PAYNE INSTITUTE COMMENTARY SERIES: **COMMENTARY**

The Future of Oil and Gas Production in Urban and Suburban Environments: "Is Colorado an Example of Where the North American Crude Oil and Natural Gas Industry Might be Headed?"

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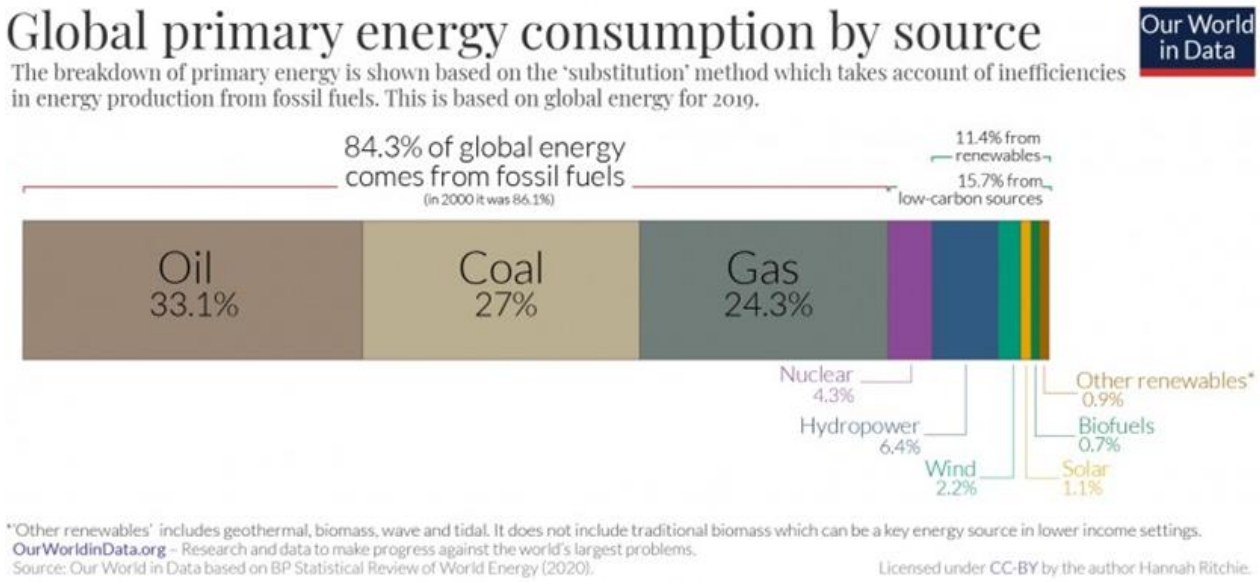
Abstract

There has and is much discussion about the future of fossil fuels, specifically the oil and gas industry. With growing concern on climate change, the need for a diversified energy portfolio, incorporation of clean energies into energy production, and the expectation for an energy transition away from fossil fuels to non-carbon energy solutions, such as renewables, signifies that the energy transition has already begun. While the energy industry is transitioning due to market forces, public policies, and technological advances, fossil fuels are not yet forgotten in the total energy supply of the future.

Currently, global oil producers are facing a complicated challenge on their path to a low-carbon energy future outlined by the Paris Agreement. The problem is how to provide the energy needed to meet the growing forecasted demand of energy to establish energy security. Demand for energy is expected to grow by 20% by 2040 and today nearly 80% of the world's energy is powered and heated by hydrocarbons. Over time the demand for energy is more than likely will continue to grow and petrochemical products will be continually produced, preventing the end of oil and gas as a viable energy source. Instead, oil and gas operations will be a matter of policy fulfillment, strategic design, and socially responsible execution. Thus, producing the new energy future will require the oil and gas industry to work with governmental agencies, environmental organizations, new digital technologies companies, and the public to develop and deploy innovative solutions to succeed in decarbonizing a socially responsible manner.

This paper looks at one specific area in the Niobrara DJ-Basin in Colorado where oil and gas production and operations comparatively meet tougher regulations than other states. The reason for the study was to observe the changes and relationship between the oil and gas industry, the growing community population and regulatory agencies of the oil and gas industry in Colorado. To show this dynamic interaction, this article provides chronological context on the basin itself, with historical examples of urban encroachment. We will discuss the relevant stakeholders and who they are, the observed impacts on oil and gas operations and what caused them, and innovative solutions being put into action to meet the needs of a net-zero carbon emission future. This article does not provide the solution but rather an internal view and reflection of the oil and gas industry based in Colorado. We ask readers to reflect if Colorado is an example of where the North American onshore crude oil and natural gas industry might be headed.



https://ourworldindata.org/energy-overview#more-than-80-of-our-energy-still-comes-from-fossil- fuels

Introduction

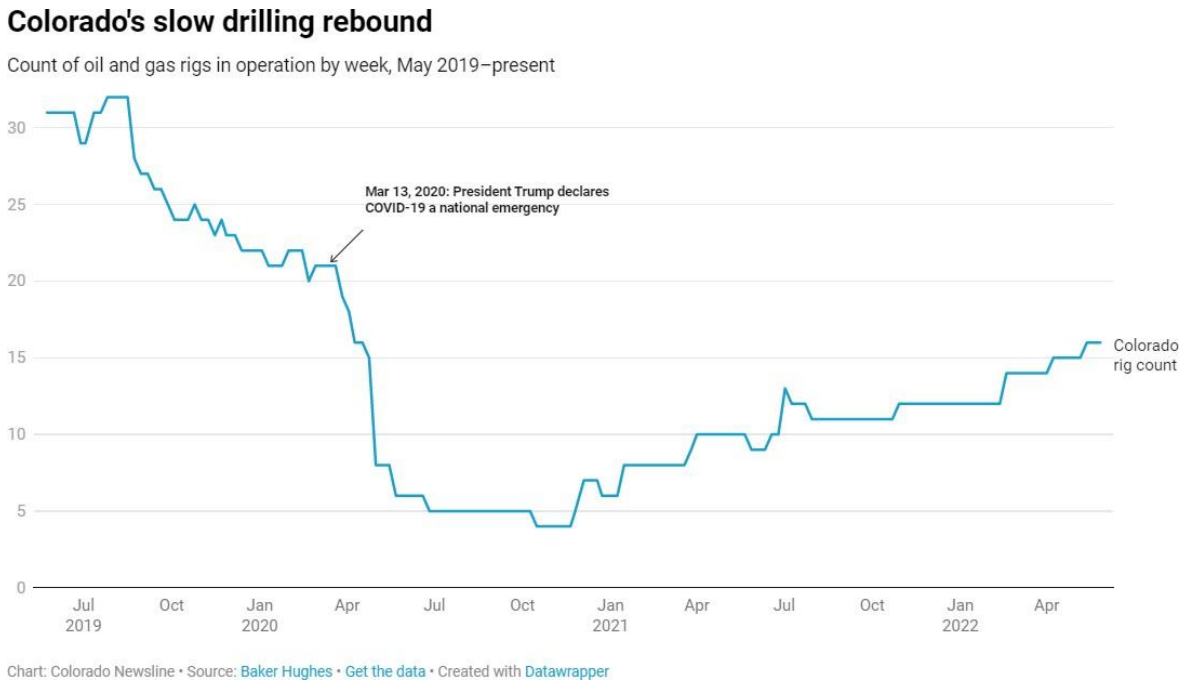
The oil and gas industry are constantly exposed to market volatility of changing supply and demand factors while also addressing ever-changing environmental and safety issues. As the industry navigates the energy transition towards Net Zero targets, stakeholders will depend on greater visibility into their business and operations to quickly understand how different scenarios impact the energy value chain. The shift to greener operations is not only essential for brand reputation – it has also become a key prerequisite for gaining regulatory approval and securing investment funding. Sustainable processes are not just good ethics, they can be good business, and will add efficiency as a critical imperative on the path to the oil and gas industry of the future. The oil and natural gas industry has to move from a defensive posture justifying its existence to a more positive proactive message of how their operations are contributing to a safer, cleaner environment while satisfying a substantial part of the energy needs of a growing economy.

Addressing efficiency and sustainability is critical to the future of the industry, but organizations can only improve what they can measure. Ultimately, whether built new or many years in the past, modern production facilities need to be smart, automated, efficient, and connected. The goal should be to connect operations, maintenance, engineering, and capital project stakeholders to a single, trusted hub of data – or Digital Twin – to break down silos, enable collaboration, and facilitate smarter, faster decisions. One version of the truth through better measurement can be a way to build trust among all parties. Integrated process simulations will help project and field teams identify ways to test and minimize the plant's carbon footprint and deliver a sustainable asset for the long term. And data-driven cultures will enable agile and resilient workflows that distinguish top performers. In the end, all this information will become the digital thread used to empower operations and equipment maintenance and a digital window into performance for all stakeholders, in ways that have not yet even been imagined.

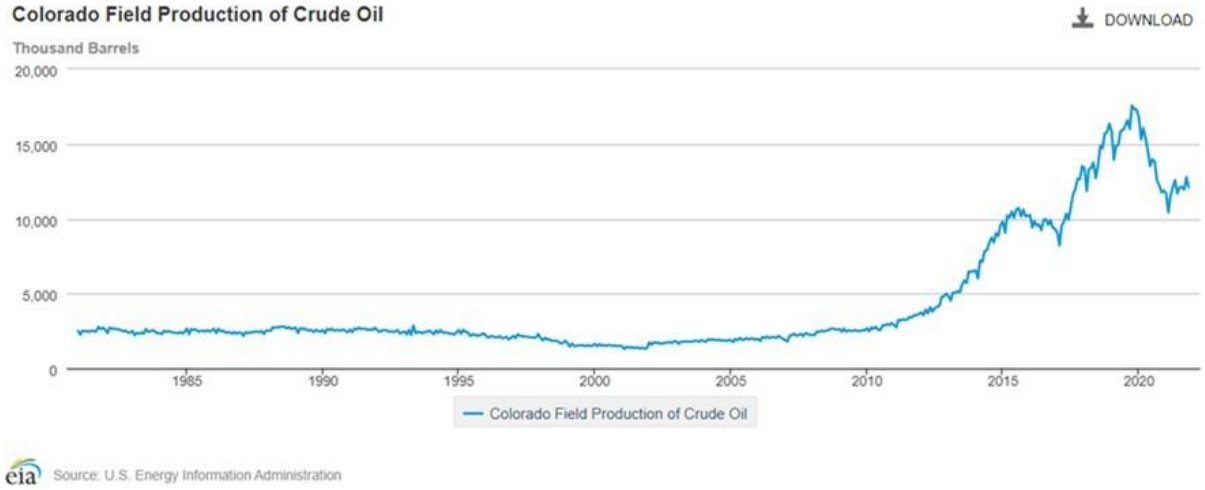
The Oil and Gas Industry in Colorado

It's no secret that operators in Colorado face a unique set of challenges, from changes in the regulatory structure to shifting public perspectives - operating in the state is not for the faint of heart. Colorado accounts for just over 4% of U.S. total crude oil production and 3% of the nation's economically recoverable crude oil reserves. In 2020, the state produced about four times more crude oil than in 2010, primarily from the increased use of horizontal drilling and hydraulic fracturing technologies. Oil wells produced 192.2 million barrels of crude in 2019, according to the Colorado Oil and Gas Conservation Commission's database. That eclipses the previous state record of 172.7 million barrels of crude produced in 2018. However, the economic slowdown due to the COVID-19 pandemic leading to "demand destruction" in the market, operators responding to investors demand for higher returns and tougher regulations negatively impacted oil output in Colorado. In 2020, the state's crude oil production declined by 10% and in 2021 by over 20% from 2019 levels. With higher commodity prices in 2022, a modest 9% growth is forecast in crude oil production but a 4% decline in natural gas production.

	Colorado Oil Production Bounces Back in 2022			
		(Colorado production Jan 1 - June 30)		
	year	Crude Oil (in Barrels)	Natural Gas (in cubic feet)	
	2018	78.3	976	
	2019	91.3	1002.7	
	2020	91.8	1048.9	
	2021	73	972.6	
	2022	79.8	937.2	

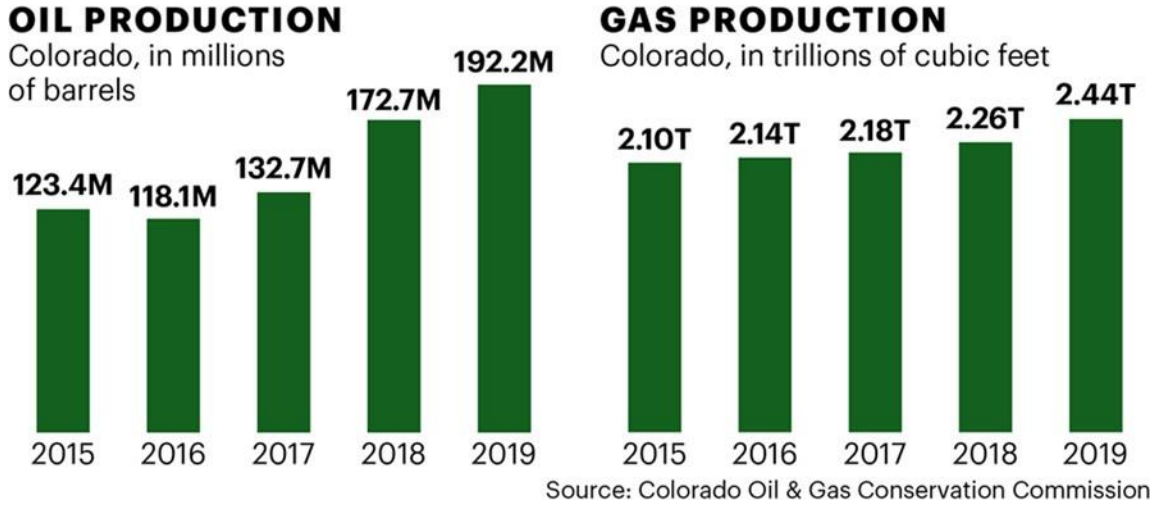


Most new oil production in Colorado comes from the Niobrara Shale formation located in the Denver- Julesburg Basin in northeastern Colorado, where oil production in one county, Weld, is the source of almost 8 out of every 10 barrels of crude oil produced in Colorado today. The Wattenberg field, much of which is in Weld County, is the fourth-largest U.S. oil field based on proved oil reserves and ninth-largest gas field based on proved natural gas reserves. In July 2022, the DJ Basin registered the largest week-over- week gain with the addition of three rigs bringing the basin's total to 21 (from a low point of four rigs at the end of 2020). The Piceance Basin in the western mountain region is the other significant natural gas-producing area in Colorado.



