, the gold price hit a high of over $840 per ounce, with a low of $650 per ounce.

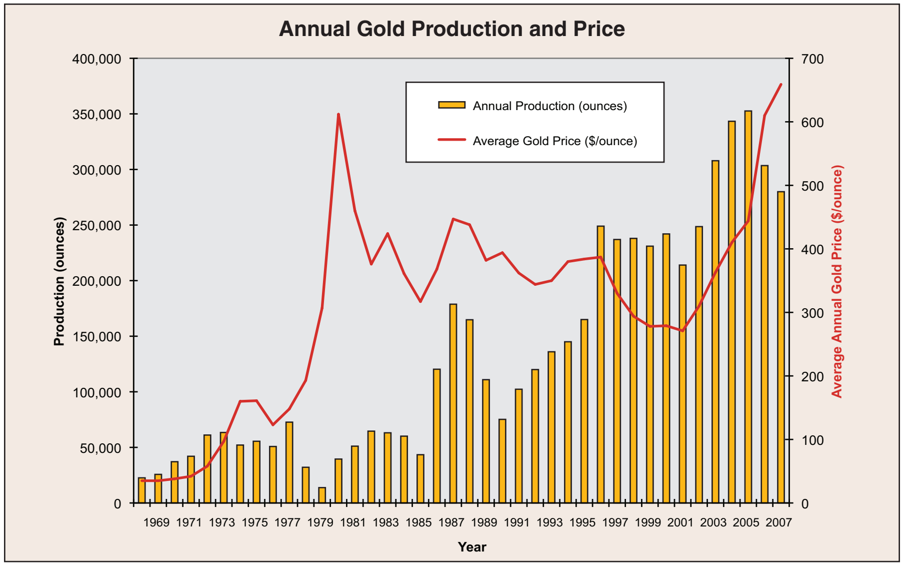


Figure 67. Colorado annual gold production and average annual gold price, 1968–2007. While production in the state has decreased the last two years, the price of gold has moved upward precipitously, raising the total value of the resource mined. The price is having the effect of stimulating exploration for new deposits and development of deposits that have lain dormant for years.

Uses of gold

The best known uses for gold are for jewelry and as option to currency. The metal, however, does have a number of industrial applications. Gold possesses superior electrical conductivity and corrosion resistance that makes it important in computer hardware, communications equipment, spacecraft, and jet engines. Gold is also important as a dental filling. Gold's main use, however, is as a monetary metal, with most of the gold bullion produced each year being stored in government treasuries and central banks. In addition to the governmental storage of bullion, in recent years an increasing amount of gold has been purchased by exchange-traded funds, or "ETF's" which are investment vehicles through which actual gold is purchased and stored for the shareholders of the fund. A single gold ETF recently reported that they held nearly 600 metric tons of gold in storage for their investors.

Gold has been sought successfully in Colorado since the earliest European explorers. The state has a rich history of gold mining. The recent rise in the price of gold generated a great deal of activity in the state, mainly with new entrepreneurs looking to reopen old mines with a history of production. There is no shortage of those old mines in the State, as a map of documented gold occurrences in Colorado indicates (Fig. 68.)

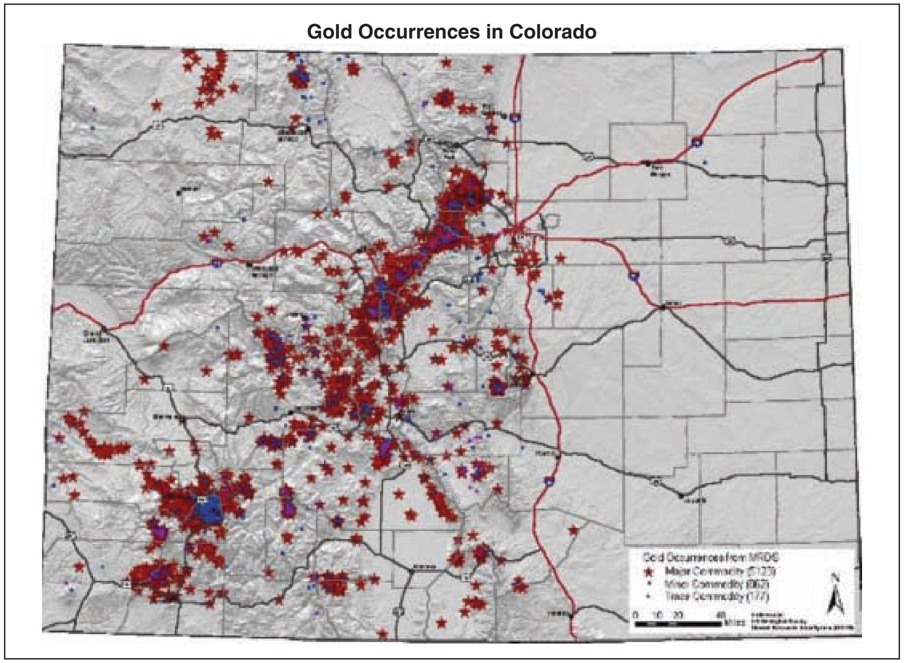


Figure 68. Map of documented gold occurrences in Colorado. Gold has been found in many locations in the state. This map includes both placer deposits (those found in streambeds) and lode deposits (those found in native rock). While the Cripple Creek and Victor Mine in Teller County is the major producer, smaller operations have recently been permitting gold mines in Boulder, Teller, Hinsdale, and San Juan counties and exploration activity is increasing as individuals and companies take new looks at old mines and prospects to take advantage of the price of gold, which exceeded $1000 per ounce in early 2008. Source: Mineral Deposits Data System (MRDS), U.S. Geological Survey.

The first thing a company or individual does in proceeding toward a mine is to explore the territory, by reading old reports, either published or in company files, studying the geology, looking for sites that may be favorable for finding more gold. A geologist goes into the field, searching either existing sites or looking for promising new locations on the ground, tramping around knocking on rocks or, possibly using non-invasive techniques such as remote sensing or geophysics to help assess good possible sites for mining. If a particular location warrants further investigation, the company must obtain a prospecting permit from the Colorado Division of Reclamation, Mining and Safety to disturb any area greater than 1600 square feet or to drill. The ability of the CGS to identify companies involved up to that stage is limited because any interactions with the State are held confidential. Once a company applies for a permit to mine or makes their activities public in some other way, they can be identified and their activities reported.