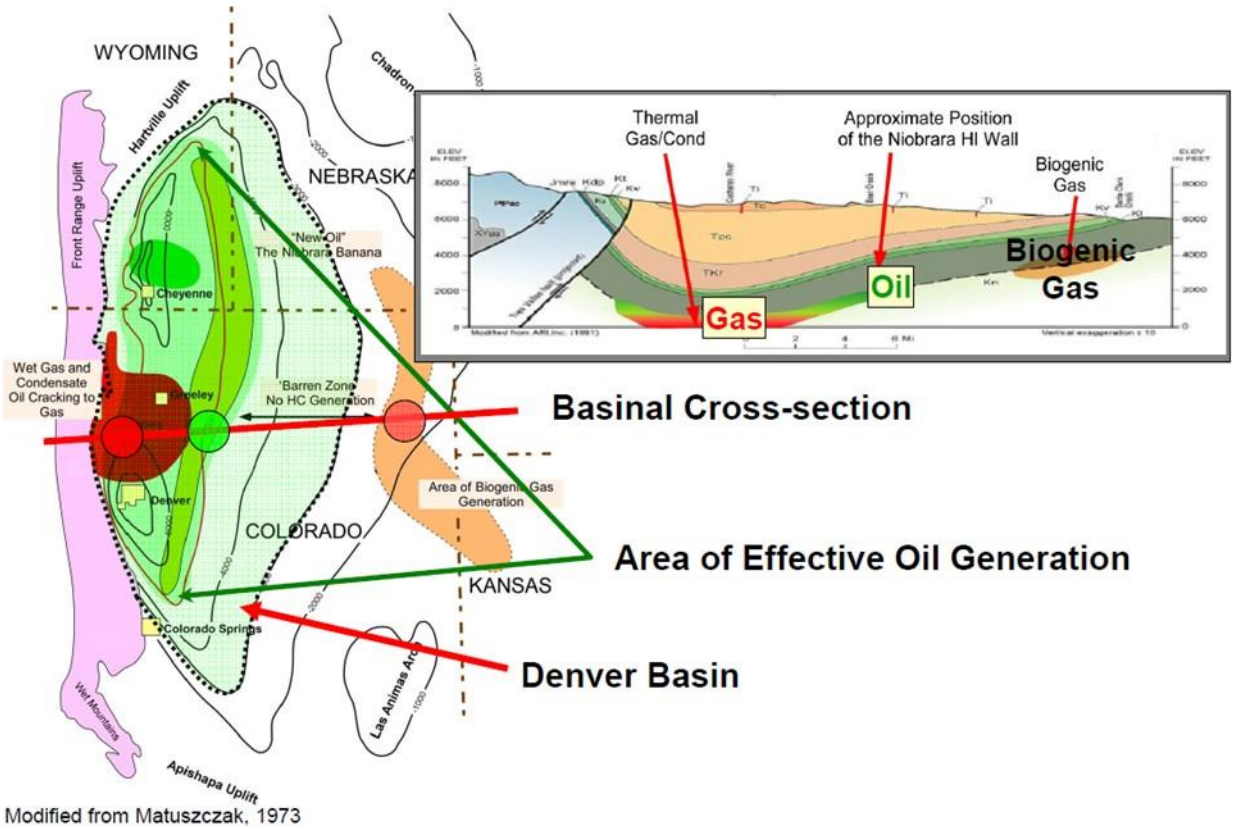
A search through the database from the Colorado Oil and Gas Conservation Commission for the DJ Basin shows that since 1999, almost 1.4 billion barrels of crude oil and 9.8 TCF of natural gas has already been produced from 13, 867 active producing wells and 121 operators.

https://cogcc.state.co.us/cogis/ProductionSearch.asp



Overview of Oil and Gas Industry in the DJ Basin of Colorado

The Denver Julesburg Basin stretches 70,000 square miles from the eastern side of the Colorado Rocky Mountains to western Kansas, western Nebraska, southeast Wyoming, and South Denver. The following figure illustrates just how far the DJ basin stretches across Colorado and Wyoming.



Modified from Matuszczak, 1973

The DJ basin is responsible for over 80% of the crude oil production in Colorado. The first oil production in the Front Range was in 1860 by Gabriel Bowen in Oil Spring, near Canon City. This was only one year after the first oil well was drilled by Edwin L. Drake in Titusville, PA. Oil Spring was discovered by the Southern Utes who used the oil seeping out of the ground as body paint and medical ointment. In 1862, Oil Spring had its first well drilled by Alexander Cassidy who formed the Colorado Oil Company. Four wells were drilled near oil spring to a depth of 60-90 feet and two were drilled to a depth of 400 ft. The deeper wells ended up not producing any oil. Up until 1870, the wells produced a cumulative 3,000 gallons of oil. In 1881, Cassidy and his partner, Isaac Canfield, drilled southeast of Canon City and struck oil at a depth of 1,445 feet. This discovery started the development of the Florence Oil Field. Production in the Florence Oil Field peaked in 1890 where it was producing more than 3,000 barrels per day.

Nearly a decade later, in 1901, Canfield noticed Boulder had similar topography as Florence. Canfield drilled the first well in Boulder beginning the Boulder Oil Field. This well is named the McKenzie #1 well. It produced up until 2007 when it was plugged due to low production levels. This well is still around today and is on the National Register of Historic Places.

The Boulder Oil Field reached peak production in 1909 producing over 86,000 barrels of oil annually. This was the first official and widely recognized development of the DJ basin in Colorado. Over the course of the field, close to 200 wells produced nearly 800,000 barrels of oil from the Cretaceous Pierre Shale. The location of the Pierre shale can be found in the stratigraphic column in the stratigraphic column below.

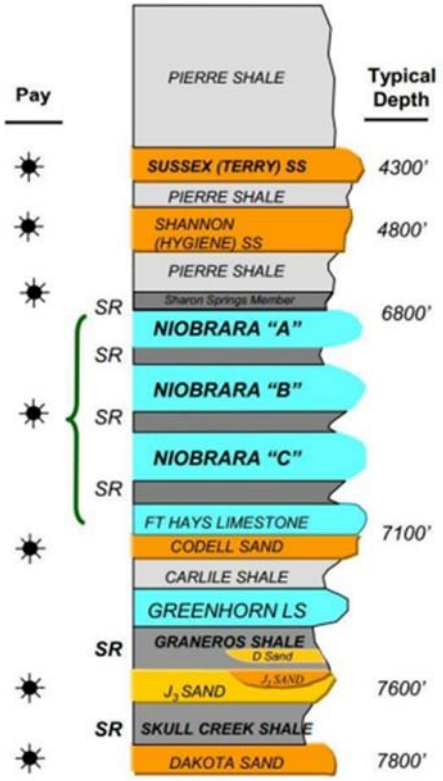


Figure 2: Stratigraphic Column of DJ Basin [7]

Background of Niobrara Formation

The Niobrara formation stretches through northeast Colorado, northwest Kansas, Nebraska, and southeast Wyoming. Deposited in a marine environment in the Western Interior seaway during the Cretaceous period, the Niobrara is a low permeability (0.01 mD to 0.1 mD) and low porosity (less than 10%) chalky limestone. The total thickness of the Niobrara is between 150 and 250 ft. It is divided into an A, B, and C bench. The locations of the benches can be found in the stratigraphic column in Figure 2 above.

The depth in the DJ basin is between 5,500 ft and 8,500 ft. The Wattenberg field section of the Niobrara is estimated to have a resource base of 3- 4 billion barrels of oil equivalent. The earlier figure shows the location of the Niobrara as well as the structure contour map of the top of the Niobrara in the DJ basin. The figure below shows a cross section of the DJ basin and highlights the Wattenberg field location. This figure illustrates how the hydrocarbon is trapped within the DJ basin. A typical field has water on the bottom, oil in the middle, and gas on the top. What's unique about the

Niobrara is the gas sits at the bottom of the syncline and oil is in the flanks of the Niobrara. The highlighted orange section on the figure is the hydrocarbon generation window. The total organic content (TOC) of the rich source rock of the Niobrara lies between 2 and 4 %.

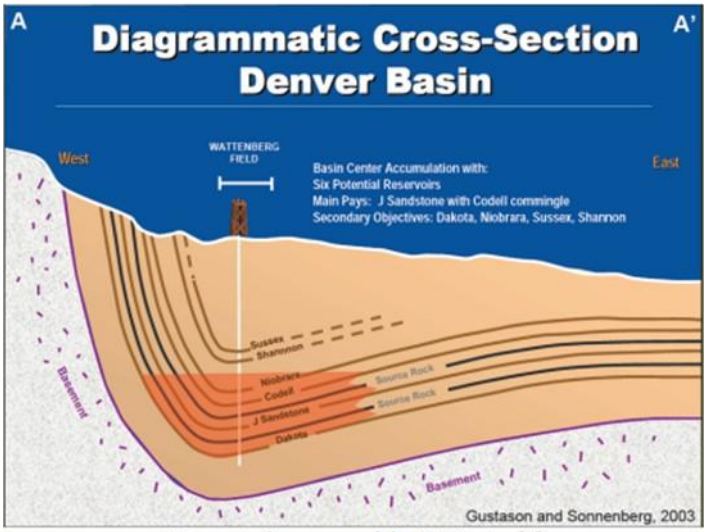


Figure 3: Structure of the DJ Basin [7]

The Niobrara reservoir was initially discovered by Amoco in 1970 during the development of the Wattenberg field in the J and Sussex sandstones. Location of the J and Sussex sandstones can be found in the stratigraphic column. The Wattenberg field is located in Southwest Weld County. In 1970, the Niobrara was discovered to have capability to produce hydrocarbon. At that time, the low permeability deemed the Niobrara formation un-economic.

The first application of a horizontal well in the DJ basin in the Niobrara was begun in 1981 by Snyder Oil Corp. The Burbach 20-3H was kicked off at 6583 ft before going 3600 ft laterally into the Niobrara B section. After two different completion methods, the well never produced economic amounts of hydrocarbon and was plugged in 1998.

In late 2009, the horizontal development of the Niobrara was accelerated. In August of 2009, EOG resources drilled the Jake 201-H well in Weld County and revived the Niobrara horizontal push in Colorado. This well had a MD of 11,420 ft and had a horizontal length of 3,862 ft. The well trajectory penetrated through the B bench of the Niobrara. The well was stimulated using a hydraulic fracturing treatment using 18 stages over 185 feet. In just 5.5 years of being online, the well produced a cumulative 187,305 bbls oil and 495,458 MCF of gas.

As of March 2022, there are currently over 6400 active wells in DJ Basin targeting the Niobrara. In the last four years, there have been almost 2250 wells completed in this formation. All of which have been horizontal wells with multistage fracturing completions. Low commodity prices in recent years have forced operators to focus on optimization of completion techniques. Clearly understanding the fracture network created by the stimulation treatment is crucial to improving optimizing production after 90 days. Using tracers for proppant, fluid, and hydrocarbons have also contributed to the more efficient completion of wells in the Niobrara.

Some historical comparisons: LA Basin and the oil industry

The oil and gas industry has a long history of operating in both remote locations and near population centers. Having oil and production facilities near to where humans live and work is not rare or uncommon. Just ask the folks in Midland or Odessa, Texas, Oklahoma City, Oklahoma or Bakersfield, California. A more recent experience is in the Fort Worth Basin with the exploitation of the Barnett Shale moving into the suburbs of Fort Worth, Texas. But oil and gas operations and urban or suburban settlements don't always make good neighbors. Here is some history from the Los Angeles Basin in southern California to draw lessons learned from in anticipating the future of oil and gas facilities in the southern DJ Basin near an encroaching metro Denver.

Most people don't realize that the Los Angeles Basin is one of the most prolific producing basins in the United States and is known for its world class oil reserves per unit or rock ratio. Tar seeps have been known in the area from prehistoric times, and the Native American population of the Los Angeles basin used the tar for waterproofing and other purposes. The Spanish settlers used it for their lamps, as a sealant for roofs, and as grease for wagon wheels. Oil was first discovered in the basin by Edward Doheny in 1892 and soon became one of the top producing states in the country. Edward L. Doheny used a sharpened 60-foot eucalyptus log to drill L.A.'s first major well in what is today's Echo Park. Just three years later the Los Angeles City Oil Field, which stretches between Vermont Avenue and Dodger Stadium, was pumping out more than half of the state's total oil production.

In the 1890s, the small town of Los Angeles (population 50,000) began a transformation driven by the discovery and drilling of some of the most productive oil fields in US history. Los Angeles became the Saudi Arabia of the time—the world's most productive oil region. Dense forests of derricks popped up around the nascent downtown and along the beach at Venice and near Long Beach on Signal Hill, which earned the nickname Porcupine Hill. By 1930, California was producing nearly one quarter of the world's oil output, and its population had grown to 1.2 million. In the decades that followed, many wells abandoned, but even more drilled, surrounded by urban and suburban growth. Machinery was camouflaged, loud noises were abated, methane pockets were vented, as residents learned to live side-by-side with oil production facilities. To this day, oil fields in the Los Angeles Basin remain productive, and modern techniques have centralized operations into smaller areas or moved offshore.

As the boom years of the basin occurred before the formation of regulatory agencies in California, record keeping was sometimes sparse, not only for oil production but for the very existence and location of the wells. R.E. Crowder, writing in 1961, counted 142 wells which likely existed, but could not be located; some may have been dry holes. A more recent survey suggested that up to 300 wells may have been drilled within the vicinity of the Los Angeles oil field but abandoned without a trace.

Signal Hill oil field near Long Beach

By 1961 most of the Los Angeles oil field was dedicated to redevelopment as a residential area, under the auspices of the Los Angeles Urban Renewal Association. At this time, 93 wells still remained active in the field, run by 22 separate companies. The relentless growth in population required more and more space, limiting and at times pushing out oil and gas development.

After an explosion which leveled a Ross Dress for Less in the Fairfax District in 1985, caused by an accumulation of methane which had seeped up from the underlying Salt Lake Oil Field, construction over Los Angeles's old oil fields became much more controversial. The city defined "methane zones" around all oil fields within its limits, and then enacted ordinances to ensure that new and existing structures within these zones were sufficiently ventilated to prevent the accumulation of explosive levels of methane. Mitigation systems for modern buildings include subsurface barriers, ventilation systems, methane detectors, and alarms. Thousands of buildings in the Los Angeles area have such systems, including the Staples Center and Los Angeles Convention Center.

Construction of the Belmont Learning Center, now known as the Edward R. Roybal Learning Center, "the nation's most expensive high school" began in 1988 adjacent to, and partially above, the former oil field, and within a methane zone. Soil tests in the early 1990s showed methane at high levels, possibly migrating up from old wellbores (not all of which were mapped, let alone abandoned to modern standards). Construction of the complex continued intermittently, with partial demolition and reconstruction after additional contamination and an earthquake fault were found. The Learning Center eventually was completed at a cost of $377 million, not far from the area that was the field's center of operations 100 years before.

In 2013, the Geological Survey estimated that between 1.4 billion and 5.6 billion barrels of recoverable oil remain in the Los Angeles basin's ten largest fields alone. In fact, it described the area's geology as "a nearly ideal petroleum system…[with] one of the highest concentrations of crude oil in the world."

In 2022 the Los Angeles City Council approved a sweeping measure that will ban new oil and gas wells and phase out existing wells. Los Angeles is home to the country's largest concentration of urban oil fields. LA's proposal builds off a statewide proposition announced by California Governor Gavin Newsom. Due to public and environmental health impacts, the state's Geologic Energy Management Agency is in the process of banning the permitting of new oil and gas wells within 3,200 feet of community sites, including homes, schools, hospitals, nursing homes, and daycare centers.

Will authorities in Colorado communities follow the lead of California and do the same by banning new oil and gas development or can the industry find ways of operating that meet stricter environmental and safety regulations and continue to produce oil and natural gas for future energy needs? That is the question that this paper wants to try to answer.

Firestone, Colorado Senate Bill sr19-181 and Colorado's Net-zero Carbon-road map

For the Oil and Gas Industry in Colorado, the world changed on April 17, 2017. A sudden violent and fatal house explosion in Firestone, located on the northern edge of the Denver-Boulder metropolitan area along Interstate 25, midway between Denver and Fort Collins, just east of Longmont, prompted statewide action by oil & gas officials and Colorado lawmakers, including the involvement of Governor John Hickenlooper. Ten days after the explosion, Anadarko Petroleum Corporation announced it would safely shut in more than 3,000 vertical wells across northeast Colorado. The home on Twilight Avenue was less than 200 feet away from a well operated by Anadarko. Company officials said the move was made out of an abundance of caution.

The well next to the home on Twilight Avenue had been there more than 20 years before the house was built. State records show the well was temporarily abandoned in 2016, but was reopened in January 2017. Regulators last inspected it in 2014 and gave it a satisfactory rating. May 2, 2017: The Frederick-Firestone Fire Protection District unveils the cause of the explosion was a "fugitive gas" — an unrefined, non- odorized gas — that leaked underground from a severed and uncapped flowline connected to a gas well near the home.

In April 2020, Colorado's top oil and gas regulators handed down at fine of $18.25 million to Occidental Petroleum Corp. — by far the largest ever levied by the state against an energy company — for its role in a house explosion in Firestone. Occidental Petroleum had acquired the assets of Anadarko Petroleum in 2019 so was the current owner of record. A federal probe determined that the April 17, 2017, blast, which killed Mark Martinez and Joey Irwin as the men were replacing a hot water heater in the basement, was caused by natural gas leaking into the home from a severed underground pipe.

The public reaction to this disaster and the election of a new governor led to rules changes for the Colorado Oil and Gas industry in early 2019 with the passing of Colorado sb19-181 bill. This was a very rapid and dramatic change in regulatory approach after the Democrats won all statewide elections in November 2018 and Jared Polis became governor. The bill was introduced on March 1, 2019, and signed April 16, 2019 and took only 45 days to become law. Several aspects of this bill fundamentally changed how future oil and gas drilling and production activities would be regulated by state and country authorities in the state.

Today, oil producing regions, like the DJ Basin, are in several of the countries that have been the most aggressive with polices, programs and capital restrictions on oil and gas producers. The reality is that these companies could no longer drill where they wanted or quickly increase their output and would be subject to a very different regulatory regime for any future drilling and production activity.

The politics in Colorado over the past several years is a good example of a trend toward greater public comment and regulatory oversight for oil and gas production activities based on safety and environmental issues. Yes, oil and gas producers have more cash from existing production given current rise in commodity hydrocarbon products. But what they no longer have is the same independence for internal exploration and development teams and programs, long term and meaningful support from capital providers, a service and supply chain able to quickly increase capacity, or the elusive "social license" among too many influential stakeholders to expand, not reduce, oil and gas output.

Here is what is happening in Colorado. While there are several factors that impact crude oil and natural gas production dominated by commodity prices, market demand, technology, and geopolitics, there is no doubt that new regulations are making it harder to get a drilling permit which will ultimately impact oil production especially for unconventional reservoirs which are characterized by rapid decline profiles. It we just look at Colorado in the past three years, crude oil production has declined by nearly 20% from 2019 when senate bill sb19-181 was passed.

In 2022, commodity prices have risen significantly, oil and natural gas production has increased modestly and a model of what it takes to get a permit to drill and produce crude oil and natural gas in the DJ Basin (at least in rural Weld County) is emerging. This paper suggests that there are seven design principles from community engagement to facilities design that will help oil and gas operators

continue to work within the new regulatory and political climate. There is a future for oil and gas producers in the DJ Basin but it is a different one than the industry was thinking about before April 17, 2017.

Colorado oil and gas regulations

Colorado first adopted methane emissions regulations for the oil and gas sector in 2014. Colorado's regulations require oil and gas companies to find and fix methane leaks, and, where necessary, install technologies to limit or prevent emissions. Colorado tightened its rules in 2019 to require semiannual leak detection, tank controls, and performance standards for transmission.

Responsibility for oil and gas regulations are split between the Colorado Oil and Gas Conservation Commission (COGCC) and the Colorado Department of Public Health and Environment (CDPHE). The Air Quality Division of CDPHE is responsible for regulation of oil and gas activity from three perspectives; ozone abatement, climate impact and air toxics (like NOX and benzene).

The mission of the Colorado Oil and Gas Conservation Commission (COGCC) is to regulate the development and production of the natural resources of oil and gas in the state of Colorado in a manner that protects public health, safety, welfare, the environment and wildlife resources. The agency seeks to serve, solicit participation from, and maintain working relationships with all those having an interest in Colorado's oil and gas natural resources.

FracFocus

One example of greater transparency to the public is FracFocus, the national hydraulic fracturing chemical registry web site. The site was created to provide the public access to reported chemicals used for hydraulic fracturing as well as objective information on hydraulic fracturing, the chemicals used, the purposes they serve and the means by which groundwater is protected. FracFocus is managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission, two organizations whose missions both revolve around conservation and environmental protection.

FracFocus was created in 2011 with a single purpose in mind: to simplify the search for chemicals used in hydraulic fracturing operations by location. This goal extended not just to providing a one-stop resource for all relevant information, but also to ensuring the information is clear and easy to understand.

The original vision began in 2010 through a partnership between the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission and supported by US DOE, which were aware of and concerned about the time-consuming and inefficient processes in place for consumers who wanted to search for this information. In a joint effort, they began planning and seeking input from states, academia, and technology and industry experts to place chemical reporting data at the general public's fingertips.

Today, what began as a voluntary reporting site with 37 participating companies now receives reports from more than 1,600 companies reporting chemicals for more than 189,000 hydraulic fracturing operations nationwide. Because of the system's success from both operator and consumer perspectives, 27 states now either require or allow companies to disclose chemical data via FracFocus.

The Controversy over setback distances

Colorado Proposition 112, the "Minimum Distance Requirements for New Oil, Gas, and Fracking Projects Initiative" was on the ballot in Colorado as an initiated state statute on November 6, 2018. It was defeated by a vote of 45% for and 55% against. This initiative was designed to mandate that new oil and gas development, including fracking, be a minimum distance of 2,500 feet from occupied buildings such as homes, schools, hospitals, and other areas designated as vulnerable. Vulnerable areas would have been defined by the initiative as "playgrounds, permanent sports fields, amphitheaters, public parks, public open space, public and community drinking water sources, irrigation canals, reservoirs, lakes, rivers, perennial or intermittent streams, and creeks, and any additional vulnerable areas designated by the state or a local government."

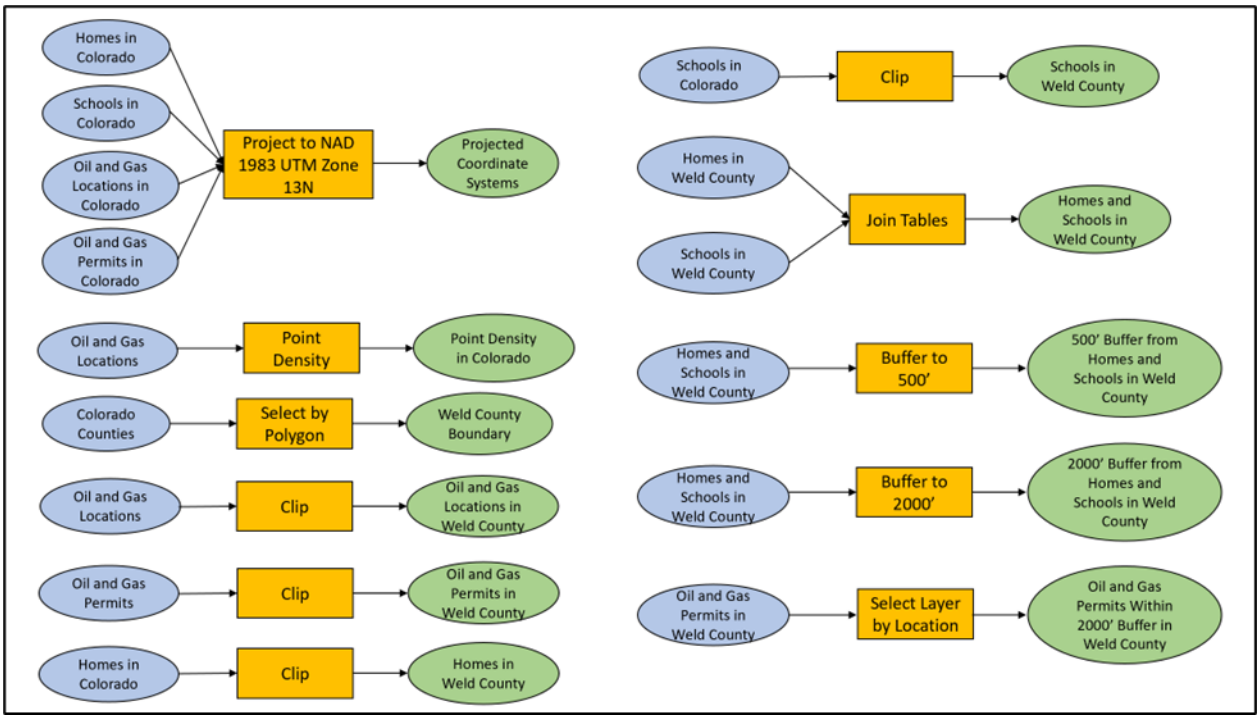
However, after Colorado Senate Bill 181, the Colorado Oil and Gas Conservation Commission finalized a set of rules in November 2020 that include 2,000-foot setback target, tighter state nuisance rules, and a more open public hearing process for drilling permits. The rules COGCC commissioners implemented will create specific exceptions for well projects to be approved if they are between 500 and 2,000 feet of a residential building but can show they aren't opposed by nearby residents or that they can protect nearby homeowners as effectively as the setback would. Recent permitting experience is showing that a less-than-2,000 foot setback distance is not impossible or even extremely difficult with creative planning solutions.

Many critics thought that a large setback distance as proposed would effectively limit future oil and gas activity to only a small area of the DJ Basin. As a part of the research for our paper, a study was undertaken with data from Weld County to evaluate the impact of the setback impact areal extents for buffer distances of 500 ft and 2000 ft were mapped.

Without new facilities design approaches (such as super-pad designs with long laterals) and a more robust engagement with the community, this analysis showed that the 2000 ft buffer distance significantly impacted a greater region of the county. This impact on the industry activity brought out a lot of concern about the viability of the industry post SR-181.

The modeling for this project was conducted using tools in the Data Management, Analysis and Spatial Analyst toolboxes within ArcMap since it was possible to appropriately assess, filter and scale the information from the collected GIS data using the Project, Clip, Buffer, Select Layer by Location, Select by Polygon, and Point Density tools to produce the 2D output layers to represent the impacts of the SB 19- 191 to oil and gas development in Colorado. In addition, the criteria to use the data management and analysis toolboxes was based on their ability to provide powerful sets and varied collection of tools to perform the desired GIS operations for this project.

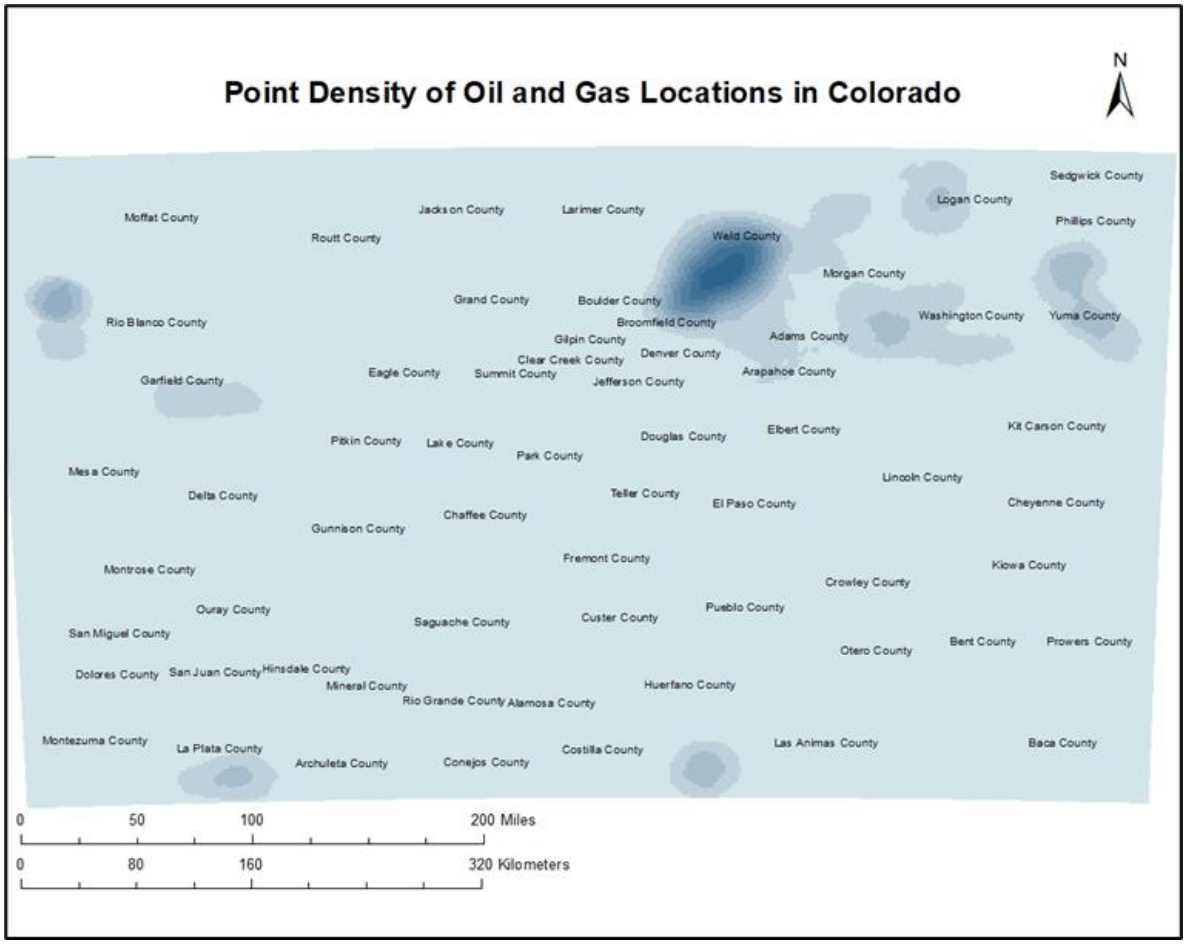
The following graphic shows the mapping processing flow:



The data was taken from the following sources.

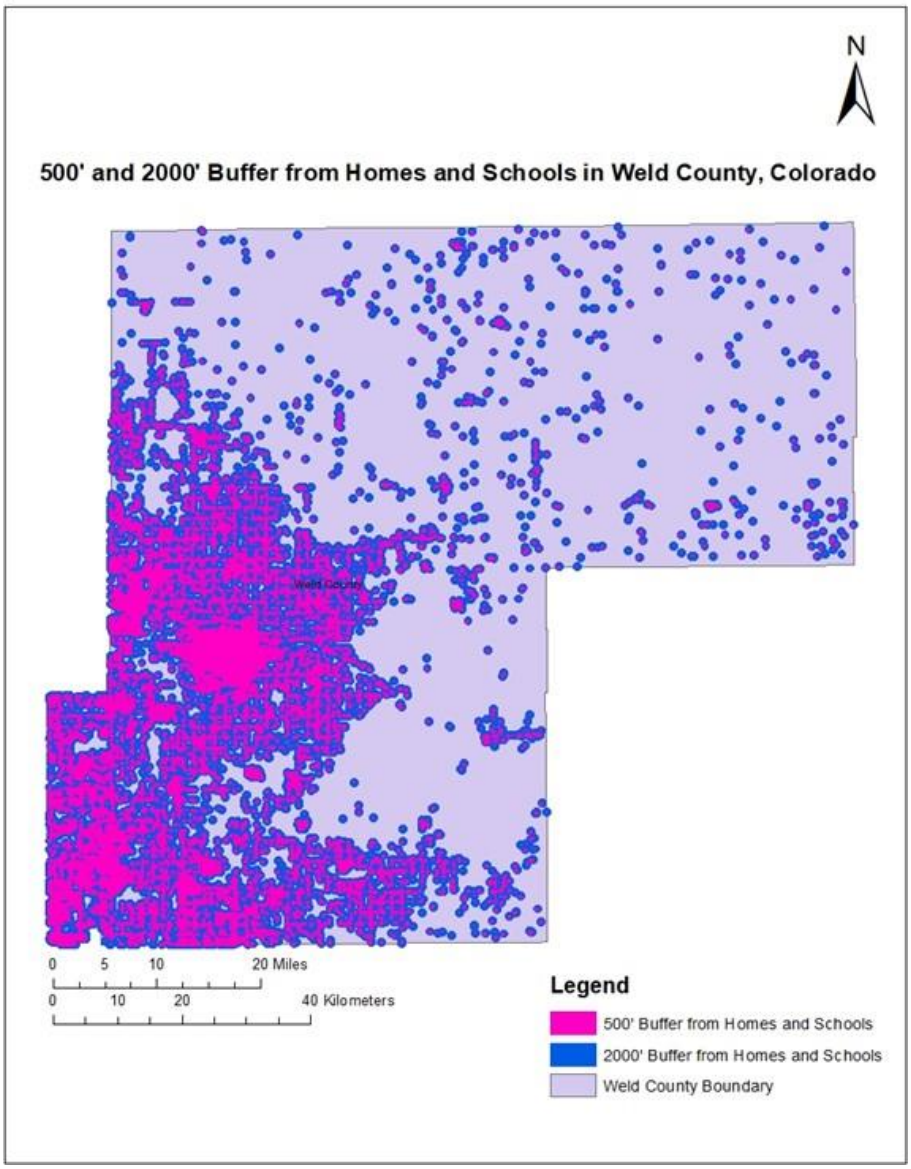
Data Category	Data Type	Source
Oil & Gas Locations	Oil & Gas Locations	Colorado Oil and Gas Conservation Commission
Oil & Gas Locations	Active Permits	
Oil & Gas Locations	Pending Permits	
Boundaries	County Boundaries	Colorado Department of Local Affairs
Schools	Prekindergarten to College Schools	Denver Regional Council of Governments
Homes	Home Addresses	Colorado Information Marketplace

As a result of the analysis conducted on ArcMap, three output layers were created to meet the project objectives. The first output map, shown in the following figure, was created using the Point Density tool from the Spatial Analyst toolbox and it represents the point density of oil and gas locations in Colorado based on the oil and gas data from the Colorado Oil and Gas Conservation Commission. In this output map, it is possible to observe the concentration of oil and gas activities in different regions in Colorado and determine the county with the most active wells and affected the most by the SB 19-181.