In early 2008, seven companies can be confirmed who are actively pursuing gold prospects in Colorado. Following is a brief description of those companies and their activity.

AngloGold Ashanti, Ltd

The Cripple Creek & Victor Mine (CC&V) in Teller County has been a joint venture between AngloGold Ashanti Ltd., a South African company, and Golden Cycle Gold Corporation of Colorado Springs. In early 2008, AngloGold Ashanti officially acquired the smaller, Colorado-based company. The mine is one of the most productive gold mines in the U.S., producing 282,000 troy ounces of gold in 2007. This total was down from 283,000 ounces produced in 2006. Total production costs were $372 per ounce of gold. Based on an average price of gold in 2007, the value of gold produced at the mine was approximately $186 million. Production was down because of higher stacking levels than anticipated on the leach pads, with more material for the leach solution to pass through.

Figure 69. Aerial photo of Cresson Mine at Cripple Creek, Teller County. The Cresson is the name used for the current active operation of the CC&V mine, but the name goes back to the 1890s, when the original Cresson Mine was an underground operation between the towns of Cripple Creek and Victor. That mine operated from the 19th century into the 1950s. Development of the current surface mine began in 1993 and it has now produced more than three million ounces of gold. (Photo courtesy of Cripple Creek and Victor Gold Mining)

There are three active and two inactive surface mining areas at CC&V. The grade is low but high volume allows profitable production (figure 69). A feasibility study is underway to extend the life of the mine beyond 2012. Preliminary results indicate 3 million additional ounces can be extracted from the area around the mine.

In August 2007, CC&V's Cresson Mine passed the milestone of 3 million ounces of gold produced. The 5,847-acre mine employs 325. The gold mineralization is hosted by veins and breccias within an alkaline volcanic complex of mid-Tertiary age. The mineralized volcanic complex is centered near the intersection of three major rock types of the much older Precambrian basement.

LKA International Corporation

LKA International of Gig Harbor, Washington, operates the Golden Wonder mine near Lake City in the San Juan Mountains of Hinsdale County. No production was realized in 2007 because of a series of issues at the mine. Since modern operations began in 1998, the mine produced nearly 134,000 ounces of gold. Recently LKA agreed to a joint venture partnership with Richmont Mines, Inc., of Montreal. The company announced that substantial exploration and development work will be required to return the Golden Wonder to production.

Mount Royal Ventures, LLC

Global Minerals, Ltd, of Vancouver, B.C., through its Colorado subsidiary Mount Royale Ventures, LLC, initiated production in 2007 from the Cash Mine in the Gold Hill district west of Boulder. The project is a vein-type deposit (figure 70) with an area is composed of 106 patented and unpatented mineral claims over an area of some 480 acres. Eighteen former mines produced within this area and it has taken 40 years to complete consolidation of the properties in the district. Included is a refurbished mill that is designed and permitted to process 50 tons of ore per day while planned upgrades will push the capacity to 75 to 100 tons per day. The first shipment to the smelter occurred on March 19, 2007, and the mine produced over 600 ounces of gold in 2007.

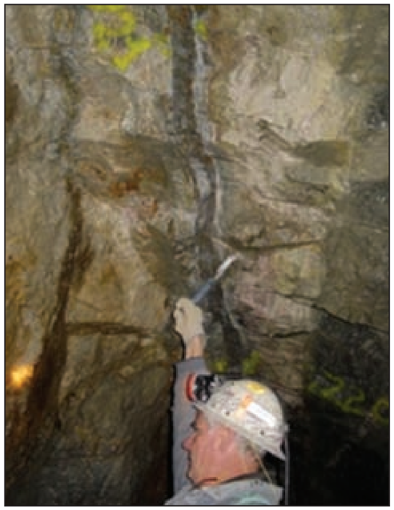


Figure 70. Mont Royale Ventures geologist Jim Paschis points out a productive vein—the dark streak running from the point of the pick to the top of the photo—in the Cash Mine of Boulder County. The gold and silver occur as native elements and as gold telluride minerals in this vein in the older rock. Super-heated fluids shot through a fault, probably beneath a volcano, leaving behind minerals from the magma that had been dissolved, including the gold and silver. Photo by Jim Burnell, CGS.

Wits Basin Precious Minerals, Inc.

Wits Basin Precious Metals, Inc., of Minneapolis, Minnesota, continued exploration and development work on the Bates-Hunter Mine in Central City, Gilpin County. The company controls the mine and mill at the site and possesses active mining and water discharge permits to cover an operation of up to 70,000 tons of ore per year. The company believes that the property contains nine mineralized veins. The mine was previously worked to the 800-foot level, while many mines in the area were productive to levels greater than 2,000 feet. The company continues to dewater the mine and will initiate an underground drilling program designed to characterize the ore to greater depths when dewatering is finished.

Calais Resources, Inc.

The Caribou Consolidated Project near Nederland in Boulder County, operated by Calais Resources, Inc., completed over 140,000 feet of core drilling and published estimates of over 400,000 ounces of gold and 12.5 million ounces of silver identified at the property. The company focused on submitting plans for a 200 ton-per-day mill and hopes to make their first shipment of concentrate by February 2009.

Colorado Goldfields, Inc.

Colorado Goldfields, Inc., a Lakewood-based company, is pursuing development of several properties in San Juan County. The centerpiece of the company's development is the Gold King Mine near Silverton, which, along with the nearby Mayflower Mine, has produced significant gold in their history. The Pride of the West Mill in Howardsville is also part of the company's planned development, with a target of 2010 to 2011 for production.

Fairburn Mining and Exploration

Fairburn Mining and Exploration is another company returning to historic properties in the Central City area. In the old Wide Awake Mining District, the company is developing the Fairburn Claim that incorporates several documented mineralized veins. The property boasts prospects for both gold and silver.

Silver

Silver is currently produced in Colorado as a byproduct of gold mining at the Cripple Creek and Victor Mine and the Cash Mine. The value of silver production is very small compared to that of gold because of the price differential between the two noble metals. In 2007, the Colorado produced more than 89,000 ounces of silver worth $1,193,522 (at an average price for the year of $13.38). The Cash Mine in Boulder County produced 4587 ounces in 2007. Silver, like gold and most other metals, enjoyed a price boom over the last four years. Figure 71 shows the average annual price of silver from 1984 to 2007. The price continues to rise, exceeding $20 an ounce in 2008 for the first time in over twenty years.