The second output map, shown in the next figure, was created using the Buffer tool from the Analysis toolbox and it represents the two different aerial extents from homes and schools in Weld County. The 500 ft buffer in pink represents the aerial extent that was previously implemented before the bill was passed in 2019 for oil and gas operations and it had a setback impact area of 2,417,695.71 acres.

The potential 2000 ft buffer in blue represents the new aerial extent discussed by the SB 19-181 for oil and gas activities and it has a setback impact area of 38,683,131.36 acres. The setback impact area difference between the 500 ft and 2000 ft equals to 36,265,435.65 acres, which shows that the 2000 ft aerial extent would significantly impact a greater region and it crucially affected oil and gas activities even in Weld County, compared to the lower setback impact area from the 500 ft aerial extent. Therefore, determining the setback impact areas for both buffer distances meet the second objective to map the setback impact areal extent for 500 ft and 2000 ft since these distances represent the minimum and proposed maximum setback distances. New facilities designs have made a significant difference for operational plans and a path for drilling new wells.



If this was going to be the new reality, even in Colorado's most productive county, the future of the oil and natural gas industry in the state was in serious difficulty. However, there was a path forward. The COGCC set four major ways oil and gas companies can win approval from the commissioners to drill within 2,000 feet but outside 500 feet. They are: getting informed consent of people living closer than 2,000 feet; placing compressors, tanks that collect oil and gas, and other surface equipment outside the setback distance; being part of a larger comprehensive area plan approved by the COGCC; or if companies can show they're taking protective measure that would be as effective as the setback.

Negotiating consent for a well project from property owners and residents within 2,000 feet is likely to become a significant requirement for many companies to win exemptions, and it may be what keeps a lot of oil and gas acreage in Colorado viable to develop.

This set the stage for the new approach that several oil and natural gas producers had to take in order permit future well locations. Some operators, like Extraction Resources (now part of Civitas Resources), Anadarko Petroleum (now part of Occidental Petroleum) and Noble Energy (now part of

Chevron) had already started to think about a new relationship with the state regulators and local communities as was described in an earlier section of our paper.

The Current View of Regulation and Its Impacts on O&G Development in Colorado

For this study, we implemented ethnographic interviews and qualitative analysis to justify the data that will be represented in the following section. Interviews were conducted with a variety of stakeholders working with Colorado oil and gas (O&G) operations and development. There was participation from operators, trade groups, elected officials, and regulatory agencies that are connected to Colorado O&G. The reason to have a variety of participants is to incorporate as many sides of oil and gas development from those who participate in the day-to-day operations of O&G. These participants accepted an invitation to participate in the study to give their experience with the implementation of new regulations and its impact on O&G operations. The approach to interviewing different stakeholders is to prevent the over-misrepresentation of actors in O&G and to get the viewpoints from the multiple relevant stakeholders. We also chose to do interviews to provide a better in situ understanding of how the regulation impacted operations and what is being done currently to handle them, instead of waiting for a peer review literature about the new forms of O&G operation and management. This study dove into understanding how the regulatory regime for O&G is layered and what O&G as an industry is doing.

We also chose to keep the participants confidential due to the public perception of trust and to receive honest responses to interview questions along with providing legal protection. To validate the data, this study used qualitative analysis of interviews and stakeholder engagement to better grasp the opinions and experiences of those involved. This analysis allowed us to identify patterns to express the procedural environment of operations and regulation of O&G. After these patterns were identified, they were triangulated with peer review data and public sessions that involved a majority of relevant stakeholders connected to the industry. This study also evaluated the expressed body language and attitudes towards certain topics to prevent potential biases in the final report. The data from the engaged stakeholder groups were compared to other relevant stakeholders to understand where there is similarities and difference in the view of new O&G regulation and operations.

There is a long history of O&G in the DJ Basin of Colorado that dates to 1970s with the Wattenberg Field discovery, which has positioned communities and companies in the unavoidable overlap of operations and communication (McKenzie et al. 2016). For the purpose of this study, we concentrated on the policy and operational development of O&G since 2012, with emphasis on regulatory changes dating from 2019, and the current activity in the Denver Julesburg Basin. The reason is that in Colorado, there was a possible collision of interests of industry and communities due to the "mini-boom" in O&G development stemming from hydraulic fracking and the growing population that led to a decrease in public support around the 2013 time period and an increase in notification requirements (Turkewitz 2018 & MacKenzie 2016). By 2013, the Front Range communities were pushing for more local control and enacting local bans of operations on O&G development to address perceived distributive injustice and differing vulnerabilities (Turkewitz 2018 & McKenzie).

During the 2019 period was the passage of SB-181 had a big difference on the permitting process for O&G that emphasized public health, safety, and welfare over a two period of restructuring the state O&G regulations being implemented in 2022 (Jaffe 2022).

After the O&G industry was identified by regulatory agencies that traditional business practices were going to be placed under more strict regulatory review, operators had to take new forms of a proactive approach to community and local government engagement. Some operators had already recognized the value in proactive public engagement but many had not. At first, there were simple additions to operations to meet the needs of engagement such as being required to send notifications of operations and making yourself available to answer questions and concerns, to now making yourself as an operator a resource to those affected by operations. While these additions of engagement were required by the Governor's Task Force, operators started to realize that "going above and beyond" with community engagement can build or rebuild trust with O&G operations and reduce regulatory risks. Regression models produced by Mayer and Malin (2018) demonstrated that trust in O&G is a key variable for local acceptance, making it a key factor in Colorado O&G development.

Due to the increased need for developing relationships in the areas of operations, O&G operators have increased stakeholder engagement by participating in proactive and continued communication with relevant stakeholders, which can lead to positive unintended outcomes for operators, communities, and O&G regulators. Through interviews, examples were given to show how making accommodations to O&G operations can help gain acceptance into the community by addressing the community's safety concerns before an event happened. These accommodations were not major changes in many cases either, simple changes in the truck scheduling to have different times the then local school bus system or agreeing to do active operations during a specified time that was approved by the local community. This leads to future acceptance of increased operations of a particular community, even when it differs from the original agreement. To do this the operators still asked and notified all those involved but it created more time for active operations. A reason for increased outreach of O&G operations is that there are a large number of actors who are directly or indirectly impacted by oil and gas so it's important to know how to communicate and address relevant stakeholders for distributive justice.

A common theme among participant groups is that between communities, industry, and regulators there have been issues in communication. For the communities, there was a lack of communication on the process of O&G operations and regulators that led to the rise of local concerns and ultimately local O&G governing bodies. During the early stages of O&G development in 2012, there was a "knowledge gap" in the communities about who the regulators are and what safeguards are already in place as industry practice. To address the "knowledge gap" O&G local governments, trade groups, and operators offer educational resources about operations through public forms of engagement and online resources. Providing the resources to communities to be educated and aware of operations has led to reasonable discussions about the concerns of O&G by removing the "surprises" of operations. The purpose of getting rid of the unknown of O&G safety and operations is that people are more likely to engage and collaborate with operators before they are upset that operations are taking place near them. A reason why O&G is taking a more proactive and continued approach to communication with relevant stakeholders is based on the issue of public trust with O&G operators it has been a challenge to build trust in their own reporting due to the history and personal ties to the O&G industry. Malin et al. (2019) suggests to use risk communicators, regulators, and activists would be better to address public perception of O&G development to prevent biases and prejudices toward reported data.

When addressing this issue with operators, it was conveyed that it would be a benefit to report to show the positive improvements that have come about in the new forms of engagement and

regulation. The supply of educational materials and increased interaction with communities gives the power to refute development plans that appeal to the operators or regulators. This seems to concurrently increase distributive and procedural (or participatory) justice in Colorado O&G operations.

For the industry, there is not a standard communication protocol on what is expected of them from the regulators, which is leading to some uncertainty in permitting applications. Through the interviews, data alluded that there is a need for more internal and external communication, early and often, between O&G operations with the regulators and those establishing policies. The reason being is that those who make the policies do not have a full idea of what the policies will do to operations or choice of deployed technologies, so industry and regulators have different timelines of operational changes. When this happens, it builds friction between industry and regulation because it puts pressure on the industry to figure out how to navigate through the "uncharted territory" of newly adopted regulation. What seems to be needed is a straightforward list of what it means to be compliant but there is not a fully established process of obtaining permits and reporting, making it complicated for the operators. Planning and permitting is still a "work-in-progress" since the 2019 law. The complexity of the permitting and regulation side is taking time away from operator staff that could be addressing other topics or issues.

There seems to be a divide in the Colorado O&G industry between firms that "go above and beyond to stay ahead of evolving regulations" and other that seems to have a "do as we're told" compliance attitude when it comes to implementing the new regulation and reporting but the requirements to do so are being viewed as a "moving target" making their efforts to meet requirements somewhat redundant. This is decreasing the consistency and the certainty of "hitting the mark of approval" for operations and the roles of the operators. There is also the issue of subjective views when reviewers evaluate permit applications. To one reviewer the permit format and information are sufficient and to another reviewer, it could not be sufficient. More staff are coming onboard for the State and the hope is that training may make this more consistent in the future. Making operators believe they have done what is expected of them but find out their submission was insufficient regardless of a similar submission approval. This has led to operators just wanting to know what is required of them to reduce back and forth between operators and regulators to get the approval of operations. Operators are looking for consistency and certainty of what is required for them to better plan their own business strategies.

Due to the regulatory changes, all relevant stakeholders had to learn how to conduct operations which led to an "ugly duckling period" and took almost a year to hit the "stride" on regulatory reviews and requirements (Jaffe 2022). Even for those operators that have a good understanding of the flowline of permitting still do not have smooth sailing to the approval of operations. It has been speculated that the regulatory agencies did not realize that the amount of data and reporting that was required to be submitted from O&G operators was going to be so immense. Currently, the regulatory agencies have a "backlog" of permits that need to be approved or reviewed. This has led to inconsistency and a more strenuous process in forecasting permit submissions of future operations. This is creating friction between operators and regulators in the sense that if operators need to be held to a certain standard to show responsible O&G development, the regulatory systems should be held to the same standard as the industry of timely responses and reporting.

The process of operating in Colorado is going to be more complicated and will continue to take longer

as more permits are required to drill, produce, vent, etc. as time goes on. At least until all laws and rulemakings are codified and there is a clear process flow for acquiring permits for O&G operations.

A finding of Mayer and Malin (2018) found that Coloradans preferred a multi-layered regulatory governance regime that also allowed for local autonomy to regulate oil and gas production. This is not too far off from what our research data has shown through ethnographic interviews and O&G site visits, both in office and field locations for Q&A about their operations and roles. As pointed out by a respondent, the new regulatory approach at multiple levels increases the time to get to operational decisions and budget commitments because the differing levels of regulatory regimes move at different speeds of data processing. Currently, regulatory organizations are attempting to increase best practices for O&G by implementing new technologies and monitoring systems, but right now it is more important that the regulatory agencies have a way to process the extra data and permits that are submitted in order to keep the same pace as those required to follow the new regulations.

As an industry, it seems information and opportunities for communities to learn, ask questions, and provide feedback about ongoing or future operations are increasing in Colorado. Many operators have always appreciated such feedback but the process was not uniform. The earlier this engagement starts, even in the planning phase, the better. A positive outcome from operators making themselves a resource is that it gets "rid of the middleman" and can reduce regulatory risk. What this means is that when someone or an institution has a concern about oil and gas operations, there is a team that is dedicated to answering the questions or concerns which can lead to faster response to those concerned. This is helpful in reducing the number of complaints that the regulatory agencies might receive and also take some of the burdens of having to address those complaints, freeing up time to do other tasks. Operators expressed enthusiasm when this topic of direct contact was brought up suggesting that it was welcomed because it reduces the number of overall complaints and prevents pushback from the local communities. Some operators go as far as to meet with community members in their homes one-on-one because operators believe people feel better about their individual concerns. The Colorado O&G operators are willing to be "knocking on the doors" of relevant stakeholders to go above and beyond what is expected.

Beyond public engagement, there is the need for an online presence due to increasing importance of social media, the push for transparency, and the reduction of participation at community meetings, pushing O&G more into the digital world. Having an online presence helps show transparency and provides resources to those not directly involved with operations of the policy process and operational progress. The online presence also gives more voice to the public to take part in oil and gas regulation through comments and feedback opportunities publicly. Industry, regulation, and communities all agreed on the need of an online presence but also the online resources need to be accessible and understandable for everyday citizens. Understandability is brought up because it impacts both the industry and citizens due to the complexity of O&G development processes and the specific technical language that is common between experts and operators. Another reason that the online presence is needed for communities is due to the complexity of "overlapping" responsibilities and jurisdictions. The online information can lead community members to their point of contact to address their own concerns about O&G development to get improved response times or local help.

This was the main reason for the need for local government regulators. Many times, community members felt that when they filed complaints with the state the response time was slow, or insufficient, or the complainant was not notified of the solution taken by the regulating agency. This influenced the

importance and benefits of having a local government body to help send concerns up the "chain" of regulatory process.

It is important to be aware that counties have differing opinions on oil and gas operations which is causing deep divisions regarding regulatory requirements (Malin et al. 2019). First of all, it needs to be acknowledged that there's a spectrum of opinions, from public support and acceptance to complete opposition O&G activities, to those who simply want to just learn about O&G operations. One reason for the difference in opinion can be related to the history that the county or the personal experiences of those who live in the county of operations. An influence that has the strongest and most consistent influence on the attitudes and policy preference for O&G of local governments is the political identity of the community (Mayer and Malin 2018 & Malin et al. 2019). The political identity of the local communities plays a large role in the acceptance of O&G development. In the context of Colorado O&G, there are drastic differences in identities and political views between the counties that are driving policies around O&G development (Malin et al 2019). Throughout the interviews, it was noted that the "political flip flop" impacts the perceptions and regulatory regimes of O&G. This has led to a decrease in consistency of understanding the community opinions and has led to uncertainty for investors. The reason that is affecting investors is that there is the concern that the money invested will actually come to fruition due the ever-changing state of regulations. It also creates more complications for those who operate in Colorado and outside of Colorado due to the more progressive nature of O&G regulation in the state of Colorado by having to operate under different requirements. Capital investment in the O&G industry for long-lived assets require a degree of consistent political and economic environment otherwise risks of failure to achieve investment returns are elevated.