Figure 71. Average annual price of silver from 1984 through 2007, based on London Metals Exchange. The price continued to increase through early 2008, reaching more than $20 per ounce at press time in March 2008.

Uses of Silver

Silver possesses the whitest color, the highest optical reflectivity and the highest thermal and electrical conductivity of all metals. These properties give silver importance in such uses as mirrors, electrical and electronic components. Silver serves as an excellent catalyst in oxidation reactions. It is the most effective metal for use on reflectors for "CSP" arrays, or concentrated solar power. The primary industrial use of silver was formerly in photography because of the photosensitivity of silver halides. While the development of digital photography has led to the decreased use of silver in photography, that still represents a major end-use of the metal and the use of silver in x-ray film has increased. The antibacterial characteristics of the metal are being exploited by the use of silver woven with fabric for odor-repellant clothing and antibacterial blankets for use by the military in Afghanistan and Iraq. Silver is also being used to replace stainless steel in hospital environments because of its antibacterial characteristics.

Silver Activity in Colorado

Silver is commonly found along with gold in Colorado's hardrock mines (figure 72). It is being produced in the active gold mines and is anticipated to be a major resource in the developing gold mines discussed in the Gold section. The Fairburn Mine in particular is rich in silver. Hecla Mining Company, a major silver producer, announced that it is undertaking an exploration program in the Creede District of Mineral County, to better define what the company estimates is a resource of at least 48 million ounces of silver in the vicinity of the historic Bulldog Mine. Boulder County's Cash Mine, operated by Mount Royale Ventures, was the only small mine in Colorado that produced silver last year.

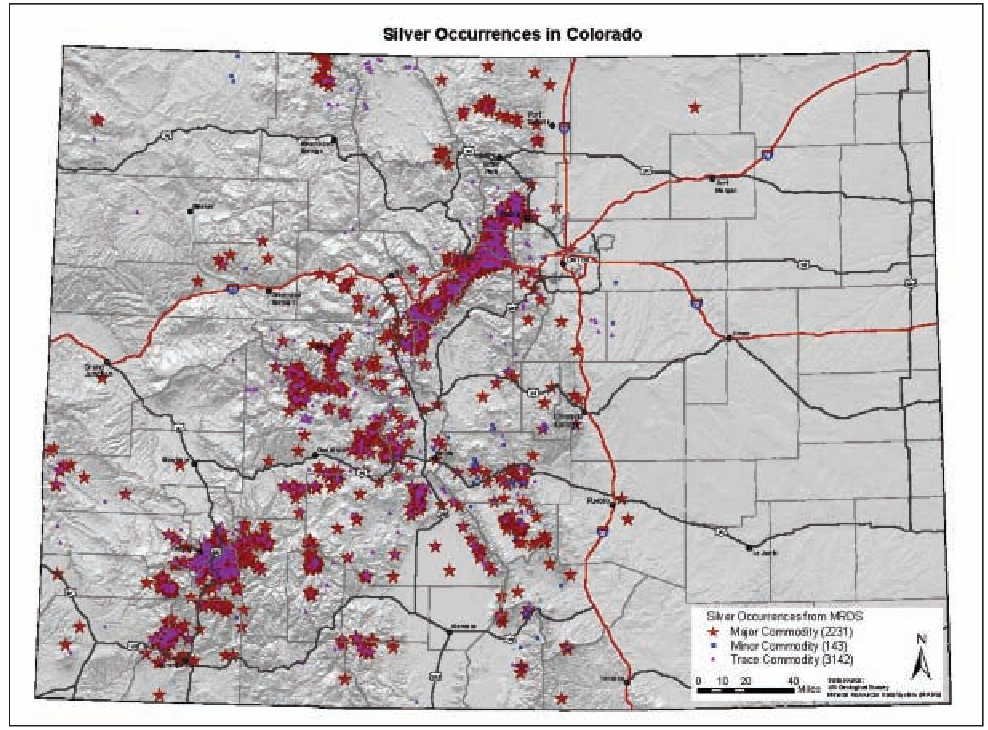


Figure 72. This map of silver occurrences across the state show that the pattern is the same as the occurrences of gold. The symbols note where silver has been found in major, minor and trace amounts, so the star—symbolizing major occurrences—is probably the best indicator of potential for economic deposits. Of course, some of those may mark deposits that have been mined out. On the other hand, locations for minor or even "trace" occurrences could occur where no careful exploration has ever been done and may signal the presence of a significant silver deposit just underground. It's that chance that keeps companies and individuals prospecting and exploring for silver. Source: Mineral Resource Data System (MRDS), U.S. Geological Survey.

Vanadium

Colorado was the state to most recently produce vanadium, but the cessation of mining at four Cotter Corporation uranium–vanadium mines in Montrose County in November 2005 eliminated that production. Colorado's uranium deposits in the Four Corners region in the southwestern part of the state, where the Cotter mines are located, are known for their vanadium content. Peaking in 2005 at over $22 per pound, vanadium prices have backed off to $8–$9 per pound range. That is still considerably higher than the$1 to $2 per pound price range of the previous ten years and makes vanadium an attractive by-product of uranium mining in Colorado. At the present time, the lack of milling capacity in Colorado has been restraining the development of uranium–vanadium mines. Mills that process uranium ore can separate the vanadium through a second process, so specialized mills are necessary for recovering both uranium and vanadium from Colorado ores. Mill capacity has been lost through recent years when nuclear power generation was out of favor and uranium prices were languishing. The current re-emphasis on nuclear power and, consequently, uranium mining (see *Uranium* section of this report) is spurring the recommissioning and development of new facilities for milling this ore. The anticipated reopening of the White Mesa Mill in Blanding, Utah, in 2008 should return Colorado to its role as a leading vanadium producer.

Uses of vanadium

Vanadium is a soft, ductile, bright white metal with good corrosion resistance to alkalis, sulfuric and hydrochloric acid, and salt water. It possesses good structural strength and a low fission neutron cross section, making it useful in applications in the nuclear industry. Vanadium is used to produce rust resistant and impact-resistant steels and as a carbide stabilizer in high-strength steels. About 80 percent of vanadium now produced is used as ferrovanadium or as a steel additive. Vanadium foil is used as a bonding agent in cladding titanium to steel. Vanadium pentoxide (V_2O_5) is used in ceramics and as a catalyst.

Base Metals

Base metals that have been historically mined in Colorado include lead, zinc and copper. There is no current production of these metals. The Leadville district in Lake County was the most prolific base metal district in the state, producing mostly lead and zinc from the Black Cloud Mine until 1999. Mines in other areas of Colorado produced base metals also, particularly in the Sawatch Range, the San Juan Mountains and the central Front Range. Prices for base metals have increased dramatically in recent years as demand from developing economies has challenged mining companies to maintain supplies (figure 73).

Additionally, a number of critical and strategic commodities are commonly found associated with base metal deposits—particularly accompanying zinc. For example gallium, germanium and indium are produced as by-products from zinc mining. Recognition of the importance of these materials in modern technology promises to spur further exploration in areas with known former production.

Uses of base metals

The base metals have numerous uses. Lead acid batteries remain the most efficient method for storing electricity and 80 percent of lead is used to make these batteries. Most copper is used in construction (49 percent), electric and electronic products (20 percent), transportation equipment (11 percent); consumer and general products (11 percent); and industrial machinery and equipment (9 percent). The

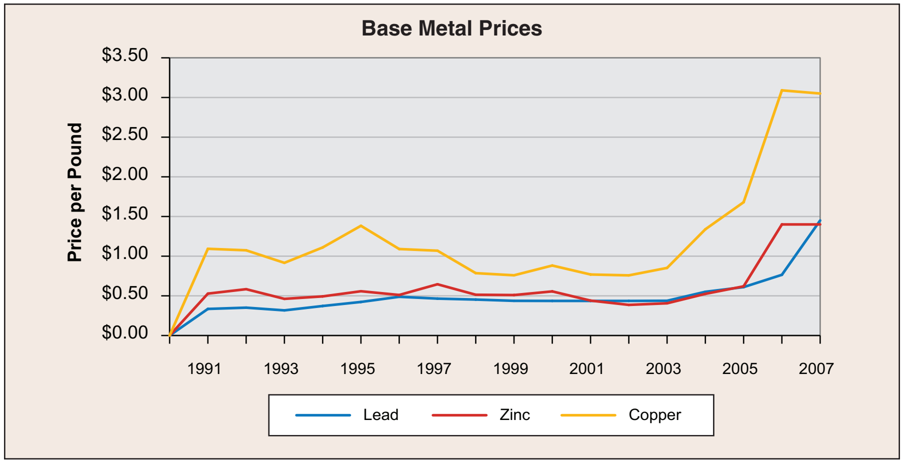


Figure 73. Average annual price of base metals copper, lead, and zinc since 1991. The major price increase that started in 2003 leveled off somewhat in 2007 for copper and zinc, probably because of the housing slowdown in the U.S., but lead prices continued to rise, reaching more than $1.40 per pound in early 2008. Rapid industrialization and economic growth in China and India are credited with driving the prices of these metals to new heights. Colorado produced no base metals in 2007, but has a history of production of zinc and lead and several potential mines in the development stage.

need for copper conductors in alternative ("green") energy will be significant. The traditional uses of zinc include anti-corrosion coatings on steel (galvanizing), zinc-base alloys, brass and bronze. Zinc has become increasingly important in para-electric and thermoelectric materials and in fuel cells for alternative energy production. Some researchers speak of a "zinc economy," based on the metal's utility in hydrogen fuel cell technology and its promise for large-scale use in the future.

Base Metal Activity in Colorado

The Colorado Geological Survey has not confirmed much exploration or development activity for base metals in the state although the history of production is rich. The one project that emphasizes lead and zinc is the Mogul Mine development by Colorado Goldfields, Inc., in San Juan County. The mine shows significant concentrations of those two metals along with recoverable copper, gold and silver. The Cashin Mine, located near the Utah border in Montrose County, has been on hold while Constellation Copper Corporation works on a sister deposit in the Lisbon Valley of Utah. Activity will likely increase, as the price of the base metals continues to rise. Copper in particular has soared, the price reaching $3.70 per pound in March of 2008.

Industrial Minerals and Construction Materials

Industrial minerals are defined as a naturally occurring rock or mineral, exclusive of metal ores, mineral fuels, and gemstones. Industrial minerals are diverse materials and are used in virtually every aspect of modern life, providing raw materials for many industries, including building, manufacturing, and agriculture. The world of industrial minerals covers more than 60 substances, from Abrasives to Zeolites, commonly invisible to the general public in their application.

Important industrial minerals and construction materials currently produced in Colorado include sand, gravel, crushed stone, silica sand, dimension and decorative stone, cement, clay, gypsum, sodium bicarbonate, peat, and helium. Total value for all industrial minerals and construction materials produced in Colorado in 2007 is estimated to be over $634 million, an increase of 2 percent over the 2006 revised total of nearly $625 million.

Each year, the industrial minerals community comes together for an international meeting—the Annual Forum on the Geology of Industrial Minerals. At this symposium, geologists from the field discuss developments and issues concerning the business and science of industrial minerals. The 2007 meeting—the 43rd Annual Forum—was hosted by the Colorado Geological Survey in Boulder in May 2007. An international group of 200 professionals attended the technical sessions and field trips.

Construction Sand, Gravel, and Crushed Stone

- Sand, gravel and crushed stone form a group of industrial minerals known as "aggregates." These materials are necessary for concrete, road base and coverings, and construction fill. While similar in many ways, these are distinct materials as can be seen from their definitions from Langer (2006).
- *Sand*: a natural granular material resulting from rock disintegration, consisting primarily of particles with a diameter of 1/16 inch to 2 mm.
- *Gravel:* unconsolidated, natural accumulation of rounded rock fragments resulting from erosion, consisting predominantly of particles larger than sand.

Figure 74. Operations at the Table Mountain Quarry, Fremont County, owned by Continental Materials, Inc. This quarry produces rock from the Dakota Sandstone, an extremely hard, durable material, good for use as rip-rap and road base.

- *Sand and Gravel:* a mixture of unconsolidated material resulting from the natural disintegration of bedrock and the subsequent transport, abrasion and deposition of the particles by ice, water, wind, and gravity. Sand and gravel normally occur together and can contain particles ranging in size from clay to boulders.
- *Crushed rock:* a material commonly produced by drilling, blasting, excavating and crushing bedrock; crushed rock tends to have angular edges.