Additionally, different revenue streams influence the acceptance of O&G development. Counties that don't need the revenue from oil and gas operations are the most vocal about restricting operations or improving upon the current practices of the industry, such as Boulder County. Those who don't have a sufficient revenue stream to fund public services are welcoming to oil and gas operations largely due to the positive economic impact from industry taxes and permit fees as well as industry support for local organizations. There are also counties that are working with oil and gas that are allowing them to operate as long as they (operators) are participating in the best practices and uphold community engagement, such as Commerce and Adams Counties. For this study, we were not able to get large enough participation to discuss the individual county concerns and acceptance of O&G development but for future research, it would be pertinent to understand the weight that each of the counties holds in the regulation and adoption of O&G policies to better predict future operations and investments.

In Colorado, the community voice and local community governments hold an important seat at the table in O&G regulation and site approval. What sets Colorado apart from other states is that local communities have the power to prevent O&G development through SB 181, have a multitude of online resources, and are given opportunities to participate in Colorado's O&G development planning and regulation.

It was mentioned by interviewers that public participation is on a downward trend, this could be indicative of the application of best practices or the rules and regulations meeting the needs of external actors, but without further research, it cannot be concluded. With oil and gas having large supporters and large disclaimers it is important to realize that there are those who chose to complain but are not willing to engage with industry, because they see it as a losing battle or simply don't want any

involvement with oil and gas. This is counterintuitive because O&G development is not going to stop, so communities, regulators, and industries should co-collaborate and take part in the right type of debate about what meets the needs of all parties.

All actors involved need to move past complaints and law suits and start to work together to develop sustainable solutions for O&G development. The O&G industry in Colorado is held to a higher standard in comparison to some other states. Leading to operators based in Colorado going above and beyond what is expected, not because it is required, but because it is the right thing to do. In order to do this, you must understand the actors involved and the only way that will happen is through continued engagement and communication of relevant stakeholders.

The critical stakeholders View: Balancing the Three leg stool

Obtaining a mineral lease for subsurface oil and gas exploration used to be the hard part. Now, for oil and gas operators it is only the beginning. The ability to produce fossil fuels in the DJ Basin and elsewhere has become a complex balancing act between state regulators and community interests. While the right to produce subsurface minerals is guaranteed in the state constitution, surface owners and even greater societal interests are getting a say in this changing landscape of engineering, economics, public health and safety and environmental voices.

But these voices are sometimes not singing the same song. Each has their own priorities and advocacies. Understanding this environment and navigating the various demands requires a serious commitment to patient listening, careful explaining and compromises in facilities designs and operational practices. After we have explored the issue of public engagement, let's explore the drivers behind each of these stakeholders before trying to balance the three-legged stool.

Regulators (Federal, State, County)

As we have stated, the rules changed for the Colorado Oil and Gas industry in early 2019 with the passing of Colorado sb19-181 bill. This was a very rapid and dramatic change in regulatory approach after the Democrats won all statewide elections in November 2018 and Jared Polis became governor. Several aspects of this bill fundamentally changed how future oil and gas drilling and production activities would be regulated by state and country authorities. https://cogcc.state.co.us/#/home

Prior to the 2019 change in state law, the COGCC's mandate had been to foster balanced oil and gas development. Senate bill 181 that year changed the agency's focus to protecting people and environment and gave local governments more of a say in where wells could be located and where

they were not. COGCC commissioners and agency staff have since overhauled state rules to prioritize reviewing well permit applications through the lens of protecting public health, wildlife and environment as much as they referee the efficient production of oil and natural gas.

Colorado's oil and natural gas industry is one of the state's largest taxpayers. It also adheres to a system that is unlike any other energy tax framework in the country, making state-to-state comparisons difficult, if not impossible. Colorado's oil and natural gas taxes are paid primarily through three mechanisms: the local ad valorem tax (assessed by each county and various local municipal taxing authorities), the state severance tax, and the state conservation mill levy. When you step back and also account for individual and corporate incomes taxes, the total fiscal flow to the state and local governments amounts to approximately $1 billion per year. From that $1 billion in tax revenue, approximately $600 million goes to public education, which includes both K-12 and higher education. https://www.coga.org/factsheets/colorado-taxes

Local governments are considering and imposing new regulations for the oil and gas industry as well. One of the industry's primary criticisms of SB-181 was that it would enable and even encourage a patchwork of local regulations across the state, something that lawmakers in Colorado had long attempted to avoid through preemptive state rules. As the opponents of SB-181 explained, neighboring localities might adopt very different—and perhaps inconsistent—regulations. Operating under this kind of jurisdiction-by-jurisdiction patchwork would be difficult and expensive, if not impossible, for producers.

These fears appear to be well-founded. The neighboring counties of Boulder and Weld are taking diametrically opposed regulatory approaches. Boulder commissioners are seeking the "toughest regulations [they] can get" and will likely adopt some of the most restrictive rules in the state. Its proposed rules would impose more stringent restrictions on oil and gas exploration and production, and will at the same time add additional restrictions on noise, vibration, odor, and seismic testing. In stark contrast, Weld County—home to nearly half of Colorado's active wells—rejected a permitting moratorium and has taken steps to facilitate, rather than restrict, new oil and gas development. For example, local officials designated unincorporated portions of the county as "mineral resource areas of state interest," prompting an agreement with the COGCC to address the backlog of permits affecting oil and gas development in the county. https://www.gibsondunn.com/colorados-sweeping-oil-and-gas-law-one- year-later/

But while it may be more difficult to get a drilling permit in many locations, drilling hasn't come to a complete stop. Under the new rules, the COGCC has approved several company projects to drill a number of wells in several areas around the state. The COGCC has so far approved at least four projects that required exemptions to the new 2,000-foot buffer between drilling locations and residential buildings. In addition to these new projects, the oil and gas industry has an inventory of about 2,600 permitted locations that were authorized before the recent change in regulations.

Though the industry is not dead in Colorado, activity measured in drilling activity to production is on the decline, not due to geology, demand or economics but due to environmental policy and local community interests.

Environmental NGOs

Another voice around the table, an often a very well organized and vocal one, is the environmental

NGO community. A non-governmental organization, or an NGO, is an organization that is non-profit, is made up of civil society, and functions apart from governmental or intergovernmental organizations or agencies. Although civil society organizations have always been around, NGOs officially came into existence in 1945 with the need of the United Nations to mark a difference between intergovernmental organizations and international private organizations. NGOs can be organized at a variety of levels for a variety of purposes. They can work at the community level, the city level, the country level, and even the international level. Not every NGO is the same, or has the same priorities or the same resources. Some, like EDF are very science and data driven, others are more legal activists that work in the policy space, sometimes in the courts. A few of the environmental NGO active in Colorado include (in their own words from websites):

Environmental Defense Fund began in 1967, as a group of scientists and a lawyer on Long Island, New York, fighting to save osprey from the toxic pesticide DDT. Using scientific evidence, their founders got DDT banned nationwide. Today, EDF is one of the world's leading environmental organizations. In the U.S., Fortune magazine called the EDF board one of the country's most influential nonprofit boards. EDF has been very involved in state and federal greenhouse gas policies, in basin-wide studies to monitor methane emissions and have invested in a high-resolution satellite to add to the top-down monitoring capabilities available to the public.

Rocky Mountain Institute: In 1982, Rocky Mountain Institute was founded as a 501(c)3 nonprofit aiming to radically improve America's energy practices. RMI's data-led focus on efficiency, whole systems analysis, and levering business to drive change has since extended their influence globally, transforming businesses, revolutionizing energy systems, and improving national economies along the way. In recent years, the rise of the climate crisis and the need to transition global energy systems away from fossil fuels has amplified the need for and impact of RMI's mission, to help usher the world toward a clean, prosperous, and secure low-carbon future for all. A spin-off of RMI is the MiQ third party verification methodology that is being used by some O&G operators.

Colorado Rising is a statewide 501(c)4 non-profit organization that works to protect Colorado's health, safety, wildlife, environment, and the future of the climate from the impacts of oil & gas development. The organization was founded in September, 2016, to focus on litigation, state agency rulemaking, administrative processes, and public education concern over several explosions, spills, leaks, and other catastrophic oil and gas accidents in Colorado, compounded by years of political inaction and the failure of state agencies to address health and safety issues drew widespread support for the effort.

350 Colorado is a grassroots movement working to build a fossil-free future powered by 100% renewable energy, and empower communities across Colorado to join to fight for environmental justice. Through their volunteer-led teams, they use a variety of tactics, such as legislation and direct action, to take on the climate crisis.

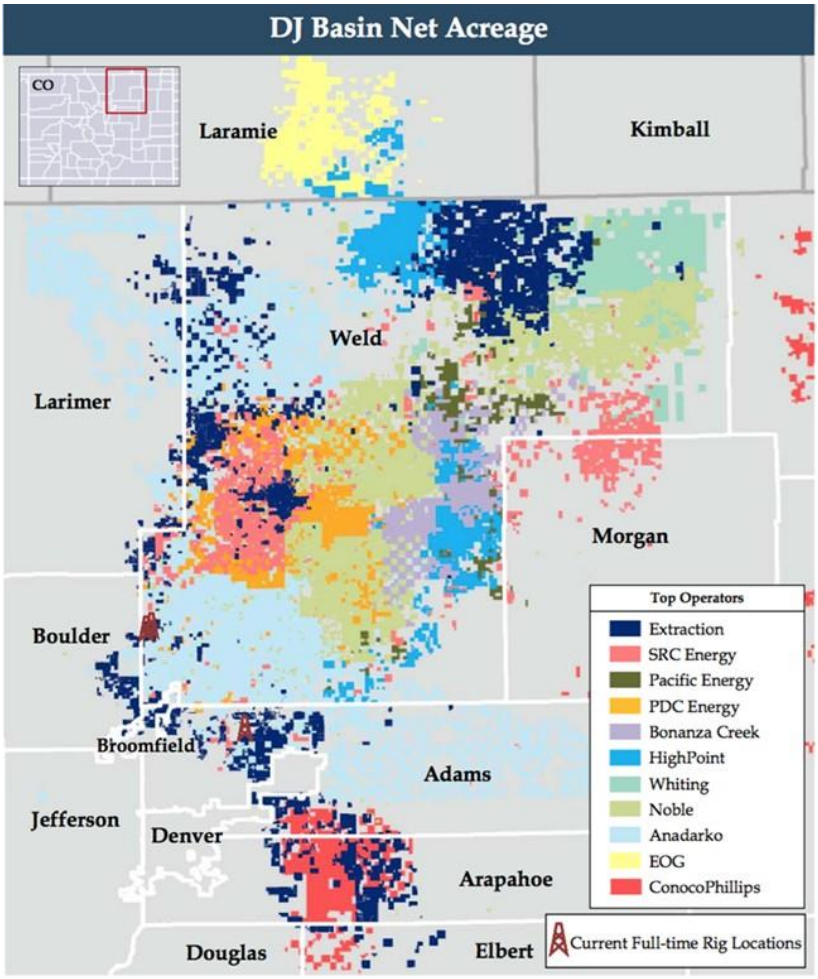
Other NGOs active in the state include Wild Earth Guardians, Sierra Club, Western Resource Advocates, and the Natural Resources Defense Council.

Communities (A tale of Six Counties)

If you just talk to representative of the oil and gas industry, you get a cautiously optimistic perspective about being able to work under the new regulations and charter of the COGCC. The next section

details several case histories of the new process of engagement with public community, county and state agencies. But to be objective we must give some space to the voices in the community who are opposed to new and existing oil and gas developments due to concerns over safety, nuisance or even climate change.

These voices are heard at just about every public engagement. Whether they come from single individuals, local community groups, or from larger state and national environmental organizations, there clearly is loud and growing pushback by some to the O&G industry in Colorado. There are also some community voices in favor of oil and gas development citing tax revenue, employment and public service contributions. One key difference between rural and suburban/urban communities is the issue of subsurface rights which bring royalties to the subsurface owners (usually rural farmers and ranchers) but rarely to subdivision home owners. But these public meetings are usually rather confrontational and represent grass roots democracy at its best and its worst.



The strength of the anti-fossil fuel voices is not evenly distributed. In some counties, like Boulder County, the environmental perspective is strongest and has been able to effectively shut down new oil and gas permitting and production, while the general majority in Weld County is in favor. Weld County even set up their own oil and gas commission to advocate for these rights against state interests. Counties caught in the middle, like Adams, Larimer, Arapahoe (Aurora) and Broomfield are trying to

balance the voice and rights on growing residential and commercial interests with oil and gas operations. Here is where the story gets most interesting.

The community has a voice and finding common ground

New regulations or not, the community surrounding the oil and gas production facilities have a say in what is going on. Even if they are the new parties to the conversation and don't know a lot about the impact of O&G operations. Especially in a state like Colorado that has a very wide-open process for public participation, an operator can no longer just rely on its mineral rights to force surface occupation. They can't just take their development plans to court and expect to win. They have to sit down with the community to educate, to listen and to build trust.

That may be a challenge to a technical engineer to think about their message with more easily understood explanations and examples. Best practice for operators in the new generation may require media training and more staff dedicated to work consistently with both regulatory committees and with public engagements. The HES (health, environment and safety) staff are a key part of the operations team, not a back-office function just doing the paperwork to get the permits necessary to start construction. O&G operators won't win every over but they have to listen to every voice.

Often at these public hearings an oil and gas operator will hear the following: "I just moved into this neighborhood from out of state. I have invested $500,000 for a home for my children and a place to build a family. Now I find out, just across the fence line, there is going to be an oil and gas production facility. My real estate agent didn't tell me that. The property developer didn't tell me that. I am not so sure I want oil and gas to be my neighbor. Aren't those fracking operations dangerous? They have a point and a vote. How does the operator respond to that voice?

But there may be some unexpected open space opportunity from oil and gas operations. That new property owner wouldn't think twice if someone told them that a new Amazon warehouse was going to be built on the vacant property next to their subdivision. They probably wouldn't complain too loudly if there was a shopping center going in on that lot or a new freeway exit to E470 or I25 so why the different perspective for an oil and gas development? The oil and gas industry are fighting against a pre-conceived notion of being dirty and dangerous. But the reality may be different for the next generation production facility.

The new production facility may even preserve more open space for nature than the shopping mall and retail warehouse or more residential and apartment development. A new facility with some effort can camouflage and minimize their footprint for the well heads, separators and the rest of the production facility. Compare the truck traffic (after drilling and completions stages) of the production facility where all products and carries away by pipeline to the truck traffic into and out of the Amazon warehouse. Now that the public understands what is really being planned, which would they prefer?

The new comprehensive area plan may even contain land swaps for parks and trails. The operator often "volunteers" to identify and reclaim existing abandoned wells and facilities to help complement the efforts of cash-strapped state agencies.

Of course, there are always those individuals and groups that will settle for nothing less than no oil field development at all ("keep-it-in-the-ground"). There are voices that are authentic, passionate with strong opinions (even if some of them have wrong ideas of what is really going on inside the sound

wall at the drilling site). Conversations with this part of the community will always be difficult and often frustrating for both sides. It is not a test of wills, but each side has to try to understand the other even if they are not going to find common ground. One operator has even renamed their public relations department to "client services" elevating their community relationships to that of their traditional midstream buyers of the crude oil and natural gas.