Because sand and gravel resources are transported and deposited by water, they are found in river valleys. Therefore, most producers near metropolitan areas are relying more on crushed stone. Stone quarries can be operated with much less visual impact and take up less space than large sand and gravel operations near a river (fig 74, 75). The cost is greater, of course, to transport the gravel from farther away to a construction site in a city and this cost is reflected in the price of the product. In the Front Range urban corridor, for example, companies find it necessary to quarry their material farther and farther away. Aggregate companies are constantly searching for opportunities to mine their product nearer the urban area or, as a second choice, near an existing rail line. Transporting aggregate by rail is much less expensive than transporting the heavy loads by truck, and truck traffic is a common objection of citizens to aggregate mining. Locating aggregate resources close enough to the urban corridor to provide product at a reasonable price is a constant problem in much of Colorado.

Figure 75. Aerial view of gravel pits along the South Platte River in Adams County. The alluvial (river-laid) sand and gravel deposits along the Front Range have been mined for years to provide aggregate used for construction and development in the metro area. Many of the quarries remain as ponds after mining is completed.

Colorado produced an estimated 57.9 million tons of aggregate in 2007 down 3.4% from 2006. Leading aggregate producers in the state include Lafarge, Oldcastle Group and Aggregate Industries (table 20). The total value of Colorado aggregate was $428.9 million, ironically a 3 percent increase over the 2006 value of 415.6 million. Sand and gravel represented 77 percent of Colorado's total aggregate production—the same proportion as in 2006. Production of sand and gravel totaled 45.6 million tons, down 4.8 percent from last year's revised production of 47.9 million tons. Average price per ton of sand and gravel in 2007 was $7.21 (fig. 76). Crushed stone production increased by 2.6 percent from 14.3 million tons in 2006 (revised) to 14.7 million tons in 2007 (estimated). Average unit value for crushed stone was $6.71 per ton (fig. 77). Forty-eight new sand and gravel and crushed stone mining permits were issued in Colorado during 2007 (Table 21). The leading producers are also listed in the accompanying Table 21.

Table 20. There are a total of 1,172 sand and gravel operations in Colorado with active permits. Listed are the companies that hold 7 or more active permits (not including state/county/city-owned operations) (Division of Reclamation, Mining, and Safety, 2008). Most aggregate operations are located as close to construction activity as possible, so most of the mines are found along the Front Range and in Mesa County.

Rank	Permittee	Number of Pits	Locations of Operations
1	Lafarge West, Inc.	66	Statewide
2	Oldcastle SW Group	45	Western Slope
3	Aggregate Industries	25	Front Range
4	Carder, Inc.	15	East Counties
5	Elam Construction, Inc.	14	Mainly Mesa County
6	Pioneer Sand Co.	12	Statewide
7	Grand Junction Pipe & Supply	11	Mesa, Delta Counties
8	Coulson Excavating Co.	9	Larimer
	Connell Resources, Inc.	9	Larimer, Routt
	Continental Materials Corp.	9	El Paso, Pueblo, Fremont
	Hall-Irwin Corp.	9	Weld
	Western Gravel, Inc.	9	Montrose, Delta Cos.
13	Varra Companies, Inc.	8	Mainly Weld County
14	Ace West Trucking Co.	7	Rio Blanco County
	Hard Rock Paving	7	Central (Park, Chaffee)
	Parkerson Construction Co.	7	Mesa County
	Valco, Inc.	7	Fremont, Gunnison, Otero

Table 21. Mining Permits Submitted 2007. The number of new mining permits issued by the Division of Reclamation, Mining, and Safety in 2007, shows the importance of aggregate as a commodity in Colorado. Here are the new permits listed by county. They were spread around the state, with Weld and Las Animas Counties seeing the greatest number of new permits, with 6 each—all for industrial minerals. Of the 55 new permits, 49 were for sand, gravel, and stone.

County	# (commodity)	County	# (commodity)
Adams	1 (s/g)	Mesa	1 (u/v)
Archuleta	1 (s/g)	Mineral	2 (s/g)
Bent	1 (s/g)	Moffat	2 (s/g)
Cheyenne	2 (s/g)	Montrose	2 (s/g, u/v)
Conejos	2 (s/g)	Otero	2 (s/g)
Delta	1 (s/g)	Park	1 (s/g)
Elbert	1 (clay)	Phillips	3 (s/g)
Fremont	2 (s/g, stone)	Prowers	2 (s/g)
Garfield	2 (s/g)	Pueblo	1 (s/g)
Huerfano	3 (s/g)	Routt	1 (s/g)
Jackson	1 (s/g)	San Miguel	1 (s/g)
LaPlata	2 (s/g, gold)	Sedgwick	1 (s/g)
Larimer	1 (s/g)	Teller	1 (gold, turquoise)
Las Animas	6 (5 s/g, 1 stone)	Weld	6 (s/g)
Lincoln	1 (s/g)	Yuma	3 (s/g)

Commodity	Sand/gravel	Clay	Stone	Gold/Silver	Uranium
TOTAL 55	48	1	1	3	2

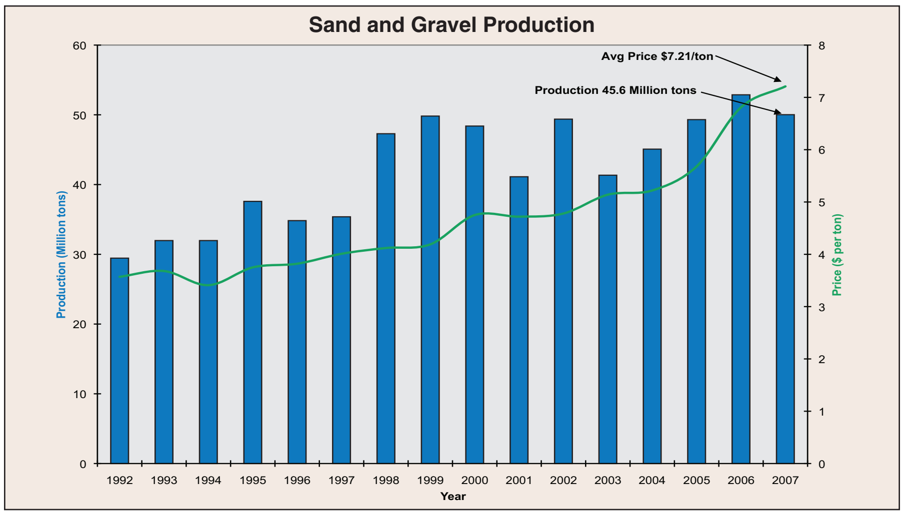


Figure 76. Production (bars) is shown in millions of tons and unit value (line) in dollars per ton for sand and gravel in Colorado, 1992–2007 (U.S. Geological Survey, 2007 data estimated). Sand and gravel production generally reflects the level of construction activity in the state, and this can be seen on the graph. Slower building and growth in 2007 directly affected the amount of the commodity produced. The price has continued to rise as operating costs have increased and producers must move further away from the urban centers to obtain the material.