Operators: A tale of Three Permits

A report commissioned by an oil and gas group in 2019 found that the industry contributed nearly $1 billion in tax revenue to Colorado. The report, conducted by the Global Energy Management Program at the University of Colorado Denver and paid for by the Colorado Oil & Gas Association (COGA), found the industry accounted for 89,000 direct and indirect jobs and makes up $13.5 billion of Colorado's gross domestic product (GDP). The report said $234.7 million in income taxes and more than $457 million in property taxes contributed to $993.3 million in tax revenue from the industry, which funds local and state government programs in education and infrastructure, among others.

https://www.thecentersquare.com/colorado/colorado-s-oil-and-gas-industry-contributes-1-billion-in- taxes-13-5-billion-to/article_ddc40b5a-4fea-11e9-a857-6ffc277017d7.html

A more recent economic study suggests that the employment on the oil and gas industry suffered more than any other sector, other than construction, during the pandemic in Colorado. Colorado's oil and gas industry lost 9,000 jobs since the Covid-19 pandemic began, according to the University of Colorado Boulder's CU Business Outlook released in December, and the industry is expected to add back only 600 jobs in 2022. This is one area of Colorado's economy, along with mining, that has not recovered to pre-pandemic levels.

The Oil & Gas commission has recently approved 17 development plans targeting 231 wells. Ten of the plans were in Weld County, three were in the Western Slope oil fields of Garfield and Rio Blanco counties, and one each in Adams, Arapahoe, Washington and Las Animas counties. Through the first week of June, 2022, the commission had approved 417 drilling permits for new wells — each approval is good for three years. In 2021, 894 permits were approved and in 2018, during the height of the state's drilling boom, 5,116 were awarded. Permitting activity is starting to recover both from better economic conditions (higher prices) and better understanding of new permitting requirements.

A short summary of three recent permit applications by leading DJ Basin operators provides some context for what it takes to operate in the basin today. While it previously took about 90 days to acquire a permit prior to 2019, it reached nearly 18 months or more of preparation and research to prepare an application with extensive engagement with the public and regulators in 2020 but is recovering to an average of about six months from submission to Hearing. Often permit applications run into the hundreds of pages and are still criticized for not better evaluating alternative development options. New permits in both rural and suburban areas takes a new mindset towards environmental stewardship, community outreach as well as an automated and efficient production schemes with a smaller surface footprint. It isn't not only about producing oil and natural gas from the Niobrara reservoir anymore. It is about getting along with your neighbors who are not familiar or vested in oil and gas operations.

- **Civitas Resources, Inc. (formerly Extraction Oil and Gas) Broomfield**

This story starts with a lawsuit. In 2015, the then leaseholder (Noble Energy) sued the City and County of Broomfield over a plan to vacate ten production locations and develop a production pad at the Livingston site to produce oil and natural gas under their lease. Noble Energy also wanted $500,000 from Broomfield as it was thought the horizontal wells would cost more than the abandoned vertical wells.

During this period, leasehold consolidation plans among several operators led to a series of swaps and buyouts so that operators had on average, a larger, more concentrated position to take advantage of longer horizontal lateral wells. Extraction Oil and Gas came into possession of the Broomfield lease and they began negotiating with Broomfield for a MOU (memorandum of understanding) to begin development.

During this period, Extraction was negotiating with the Broomfield authorities and the state for a new comprehensive drilling and production plan. These negotiations took from 2016 to 2018 but ended finally with the state approving the 94 well drilling plan and a new service operating agreement was agreed to with Broomfield, and development began.

These development sites are just south of E470. A protective berm of top soil pretty much conceals the sites from most public view. New operations are behind sound walls, bales of hay and other sound reducing solutions. Local asset management teams employed automation and air quality monitoring solutions for each site. The emissions from these sites are so low they fall below the threshold for air quality permits. As in the case of the Chevron Mustang operations (discussed below), Civitas has committed to proactively abandon and reclaim orphan wells on the property. Their current abandonment program reclaims from 100 to 150 wells per year. All of these negotiations came before the CO sr19-181 law.

Extraction filed for Chapter 11 bankruptcy in June 2020, making it the second largest U.S. shale producer at the time to declare bankruptcy in the 2019-2020 downturn. Based in Denver, the company is primarily focused in the Wattenberg Field in Colorado's Denver-Julesburg Basin. The company emerged from bankruptcy on Jan. 20, 2021 with a new E&P business and governance model led by a new executive team.

Civitas Resources (built on assets of formerly Bonanza Creek Energy, Extraction Oil and Gas, and Crestone Peak) was created through the merger of three independent Colorado exploration and production companies on November 1, 2021. Civitas Resources, Inc. is Colorado's first carbon-neutral oil and gas producer and is focused on developing and producing crude oil, natural gas and natural gas liquids in Colorado's Denver-Julesburg Basin. The company is committed to pursuing compelling economic returns and cash flow while delivering best-in-class cost leadership and capital efficiency. The company has taken the step to assume fiduciary responsibility for emissions by committing to buy offsets to balance against any greenhouse gas emissions from their operations. The company is currently drilling and building out their production plans in the Broomfield MOU and continue to advocate for low emissions infrastructure and proactive community engagement.

- **Kerr McGee McGavin permit near Firestone (part of the Long's Peak development plan)**

Not every plan works the way you intend. An application by Kerr McGee to drill 26 wells within 2,000 feet of homes in Firestone was rejected by Colorado regulators in early 2022. It was the first major test of the state's target that oil and gas drilling be set back at least 2,000 feet from homes and schools. Both supporters and opponents of Kerr-McGee's plan agreed during public testimony that the decision would be precedent setting. The site, called the McGavin location, is part of Kerr-McGee's Longs Peak comprehensive area plan. The proposed pad is next to a wetland, the Saddleback Golf Course and the Firestone Trail.

A long row of newly-built homes in the Falcon Point at Saddleback subdivision line a large empty field in Firestone, Colorado. (Kathryn Scott, Special to The Colorado Sun)

The Colorado Oil and Gas Conservation Commission turned down the Kerr-McGee application to drill wells on two pads in Firestone saying that the company had not shown its plan was protective enough or that there had been an adequate evaluation of alternate sites. The vote was 4-1, with Bill Gonzalez, who is a former oil industry executive, casting the lone vote in support.

In an advisory letter to the COGCC, the Colorado Department of Public Health and Environment had outlined 13 actions which it said should be conditions of approval, adding "if Kerr-McGee is unable to implement CDPHE's recommendations, then CDPHE recommends that COGCC deny the McGavin location." Among them was a call to use quieter, less polluting drill rigs, drilling muds free of volatile chemicals and the use of pipelines to transport water off site to cut down on pollution from tanks and truck traffic. CDPHE had also asked Kerr-McGee to provide a site and electricity so its Colorado Air Monitoring Mobile Laboratory could monitor the McGavin site.

After initially rejecting this request, Kerr- McGee has offered to pay for the operation for the mobile lab if CDPHE found a suitable monitoring location in the neighborhood. However, the story on this permit is quite over yet. Kerr-McGee (Occidental), announced concessions during a recent Colorado Oil and Gas Conservation Commission hearing. The company wants to drill 26 wells near 87 homes inside the state mandated buffer, with the closest residence 763 feet away. Kerr-McGee reversed course and agreed to use an electric rig and non- polluting drilling muds and to pipe waste water off site in a bid to drill oil and gas wells in a Firestone neighborhood.

The Kerr-McGee application includes a second Firestone site, Columbine, where the company wants to drill seven wells within 2,000 feet of seven homes. The biggest concern of commissioners with the Columbine site is that another 40 homes are slated to be constructed in the buffer area. https://coloradosun.com/2022/02/17/firestone-oil-gas-mcgavin-kerr-mcgee-2000-foot-setback/

- **Chevron's Mustang CDP near Greeley**

Chevron's Mustang comprehensive drilling plan (CDP) is the first ever CDP approved by the Colorado Oil and Gas Conservation Commission. It is a blueprint for lower-carbon energy development that supports the goal to minimize the surface footprint in and around communities. Again, these negotiations came before the CO sr19-181 law and are in rural Weld County. The CDP involves:

- 64,000 acres of farmland southeast of Greeley, Colorado in Weld County, encompassing rural lands with no municipalities within the boundaries – enabling us to combine facility locations with innovative processes and technology to reduce their surface footprint and greenhouse gas emissions
- More than 400 drill sites were approved in a six-year - instead of two-year - drilling program that provides the operator with the flexibility to develop long-term plans that enable them to work a schedule around seasonal crops and wildlife patterns
- Plugging and reclaiming more than 1,400 older vertical wells and related production facilities, then reclaiming the land for other uses such as farming.

Chevron has posted many of their experiences with new facilities and operations designs on their website. For more information these articles describe this operator's approach.

https://colorado.chevron.com/environment/using-electricity

https://colorado.chevron.com/environment/tankless-

facilities https://colorado.chevron.com/our

business/operations-control

Many of our final conclusions and recommendations come from the experiences of these three major DJ Basin operators.

A New Pattern emerges

Colorado's top oil regulating agencies have established standards that are among the toughest in the United States. But oil and gas producers are adjusting to the changes and a new wave of projects are being proposed. Oil companies have sorted out how to make projects meet the higher standards and navigate the permitting process, but that adjustment has slowed oil development over the past several years. Only five new drilling permits won approval in 2021, a year already made difficult by lower commodity prices and supply chain shortages. What the industry seeks now is more certainty and stability.

Analysts have been watching how companies navigate Colorado's tight drilling regulations. The stock price of Colorado operators has tended to trade at a discount because of Colorado's reputation as difficult for oil and gas projects despite an improving dialogue between COGCC, CDPHE, community groups and industry.

Here are three examples of recent large project plans in rural Weld Co. that show oil and gas development can adequately protect environment, regulator says. These permits are the largest activity approved since 2021 state reforms.

- **Bayswater** announced the COGCC approval of the **Ruby 7-J Oil and Gas Development Plan (OGDP)**. Bayswater expects to start construction on its 32-well project, located outside the town of Ault. The project will use pipelines to carry crude oil and natural gas offsite. During the hearing, the COGCC praised many of Bayswater's Best Management Practices (BMPs), including their efforts to reduce surface footprint by limiting well pads and storage tanks and mitigate emissions via vapor capture and compression technology. This OGDP approval marks the second permit approved in the Denver-Julesberg (DJ) Basin for Bayswater under the COGCC's new regulatory framework.
- **Responsible Gas role in Utility Supply chain**: **Bayswater** earlier this year began working with energy-tech company **Project Canary**, based in Denver, which does real-time, continuous air emissions monitoring of methane. The two companies are part of a "landmark pilot project" working with **Colorado Springs Utilities**, **Colorado Interstate Gas Co**. (a subsidiary of Kinder Morgan, Inc.) and **Rimrock Energy Partners, LLC**. Project Canary provides certification of "responsibly sourced gas." The pilot works like this: "Bayswater drills for natural gas, which is processed by Rimrock Energy Partners, then delivered to Kinder Morgan, which finally transports the gas to Colorado Springs Utilities. Project Canary has a network of solar-powered air quality monitoring units spread throughout the Colorado Springs project. These units provide real-time data captured and stored on the 'Canary Cloud".
- **PDC Energy Inc**. has secured approval for its **Kenosha Oil and Gas Development Plan (OGDP)** in rural Weld County, CO. The OGDP entails 69 wells on three pads. PDC committed to use pipelines to carry away crude oil and natural gas, conduct air emissions monitoring and take other steps to minimize potential impacts from its project covering 3,370 acres. The project generated no formal petitions of opposition, and no one argued against its

approval in a June, 2022 hearing. Two dozen out of 29 surrounding property owners signed letters approving the project. The approval by the Colorado Oil and Gas Commission "marks an important next step as PDC further increases its permitted inventory by another rig year and solidifies drilling and completion activity well into 2024," according to the Denver-based independent. PDC expects to soon have more than 550 permits and drilled-but-uncompleted (DUC) wells. In a recent update, PDC said it expects capital investments to total $950 million to $1 billion in 2022, up from a previous forecast of $900 million to $1 billion. The firm expects $775-825 million of that total to go toward the Wattenberg field in Colorado's Denver-Julesburg (DJ)-Niobrara Basin. https://www.naturalgasintel.com/pdc-gains-ok-to-expand-colorado-oil-natural-gas-drilling- program/

New development proposals to watch

There are three pending comprehensive area plan application that have been submitted since the 2019 law that will further test the COGCC's process of applying its 18-month-old higher standards to projects that coordinate the development of wells and facilities across hundreds or thousands of acres. The first one has already been approved.

1) **Kerr McGee's Bronco CAP**: On August 10, 2022, the COGCC approved the first Comprehensive Area Plan (CAP) under the Mission Change Rules for Kerr-McGee Oil & Gas Onshore LP in Weld County. Under COGCC Rule 314, the approved "Bronco" CAP grants Kerr-McGee the exclusive right to develop within the CAP's geographic boundaries, among other incentives, for a period of six years from the date of approval and implements best management practices to address cumulative impacts. The Bronco CAP plans to develop as many as 209 wells in a rural part of Weld County away from homes. Houston-based Occidental Petroleum envisions gathering oil and gas from beneath 39 square miles of a single Well County ranch, off Interstate 76 northwest of Roggen. The development involves developing wells on a ranch owned by one surface property owner. The work plan wouldn't put a well within a mile of any homes, the company said. "The location of the Bronco (plan) allows KMOG to avoid people as a whole and therefore (it) does not expect adverse impacts to public welfare," read the company's application. The proposed development encompasses approximately 24,331.75 mineral acres in unincorporated Weld County with 11 conceptual locations. The permit was submitted in April, 2022.

2) **PDC Energy's Guanella CAP**, also in Weld County, On August 2, PDC passed a major milestone in the permitting process by receiving the Completeness Determination on its Guanella CAP from the Colorado Oil & Gas Conservation Commission ("COGCC"). The Guanella CAP covers approximately 35,000 consolidated net acres in rural Weld County with approximately 450 well locations accessed by only 22 surface locations. With the Completeness Determination passed, PDC now enters the technical review phase and 60-day public comment period. In June 2022, PDC was granted unanimous approval for a 69-well Oil and Gas Development Plan ("OGDP") and a 30-well OGDP, the Company's second and third approval under the new permitting process. Combined, these two approvals provided the Company 99 additional permits. Together, these approvals and the in progress Guanella CAP application, represent the Company's planned Wattenberg Field turn- in-line ("TIL") activity into 2028. Over the coming months, the Company expects to submit several additional OGDPs expanding its inventory of permitted locations to support the most efficient development of the core Wattenberg Field.