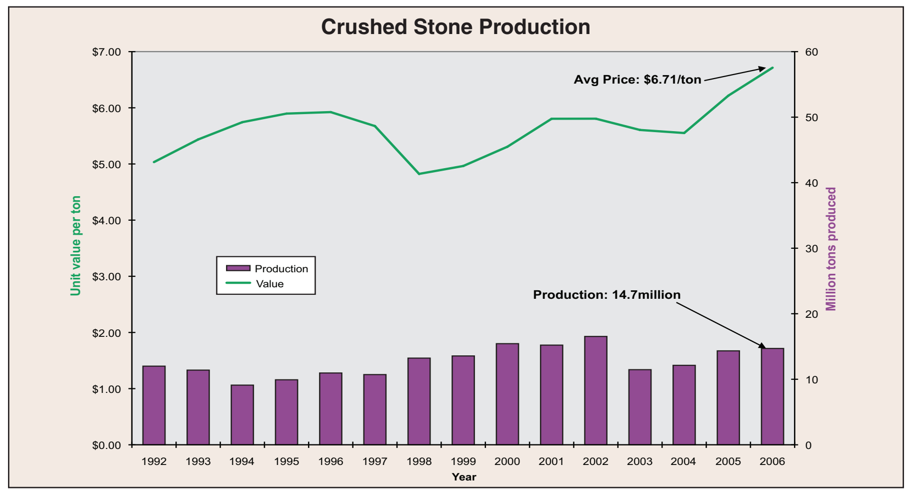


Figure 77. Production of crushed stone (represented by the bars) and unit value (line) for crushed stone in Colorado, 1992–2007 (U.S. Geological Survey, 2007 data estimated). Crushed stone is commonly used interchangeably with sand and gravel for construction. Colorado's Front Range area has historically used more sand and gravel from the alluvial deposits along the streams (particularly the South Platte River), but that proportion is changing to favor crushed stone as the resource is depleted along the rivers. Also, stone quarries are considered more favorable near populated areas because they create less visual impact.

Industrial Sand

Industrial sand differs from the sand and gravel of aggregate production in that it refers to high-purity silica sand with closely controlled sizing. Special properties such as specific purity, grain size, color, hardness, make this commodity a higher margin product than the construction sand discussed above (Herron, 2006).

Colorado's leading industrial sand company is the Ohio-based Oglebay Norton Company. The local division office, Oglebay Norton Industrial Sands (ONIS), is located in Colorado Springs. ONIS markets "Colorado Silica Sand," specialty industrial sand that is used primarily as filter media for water purification plants and as a construction material, largely for stucco. Some of their smaller markets include hydraulic fracturing material for oil and gas drilling, gravel packs around water wells, and other applications where roundness, permeability, and strength are important parameters. Additionally, the sand is used as a landscaping material. The majority of product is exported outside of Colorado. An estimated 34,000 metric tons of industrial sand was produced in the state in 2007.

Dimension and Decorative Stone

Dimension stones are quarried slabs or blocks of attractive rock that are used for decorative construction, facing panels, flagstone, sculptures and monuments, and many other projects requiring large, competent masses of stone. Many dimension stone producers may also crush and market some of their stone for landscaping purposes. Colorado produced an estimated 20 thousand tons of dimension stone in 2007 with an estimated value of $2.5 million. This is an 11 percent increase over the revised 2006 production figure of 18 thousand tons. The principal Colorado dimension stones include marble, sandstone and granite (figure 78). The flagstone from the Lyons Formation in Boulder and Larimer Counties is the most widely used material among Colorado dimension stone, along with some granite and marble.

Both crushed rock and whole boulders are used as a decorative landscaping material. Granite, gneiss, sandstone, volcanic rock, obsidian, marble, and quartz pegmatite are some of the rock types currently being mined in the state for decorative use. Natural boulders that have a covering of lichen on them are commonly known as "moss rock" in the landscaping industry. Usually, the larger the percentage of the rock covered with the colorful lichen, the more valuable it is. Numerous small decorative stone mines and quarries are located throughout Colorado. No specific production figures are available for statewide decorative stone production. The following table lists active permitted quarries for sandstone, stone, granite, and other decorative stone.

Table 22. Active permitted stone quarries. Most of the decorative stone (dimension stone) production comes from the Lyons sandstone where it occurs in Boulder and Larimer Counties. This is the fine, buff to pink-colored flagstone used throughout the state and well known for the buildings on the Boulder campus of the University of Colorado.

Permittee	Quarry Name	Commodity	County
Arkins Park Stone Corp.	Sprague Red Lyons	Sandstone	Boulder
	Berthoud Pink	Sandstone	Larimer
	Arkins Park	Sandstone	Larimer
	Berthoud Sunset	Sandstone	Larimer
B & B Stoneworks	Hodgekiss	Sandstone	Larimer
Barnard Quarries	Barnard	Sandstone	Boulder
BCI Landscaping	BCI	Sandstone	Boulder
Blue Mountain Stone	Beech Hill	Sandstone	Larimer
Carter Lake Enterprises	Masonville	Sandstone	Larimer
Colorado Quarries	Black Obsidian	Stone	Custer
	Hardship Lode	Stone	Custer
	Siskin	Stone	Custer
Colorado Red Rose	Red Rose	Granite	Larimer
Colorado Stone Quarries, Inc.	Yule Marble	Marble	Gunnison
ELB Stone, Inc.	Buster	Sandstone	Larimer
Front Range Buffalo LLC	White Buffalo	Sandstone	Larimer
Glade LLC	Glade	Sandstone	Larimer
Glenn Southwick	Masonville Stone	Sandstone	Larimer
Hector Rodriguez	Indio Red	Sandstone	Larimer
High Plains Stone Co.	South 40	Stone	Fremont
Ignacio Vasquez	Perdue	Sandstone	Boulder
Leonard Loukonen	Weaver	Sandstone	Larimer
Loukonen Brothers Stone	Beech Hill	Sandstone	Boulder
Lucio Vasquez	Lucio Vasquez	Sandstone	Boulder
Luis Vasquez	Red Wolf	Sandstone	Boulder
	Lyon King	Sandstone	Larimer
Mayne Industries	Dotsero	Volcanic	Eagle
O & A Stone LLC	Vasquez #2	Sandstone	Boulder
Phillips Stone Co.	Phillips	Sandstone	Boulder
Rocky Mountain Investments	Rocky Road	Sandstone	Larimer

Figure 78. Worker shapes flagstone from the Lyons Sandstone in the quarry near Lyons in Boulder County. The stone is used as flagstone for buildings, walls, walkways and other decorative purposes.

Cement

Cement is a powdered product made of blended lime, silica, alumina and iron oxide mixed with a small amount of gypsum. The principal constituent is limestone, so cement plants are generally located near a source of limestone. The limestone is heated to elevated temperatures (through a processed called "roasting") to break down the constituents and leave behind the calcium oxide component of the limestone. Depending upon the exact composition of the limestone feedstock, other mineral products are added to adjust the composition to the desired mix. These additives can include clay, shale, sand or sandstone, fly ash or any number of other components. Most concrete goes into the ready-mixed concrete industry, i.e. that concrete delivered to a worksite in cement trucks, blended specifically for the job. In recent years, the United States imported more than 20 percent of our cement consumption. That figure dropped to 17 percent in 2007, probably reflecting the overall reduction in demand.

According to the Portland Cement Association (PCA), cement consumption declined 6.8 percent nationwide in 2007; with additional decline forecast for 2008. An ongoing slump in residential construction caused by softening of the housing market and higher inflation and interest rates, has not been offset by non-residential construction as was hoped. According to the preliminary figures from U.S. Geological Survey, Colorado produced a total of 1.97 million metric tons of cement in 2007, just slightly more than the 2006 total of 1.95 million metric tons. The calculated value for the product was $191 million, just about a 3 percent increase, indicating the higher price of the product in 2007.

Cemex, Inc., Boulder County

Portland and masonry cement are produced at the Cemex, Inc., mine and processing plant near Lyons. The plant uses the dry processing method to produce cement that is utilized in the Front Range urban corridor. Cement ingredients (limestone and shale) are mined locally from the Niobrara Formation and the overlying Pierre Shale.

GCC Rio Grande, Inc., Pueblo County

GCC Rio Grande, Inc., a subsidiary of Grupo Cementos de Chihuahua, has been planning and permitting a new cement plant in Pueblo during the past several years. Construction of the plant and mining facilities began in mid-2005 and is scheduled to open and begin operation in the spring of 2008. The mine and processing plant is expected to produce about one million tons of cement per year. The Fort Hays Member of the Niobrara Formation will be mined for the main cement ingredients.

Holcim (US), Inc., Fremont County

The Portland Plant near Florence is operated by Holcim (US), Inc. The majority of their product is used in the metropolitan Denver area and throughout Colorado, although some cement is also distributed to neighboring states such as New Mexico, Wyoming, Kansas, and Nebraska. Limestone from the Fort Hays Member of the Niobrara Formation of Upper Cretaceous age is mined by Holcim as the principal raw ingredient for their cement (figure 79). The Codell Sandstone, also Upper Cretaceous age, is mined for use as a silica additive. Most of the company's gypsum is imported from New Mexico; some gypsum is produced as a byproduct of Holcim's lime calcining plant.

Figure 79. Holcim Quarry in Florence where the company mines the Niobrara formation. The quarry is adjacent to the cement plant which features the largest single kiln line in the United States, capable of producing nearly two million metric tons of cement per year. Holcim's cement products service mainly the Colorado area.

Clay and Shale

Clays are a very important industrial mineral, used in many applications in the economy. Most of the clays mined in Colorado are classified as common clay, which are fine-grained minerals composed of hydrous aluminum silicates and includes shale rocks. A defining characteristic of clays is their malleability. Because they exhibit plastic behavior when wet, clays can be shaped into various forms and made into a hard product when heat is applied. Hence, clays are a widely-used ceramic material, and are used for brick, tile, pipe, pottery and stoneware and roofing tile. Other lesser known uses include fillers in paint and other products, additives to cement and for plugging drillholes and lining ponds to prevent water seepage (Keith and Murray, 2006).

Clay production has a long history in Colorado. The first recorded production was in 1880, but probably goes back to the 1860s when the towns of Denver and Golden were growing. Refractory brick for furnace lining was required in 1866 for the first smelter built in Blackhawk and the clay for the bricks was probably of local origin. Clay mining is thought to have begun in Golden in 1876 (Scott, 1990). Most of the clay was historically mined from the hogback areas along the Front Range, and now comes mainly from the counties of Jefferson, Elbert, Douglas, El Paso, Pueblo, and Fremont.

In 2007, Colorado clay mines produced an estimated 200 thousand tons of clay valued at over $1.25 million. This represents a decrease of 5 percent from the 2006 production total of just over 211 thousand tons. In eastern Colorado, clay is mined principally from three geologic formations: the Laramie Formation (Upper Cretaceous), the Dakota Formation (Lower Cretaceous), and the Dawson Formation (Upper Cretaceous to Tertiary). Elsewhere in the state, clay deposits within the Lykins, Morrison, Benton, Niobrara, Mesaverde, and Vermejo Formations (ranging in age from Triassic to Cretaceous) have also been exploited.

Higher quality clays have also been produced from the Dakota and Dawson Formations. Both formations locally contain resources of refractory clay, to be used in the manufacture of refractory ware, such as crucibles and high temperature firebricks for kilns. Current market demands have not warranted active mining of these deposits. Additionally, bentonite clay layers are found in altered volcanic ash in Fremont County, and locally in the Jurassic Morrison Formation and the Cretaceous Pierre Shale. Bentonite is frequently used as an absorbent material (such as in kitty litter or to clean up hazardous fluid spills) and as a containment barrier (such as in clay liners for landfills). Colorado typically produces approximately 1,500 to 5,000 tons of bentonite annually, although, actual production and value data for bentonite is unavailable.