3) **Crestone Box Elder CAP** application and supporting materials were posted to the COGCC website on June 2, 2022. The proposed CAP development encompasses approximately 37,520 mineral acres with approximately 20 planned Oil and Gas Locations and an estimated 151 new horizontal wells, all within the City of Aurora. Crestone is a subsidiary of Civitas Resources. The Box Elder CAP covers an area of approximately 55 square miles located in mostly rural and currently undeveloped areas within the boundaries of the City of Aurora. The nearby unincorporated community of Watkins, just east of the CAP area, once was known as Box Elder, for the maple tree variety commonly found in

Colorado, which is the reason for the CAP name. Box Elder Creek flows through a portion of the area. Compared with traditional oil and gas development planning, the CAP process enables oil and gas operators to consolidate locations, eliminate redundancies, build fewer well pads and disturb less land area, while also taking future community development into account. Crestone's Box Elder CAP features the following footprint reductions, subject to change during the consideration process, compared with what is permitted by its existing Aurora operator agreement:

- Eliminates 16 planned well pad locations or expansions in the CAP boundary through consolidation
- Reduces disturbed acreage by 55 percent
- Eliminates the need for many miles of access road and pipelines
- Reduces emissions of volatile organic compounds (VOCs) by 44 percent
- Reduces water use for drilling and completions by 36 percent

Crestone uses several best management practices to reduce impacts, including these steps:

- Deploying real-time, continuous air quality monitoring through Project Canary technology, which alerts Crestone to any abnormal readings so the company can take immediate action.
- Using an innovative, synthetic base, high-performance drilling fluid which is virtually odor-free, non-toxic and readily biodegradable, meaning it's environmentally friendlier and results in less waste. Read more here.
- Crestone uses a vent-free fully enclosed flowback process for all of our wells. This captures temporary natural gas emissions coming from a well just before it goes into production. Gas is directed to a pipeline to be transported off-site, rather than vented or flared, reducing any potential impact on air quality.
- Shielding derrick lights or orienting them downward to minimize light pollution and visual impacts on neighbors while maintaining a safe work environment for our contractors and employees.
- Utilizing Quiet-FleetTM hydraulic fracturing technology and electric drill rigs, when line power is available, to decrease noise.
- Consolidating well pads along the same corridor to utilize the same truck route and creating a traffic plan to eliminate truck traffic during school bus pick-up and drop-off times and rush hour.
  https://www.civitascommunityrelations.com/box- elder-cap

"We have a lot of rules"

The Colorado Oil and Gas Conservation Commission unanimously approved a sweeping set of new rules in early 2021. The moment marks an end to a 1950s-era system designed to "foster, encourage and promote" the development of fossil fuels in Colorado. Under the new rules, the state will now work to "regulate" the industry to protect public health and the environment. Colorado isn't new to setting the pace on state oil and gas restrictions. In 2014, the state became the first in the country to crack down on methane, a potent greenhouse gas able to escape from wells and pipelines.

The new rules, effective Jan. 15, 2021, will affect almost every stage of the oil and gas extraction process in Colorado. The move also comes as the industry has struggled during the COVID-19

pandemic, with nearly 8,000 Colorado oil and gas workers filing unemployment claims between mid-March and the end of October.

In a broad sense, SB19-181, the name of the bill behind the changes, reworks how Colorado approves any new oil and gas wells. Previous regulations largely left decisions about permitting to the commission. Under the new rules, local governments can approve projects along with state authorities. Coloradans will also have greater standing to participate in future decisions about oil and gas drilling. State regulations also become a "floor" for local governments. While cities and counties can pass more restrictive regulations, they cannot weaken the ones the state recently approved.

Growing Pains

Discussions are ongoing about creating the many regulations needed to implement Senate Bill 181. Both the state regulators and operators are adjusting to the new rules and recruiting and training staff to handle the new approaches. Even the state commissioners are learning how to be a professional council rather than a volunteer organization. The COGCC permitting staff is growing from its current size of eight specialists to a target of 14. It is fair to say that the current long lead time and current permitting backlog are signs of growing pains for all parties.

The industry and regulators are still trying to figure out how to best measure (rather than estimate) emissions as new technology brings new tools to the toolkit. But everyone knows that this is a one-way street with future regulations only getting tougher. Current discussions have taken "economics off the table" as the state no longer considers the operators profitability thresholds as influencing factors. It is the operator's responsibility on making profitable investments. It is the state's responsibility to protect public health and the environment. Future regulations will also not have a lower limit on the type of facility under the rules. That may not be good news for small "stripper" production operations. There may be some exceptions for small operators but no loop holes for small businesses on safety and environmental performance.

Here a few examples of the new regulations

- When considering drilling permits, state regulators will soon have to account for previous environmental impacts to nearby communities. New wells must be located to avoid any harm to aquatic habitats and critical wildlife species. Certain chemicals will no longer be allowed for hydraulic fracturing.
- Routine flaring or venting will not be permitted, requiring operators to use other methods to get rid of excess natural gas. Environmental advocates say Colorado is only the second state to enact such a restriction.
- The commission also gave final approval to a controversial 2,000-foot setback between new wells and occupied buildings. Operators can apply for exceptions through four so-called "off-ramps," which could allow drilling as close as 500 feet to homes and schools. For example, an exception could be granted if companies develop "substantially equivalent" protections for public health and safety. Operators could also have property owners or tenants sign a waiver to allow drilling within the buffer zone.

https://www.cpr.org/2020/11/23/colorado-has-a-brand-new-set-of-oil-and-gas-rules-with-a-focus-on- regulating-the-industry/

And the state is not done yet. Over twenty new rulings were made in 2022 by the CDPHE impacting oil and gas operations. How is the new regulatory environment impacting how the oil and gas industry sees Colorado? In a statement, Dan Haley, President & CEO of the Colorado Oil & Gas Association, said the additional rules mean, "*Colorado now undoubtedly has the toughest oil and natural gas development regulations in the country.*" With the passage of SB19-181 and other policy shifts since, the energy industry in Colorado will annually incur nearly $160 million in new regulatory direct costs every year, according to the Colorado Oil and Gas Association.

This number doesn't include recently adopted rules on financial assurance and greenhouse gasses, which are anticipated to drive upwards of $106 million.

https://coloradosun.com/2022/04/10/colorado-oil-energy-russia-independence-opinion/

But things may be looking up, both for the industry, local communities as well as the planet.

Last Ones Standing

Some analysts believe the last operators standing in the DJ Basin will be today's major producers with the financial resources to adapt to the longer-term planning cycles, the technical resources to manage the expanding measurement and data processing requirements, the public affairs staff to stay involved in community engagement and government rule making and the operational expertise to design, build and operate the new production facilities designs.

The list of these companies may be limited to Occidental Petroleum, Chevron Oil and Gas, PDC, Bayswater and Civitas, with little room for smaller companies with smaller scattered lease positions, a majority of legacy stripper wells. Smaller operators may have difficulty adapting to the new flood of regulations and will be unable to stay ahead of the curve. These operators will ride out the declining production from older wells and slowly exit the basin or get acquired. The top producers are increasingly coming from a series of mergers and acquisitions including:

- **Civitas** (Latin for community) is Colorado's largest pure play oil and natural gas producer. Civitas Resources, which formed in May, 2021 after the merger of two Colorado oil and gas companies, acquired Denver-based **Crestone Peak Resources** in all-stock deal to further consolidate operations along the Front Range. Civitas said in a statement the acquisition of Crestone will result in an enterprise worth about $4.5 billion. The company will have operations over roughly a half- million acres, daily production of the equivalent of 160,000 barrels of oil and proven reserves of the equivalent of 530 million barrels of oil. The move is more consolidation of oil and gas operations in the Denver-Julesburg Basin, the center of oil and gas production in Colorado, as companies focus on reducing debt and costs, and increasing cash flow.

  In May, 2021, Denver-based **Bonanza Creek Energy** and **Extraction Oil and Gas Inc**. agreed to an all-stock merger valued at $2.6 billion to create Civitas Resources. Crestone formed in 2016 and acquired **Encana Corp**.'s oil and gas properties in the Denver-Julesburg Basin. Crestone's primary shareholder is the Canada Pension Plan Investment Board, which will become Civitas' largest shareholder upon closing, Bonanza Creek's operations were concentrated in the rural portions of the Wattenberg Field in the D-J Basin. Extraction has tended to operate in some of the fastest-growing areas along the Front Range. Extraction

emerged from Chapter 11 bankruptcy in January, 2020.

Not done yet, February 1, 2022 – **Civitas Resources, Inc**., announced that it has signed definitive agreements to acquire privately held Denver-Julesburg Basin ("DJ Basin") operator **Bison Oil & Gas II**, LLC for approximately $346 million of consideration, consisting of 2.3 million CIVI shares, $45 million in cash and the assumption of approximately $176 million in debt and other liabilities. The Transaction closed in the first quarter of 2022 and demonstrated Civitas' approach to consolidation with a focus on value creation and accretion. Key executives include **Ben Dell**, managing partner of Kimmeridge Energy Management Company LLC and chairman of the board for Extraction Oil & Gas, recently announced CEO **Chris Doyle** and Chief sustainability Officer, **Brian Cain**.

- **Chevron acquires Noble Energy**: On July 20, 2020, Chevron and Noble Energy entered into a definitive merger agreement providing for Chevron's acquisition of Noble Energy in an all-stock transaction valued at $5 billion, or $10.38 per share. The acquisition of Noble Energy brings low-capital, cash-generating offshore assets in Israel, strengthening Chevron's position in the Eastern Mediterranean. Noble Energy also enhances Chevron's leading U.S. unconventional position with de-risked acreage in the DJ Basin and 92,000 largely contiguous and adjacent acres in the Permian Basin.

- **Occidental acquires Anadarko:** terminated its merger agreement with Chevron Corp. in 2019 and has entered into a definitive merger agreement with Occidental Petroleum Corp. Under this agreement, Occidental will acquire all of the outstanding shares of Anadarko for consideration consisting of $59.00 in cash and 0.2934 of a share of Occidental common stock per share of Anadarko common stock, in a transaction valued at $57 billion. The transaction closed on May 10, 2019 second half of 2019, subject to approval by Anadarko shareholders, regulatory approvals, and other customary closing conditions.

- **PDC Energy acquired SRC Energy** in 2020 for $1.7 billion to become second largest producer in the DJ Basin. PDC completed its acquisition of DJ pure-play **Great Western Energy LLC** in a $1.3 billion cash-and-stock deal in May 2022.

It will take long-term strategic commitment to stay in the DJ basin and ongoing attention to commodity prices and operational costs to remain one of the last ones standing. A more detailed timeline of significant events in the DJ Basin can be found in the appendix to this report. The table below shows the top 15 most active operators currently working in the Niobrara.

Table 1: Top Operators in the Niobrara in the DJ Basin (Last 4 Years)		
Rank	Operating Company	Well Count
1	CIVITAS RESOURCES, INC.	579
2	PDC ENERGY	555
3	OCCIDENTAL PETROLEUM	373
4	CHEVRON	293
5	GREAT WESTERN PETROLEUM	146
6	BONANZA CREEK ENERGY	128
7	BAYSWATER EXPLORATION & PRODUCTION, LLC	98
8	VERDAD RESOURCES	124
9	MALLARD EXPLORATION LLC	37
10	PETRO OPERATING CO.	24
11	CONFLUENCE DJ	10
12	PROVIDENCE OPERATING LLC DBA POCO OPERATING	11
13	CUB CREEK ENERGY	8
14	WHITING	8
15	NICKEL ROAD OPERATING	7

Impact of new Technologies

Until recently, detecting methane leaks, or other greenhouse gases emissions, was difficult and expensive. As the main constituent of natural gas, methane can escape from aging pipes and valves, from production sites and midstream pipelines (fugitive emissions and vents). An operations condition known as methane slip is particularly significant. Methane slip is an event whereby gaseous methane escapes into the atmosphere. This can happen anytime methane is stored, transported, or used. As awareness has grown about methane's feasibility as a greener fuel for the energy transition, so has the attention on methane slip.

Just a decade ago, the process of finding these leaks was very labor intensive (LDAR – leak detection and repair procedures). No operator puts methane into the atmosphere on purpose, except as a safety solution in emergency situations. Leaks, meanwhile, are notoriously hard to find. Plumes are colorless and odorless and need to be detected by thermal or infra-red cameras often called FLIR (forward looking infrared). While they can be detected with the right equipment, until recently this relied on "the old-fashioned method of going around with a hand-held camera, and a person driving a truck from one place to another". The US alone contains more than a million oil and gas wells, and many thousands of transmission pipelines – a vast area to monitor.

Two major breakthroughs have dramatically changed this picture. The first is technology. Today, we have eyes in the sky. In the past five years, new aerial methane sensors have been developed, deployed on satellites, planes, and drones. These allow us to accurately find and fix leaks in a much more proactive fashion. Resolution from airborne sensors is improving from basin specific, to field/asset pad specific to in some cases, component-specific. This is often referred to as Top-Down measurement.

https://www.ogci.com/why-its-time-to-tackle-methane/

But picking the right technology approach means considering survey frequency and detection threshold. The traditional OGI (Optical Gas Imaging) camera is still the most accurate (threshold of 0.1 kg/hr.) but a hybrid detection approach using satellites (threshold 2500 kg/ day) as a first alarm

pass. Then sensors mounted in aircraft or drones (threshold from 1-10 kg/hr.) or a continuous monitoring solution "at the fence line" can provide more details to guide the OGI camera, with the maintenance crew to the specific component at fault. These links provide more information about a few of the leading companies operating in this space.

(https://www.projectcanary.com/, https://seekops.com/, www.bridgerphotonics.com

https:// www.kayrros.com/ and https://www.bakerhughesds.com/measurement-sensing/lumen

The sensors are miniature – even the methane-measuring satellites are often smaller than a microwave – and can beam images and GPS data back down to earth, alerting oil and gas companies or national governments of any leaks. In the past decade, a cluster of start-ups (like GHGSat, and CarbonMapper) as well as federal agencies (like NASA and the European Space Agency) and NGOs (like EDF) have attached methane sensors to satellites, planes, and drones. With these platforms, operators can now accurately detect and locate emissions from above. Once leaks are found, they can then be fixed – either by burning the methane as it is released (flaring or combustion), or by simply repairing the source of the leak. The question is which tool to use and when, and it is a question of scale and economics.

The second breakthrough is in methane reporting. Internationally, this shift has largely been driven by the UN, through a body called the Oil and Gas Methane Partnership. Comparability of data is extremely important. Global data helps not only climate scientists but allows regulators and politicians to agree common standards.

The UN's new framework, named 'OGMP 2.0', was launched in November 2020, and requires that energy companies "report on all their assets, both operated and non-operated" as the new "gold standard" for methane monitoring. Currently, reporting is often voluntary. However, the incentive for companies to act is growing. In the future it may become a requirement not just for regulators but to internal investors as well. https://www.ccacoalition.org/en/resources/oil-and-gas-methane-partnership-ogmp-20-framework

Another important initiative in cataloging methane emissions is called **Veritas**. Veritas, a GTI Energy Differentiated Gas Measurement and Verification Initiative, is designed to accelerate actions that reduce methane leakage from natural gas systems. The effort brings together scientists, academics, environmental organizations, certification organizations, and industry participants to demonstrate emissions reductions in a consistent, credible, and transparent way. The initiative will develop accurate and verified methane emissions intensities and the necessary protocols to calculate measurement-informed methane emissions for natural gas systems, by segment. https://www.gti.energy/veritas-a-gti-methane-emissions-measurement-and-verification-initiative/

The key learnings from researchers over the past five year suggest that no one technology works in every basin. Emissions can vary widely by basin or by operator. In statistical terms, the emissions follow a log-normal distribution making "snapshot" measurements uncertain. Emissions are dominated by a small number of super-emitters that are unpredictable and intermittent.

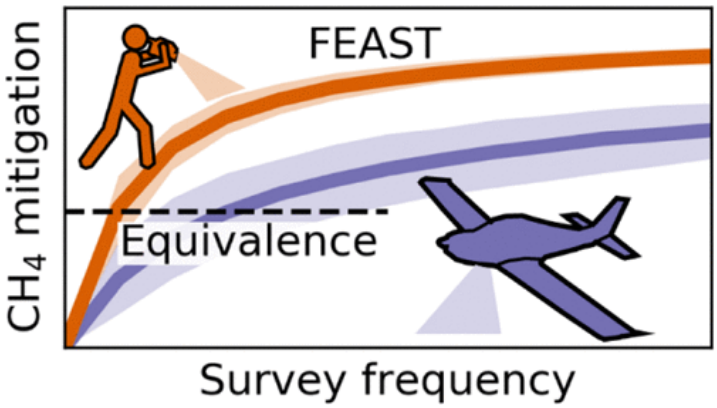
Recent studies suggest that the top 5% of emissions events are responsible for from 35% to 66% of the total emissions at a production site. Most of the time equipment in the field works and a low frequency, high threshold survey may not find significant emissions sources. Conventional inventory methods can underestimate emissions as current emissions factors do not address the super-emitter problem just as infrequent surveys often miss fugitive emissions events. But the new technology offers

promise in our ability to identify, locate and quantify emissions and help operators to respond more quickly with timely repairs.