Five companies are involved in mining clay and shale products in Colorado.

The *Acme Brick Company* of Denver owns and operates five clay mines in Jefferson, Elbert, and Douglas counties: two mines produce clay from the Cretaceous Dakota Group, two produce from the lower Dawson (Denver) Formation (Paleocene), and one produces from the upper Dawson Formation (Eocene). In 2008, the company plans to open a new clay mine in Elbert County to produce from the lower Dawson Formation. Standard open-pit mining methods are utilized at all mines.

Lakewood Brick owns and operates two clay pits, Doughty and Church, in Jefferson County near Rocky Flats and supplements its stockpiles with clay purchased from other local suppliers. *Robinson Brick Co*mpany operates 14 clay mines in five Colorado counties—Jefferson, Douglas, El Paso, Elbert, and Pueblo. These mines produce from the Dakota Formation, Benton Shale, Fox Hill Sandstone, Laramie Formation, and Dawson Formation—all of Cretaceous age (figure 80). *Summit Brick and Tile Company* produces clay from 10 Summit Brick mines in El Paso, Fremont, and Pueblo Counties. Summit's red-burning clays are derived from the Morrison Formation and from the contact zone between Precambrian Pikes Peak Granite and the Pennsylvanian Fountain Formation. Standard open-pit mining techniques are used at all the mines (fig. 81).

TXI Operations is somewhat different than the other manufacturers. The company mines the Pierre Shale in northern Jefferson County for use as lightweight aggregate. The raw shale is kiln-fired to drive off excess water and force expansion of clay mineral molecules. The resulting product is light-weight and low in density. Lightweight aggregate is used in place of regular sand, gravel, or crushed stone in applications where excessive weight is undesirable, such as floors and walls in multi-story buildings. Cinder blocks are commonly made with lightweight aggregate.

Figure 80 (below). After the clay is mined and blended, it's pressed into bricks at the Robinson Brick plant in Denver and fired in the kiln.

Figure 81 (right). The Flintlock Mine along the Front Range west of Golden. Robinson Brick extracts clay from fourteen small mines along the Front Range and blends the various clays to achieve the desired product for each batch.

Gypsum

Gypsum is a hydrated calcium sulfate, a mineral most commonly formed in a sedimentary environment by the evaporation of brines in a saltwater basin. Gypsum and its close relative anhydrite are termed "evaporite" minerals, a group of water-soluble minerals formed in a similar way. Other common evaporite minerals include halite (table salt), borax and trona. Colorado production is estimated by the U.S. Geological Survey as 626,000 metric tons in 2007 with a value of $3.24 million.

There are many uses for gypsum, from soil amendment to glass additives to a key component in cement, but by far the most common is as plaster and in wallboard. To produce wallboard, the gypsum is calcined and converted into plaster (calcining is the process by which water is driven off by heating), mixed with various other materials and water to produce a slurry, which is then extruded between continues sheets of paperboard and subsequently hardened. The sheets of gypsum wallboard are then cut to the desired size, dried and bundled for sale. Colorado's largest producer—*American Gypsum* in Eagle County—produces raw material for their on-site wallboard plant, located in the town of Gypsum (figure 82). Another major producer is *Colorado Lien*, a subsidiary of Pete Lien & Sons, Inc. Colorado Lien produces gypsum from the Munroe Quarry near Fort Collins where it is used in cement production.

Sodium Bicarbonate and Soda Ash (Nahcolite)

Natural Soda, Inc., Rio Blanco County: Natural Soda Inc. uses solution mining to recover naturally occurring sodium bicarbonate from nahcolite on its U.S. BLM leases in the Piceance Basin in northwest Colorado. The facility has a permitted production capacity of 125,000 tons per year. Both food-grade (baking soda) and industrial-grade sodium bicarbonate are produced at the plant by mining high-grade nahcolite (>80 percent) from the "Boise bed" of the Green River Formation. Water is pumped into the Boise Bed through drill holes and the nahcolite dissolves. That nahcolite-bearing solution is pumped to the surface via separate recovery wells and the bicarbonate recovered.

Figure 82. A dozer operates at the highwall of American Gypsum's Eagle County mine. The gypsum from the mine supplies raw material for the drywall plant adjacent to the mine, fabricating gypsum wallboard for construction in the Colorado region.

Uses of sodium bicarbonate: The uses of sodium bicarbonate are food (32 percent); animal feed (24 percent); cleaning products (9 percent); pharmaceuticals and personal care (9 percent); chemicals (8 percent); water treatment (6 percent); fire extinguishers (2 percent); paint blast media (2 percent); miscellaneous (8 percent). (Source: Chemical Market Reporter.)

Gem and Specimen Minerals

The varied geological environments of Colorado provide a large variety of gemstones and specimen-quality minerals. Small mining operations periodically produce commercial quantities of stones, but most of the activity is by amateur collectors. Notable deposits are often operated by weekend miners who provide quality material to the gem and mineral trade.

The US Geological Survey estimates that Colorado produced gem and specimen minerals worth $266,000 in 2007, slightly less than the total estimated for 2006. Colorado ranks 9th among the gem-producing states. Because of the nature of the commerce in gems and specimen minerals, it is impossible to accurately estimate the total value. Anecdotal evidence indicates that the actual value may be somewhat greater; gem and mineral shows in the State generate several million dollars in transactions each year, but there are no data indicating how much of the trade is attributable to specimens from Colorado.

Colorado is famous for several specific types of gemstones and specimen minerals. Rhodochrosite (the official State mineral) from the Sweet Home Mine in Park County is probably the most famous, although aquamarine (the official State gemstone) from Mount Antero in Chaffee County is known around the world. Among Colorado minerals that generate a high dollar volume are varieties of cryptocrystalline quartz. In its various forms, this mineral is known as carnelian, chalcedony, onyx, sardonyx, chrysoprase, agate, jasper, petrified wood and many others. It is found in many locations around the state, with petrified (agatized) wood occurrences in Arapahoe, Douglas, Elbert, and El Paso counties.

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