A recent research report (Multi-scale Methane Measurements at Oil and Gas Facilities Reveal Necessary Framework for Improved Emissions Accounting, Wang et al, 2022) summarizes their findings this way:

1. Methane emissions exhibit significant intraday and daily variations, resulting in a range of three orders of magnitude in snapshot measurements both at the site-level and at the equipment-level.
2. GHGRP (Greenhouse gas reporting protocol)-based inventories, on average, underestimate methane emissions at the basin- and national-level. However, individual sites can have lower emissions than inventory estimates and
3. Characterizing operator-specific distributions of the frequency and duration of intermittent emissions events is critical to developing an accurate annualized emissions estimate

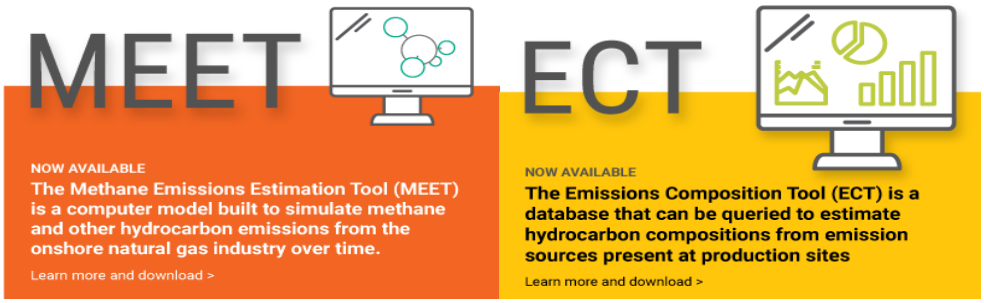
Traditional emissions tracking models (like the GHG Inventory from EPA and state databases) use a hierarchy of facility/equipment/component to build emissions estimates. Newer models use a formula of leaks (normal wear and tear of equipment) plus vents (like pneumatics and diesel engines) and the key factor of anomalous vents (the intermittent super-emitters like tank thief hatches). The **FEAST model (Fugitive Emissions Abatement Simulation Tool)** from the University of Texas at Austin is an example of the new approach to emission modeling. (http://www.arvindravikumar.com/feast.) New technologies can significantly reduce the cost of addressing methane emissions from the oil and gas industry and improve forecasting.



Another example of this new generation of methane emissions modeling tools is the **Methane Emissions Estimation tool or MEET**. MEET is an open-source modeling tool that helps regulators, industry and the research community more accurately track methane emissions in oil and gas production facilities and basins.

The variation of methane emissions at production facilities over time and space is one of the most significant challenges to accurately estimating industry emissions. The MEET model is the first of its kind to enable estimation of emissions with such a high accuracy in time and by source, while being scalable to large producing regions. The tool is modular, customizable and allows users to simulate emissions for a variety of production facilities in any basin that are dynamic in space and time, as well as providing uncertainty estimates.

Developed by the University of Texas at Austin (UT), in collaboration with Colorado State University and SLR Consulting, the source code has been made available as open source hosted by UT. The release of the software comes on the heels of a three-year study aimed at improving estimation of methane emissions by developing flexible and accurate models using the latest science available. https://methanecollaboratory.com/methane-emissions-estimation-tool/



Operators seemed to have three choices in this new regulatory environment. They can do the minimum of repair and maintenance to existing facilities and target only compliance with existing regulations (the low-bar of compliance only), while in several states these regulations are getting tougher.

Second, they can leverage the hybrid detection, multiple technology approach tailored to their specific basin and type of operations and lower their emissions from between 10% to 30% but with a more proactive and focused LDAR program for leak repair.

But ultimately an operator may have to start with a clean sheet for next generation facilities approach and "design emissions out" (up to 80%- 90% emission reduction potential) with radical new solutions like electrification (from grid on on-site sources), pipelines replace tanks and trucks, instrument air replaces high-bleed pneumatics, more automation and remote surveillance with continuous monitoring of air quality and in more remote locations use of excess natural gas production from a closed combustion incinerator or a power-on-site solutions. But the key will be a facilities and process engineering design that works to provide a closed-loop solution that captures, separates, recycles and uses all product streams from the well bore to a pipeline that will carry that product (crude oil, natural gas, natural gas liquids and produced water) offsite.

The Changing Nature of HSE (Health, Safety and Environment)

Oil and Gas producers have always been focused on safety and have process safety managers keeping track of regulations like those from federal and state OSHA organizations. In 1970, Congress passed legislation known as the Williams-Steiger Occupational Safety and Health Act, commonly known as the OSH Act, or **OSHA**. President Richard Nixon signed the legislation on December 29, 1970. The OSH Act gave the federal government the authority to set and enforce workplace safety and health standards for most of the country's workers.

To that end oil and gas companies formed organizations called **HSE** (or some variation of those letters) to be responsible for corporate response to Health, Safety and Environmental matters. But while the

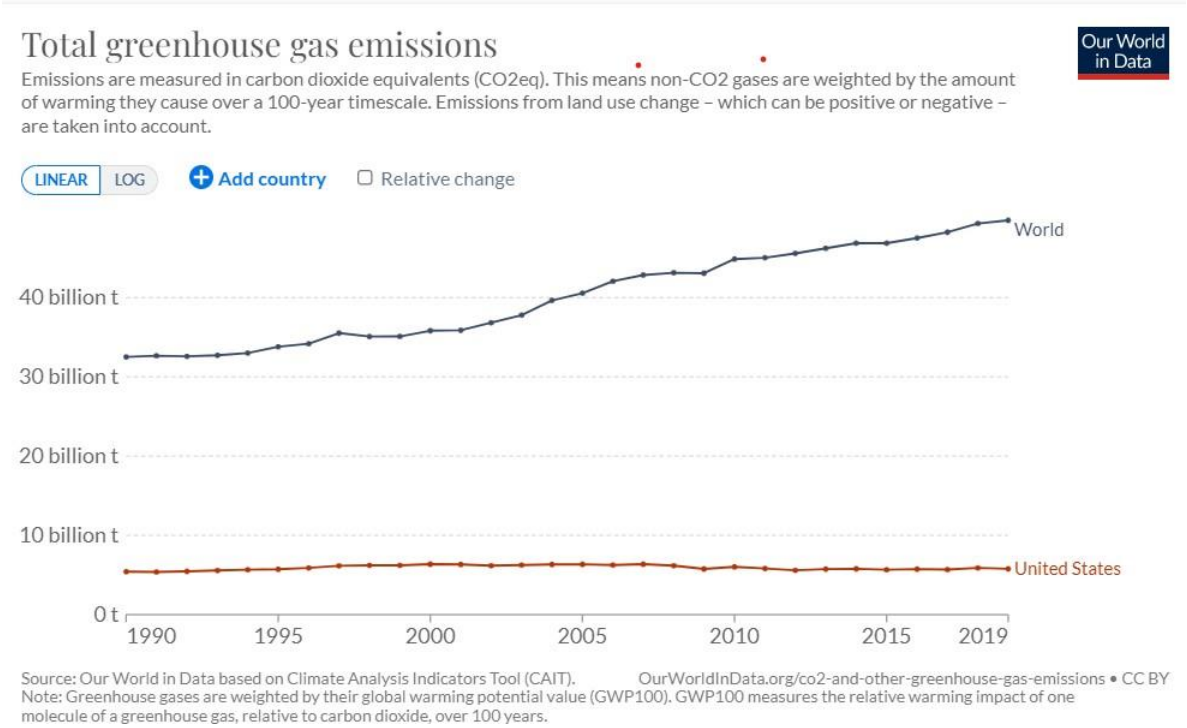
early focus was on safety, it didn't take long for the environmental issues to become important as well. But the initial focus for environmental specialists were compliance with regulations on air and water quality. The HSE group was responsible for keeping up with changing regulations at federal and state level, communicating those requirements to operations, making sure they were in compliance and filing the necessary paperwork and permits to the appropriate authorities. Recently there is a greater emphasis on greenhouse gas emissions.

EPA has prepared the **Inventory of U.S. Greenhouse Gas Emissions and Sinks** since the early 1990s. This annual report provides a comprehensive accounting of total greenhouse gas emissions for all man-made sources in the United States, including carbon dioxide removal from the atmosphere by "sinks," (e.g., through the uptake of carbon and storage in forests, vegetation, and soils) from management of lands in their current use or as lands are converted to other uses. The gases covered by the Inventory include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride.

The national greenhouse gas inventory is submitted to the United Nations in accordance with the Framework Convention on Climate Change. In preparing the annual emissions inventory report, EPA collaborates with hundreds of experts representing more than a dozen U.S. government agencies, academic institutions, industry associations, consultants and environmental organizations. EPA also collects greenhouse gas emissions data from individual facilities and suppliers of certain fossil fuels and industrial gases through the **Greenhouse Gas Reporting Program**.

https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

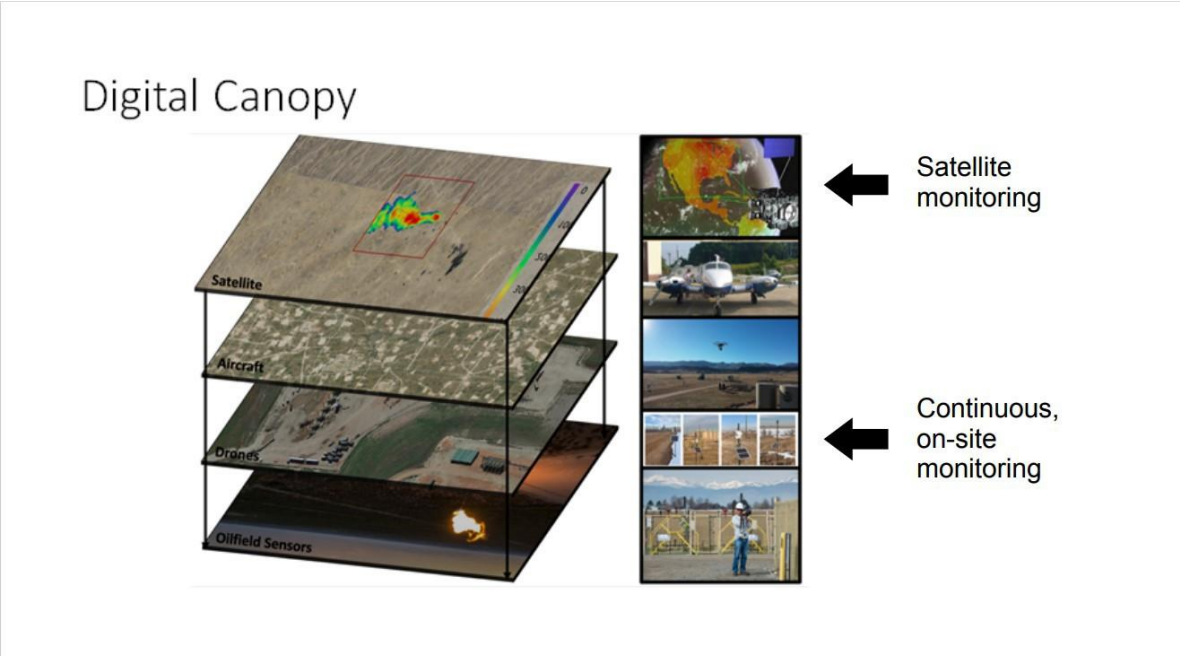
The United States Environmental Protection Agency (EPA) began regulating greenhouse gases (GHGs) under the Clean Air Act from mobile and stationary sources of air pollution for the first time on January 2, 2011. Standards for mobile sources have been established pursuant to Section 202 of the Clean Air Act, and GHGs from stationary sources are currently controlled under the authority of Part C of Title I of the Act.



Global energy-industry-related carbon dioxide (CO2) emissions rose by 6% in 2021 to 36.3 billion tons, the highest-ever level, as the world economy rebounded strongly from the COVID-19 pandemic, according to an International Energy Agency (IEA) report. Combined with the methane emissions estimates that the IEA published earlier this year and estimates of nitrous oxide and flaring-related CO2 emissions, the new analysis shows that overall greenhouse-gas (GHG) emissions from the energy industry also rose to their highest-ever level in 2021—40.8 Gt of CO2 equivalent (CO2eq).

The current discussion around the climate impact of industrial greenhouse gas emissions is centered around measurement of actual emissions rather than the traditional estimation techniques. The future oil and gas production facility will have to take into consideration the objective of eliminating or at lease minimizing GHG emissions and to demonstrate that requirement through specific measurement and reporting techniques. The phrase "**Measure what Matters**" is becoming more common as environmental NGO as well as regulators better understand the limits to previous reporting methods.

Approaches to measurement range from satellites, to aircraft surveys, to drone inspection surveys to various types of continuous monitoring and ultimately to operations procedures like LDAR (leak detection and repair) and use of FLIR (forward looking infrared) thermal camera surveys will have to be adopted.



Measure what Matters is even one of the pathways in the SPE (Society of Petroleum Engineers) Gaia framework. https://www.spe.org/en/gaia/9-element-strategic-programming-framework/ We at the Payne Institute of Public Policy have coined the term **Digital Canopy** for Emissions Detection to try and frame the advantages and limitations of these various techniques and to begin to reconcile the top down and bottoms up measurements to develop a way to more accurately measure emissions and to help operators more proactively identify, locate fugitive emissions leaks and to quantify the size and impact of the largest "super-emitter" events.

https://payneinstitute.mines.edu/wp-content/uploads/sites/149/2020/04/Payne-Commentary-Series- A-Digital-Canopy-How-to-Get-to-Transparency.pdf

The Keys to the Future Oil and Gas production facility: The Colorado Story

From our research, field trips and interviews along with the success, or failure, of drilling and production permits since 2019, we have identified the following seven facilities design and public engagement principals as key elements for the future oil and natural gas production facilities for the DJ Basin, and maybe even for other North American onshore shale basins. The increasing regulations may start in Colorado but will most likely be adopted in some form in other producing states. New Mexico has already begun a review of their environment regulations and could follow Colorado example. These are our thoughts and we are responsible for them, but we have validated them with experienced subject matter experts from major operators involved in these major capital decisions.

While no two drilling and production permits are exactly the same, these concepts can and should be broadly applied as much as practical. They are more of a toolkit than a template. They are best focused on new permits and facilities, but the challenge of operating legacy operations will still be a part of the operator's responsibility, especially as many of these older vertical wells, or first-generation horizontal well pads, are critical to hold leases for future development.

Factors such as geology, economics, proximity to infrastructure (both pipelines and grid power), leasehold configuration, proximity to residential and commercial properties (remember the 2,000-foot standoff consideration) will all influence the design of the next generation of oil and natural gas production facilities. Operators may also have to factor in the impact of community expectations for "unquantifiable and perceived risk" factors in their designs.

This is more than just a conversation internal to the company based on costs versus production value analysis (like ROI- return on investment or ROCE- return on capital employed) but one that involved community and regulatory requirements. It may take deeper pockets, a longer strategy planning time horizon and an ESG (environmental, social & governance) investment perspective from the top of the corporate hierarchy, but this is the new evaluation equation that is evolving. But these seven design principles will help, even if an operator only holds these solutions in a "toolbox" and applies them to specific opportunities.

1) **A large consolidated and compact leasehold**, preferably away from urban or fast growing suburban residential areas. The focus of this paper is future facilities design near urban and suburban environments but the safest way to minimize difficulties is to avoid them in the first place. In the DJ basin that favors the rural areas of Weld County where the bulk of the production comes from anyway. This approach is summarized in the phrase: "*avoidance, miniaturization and mitigation*." According to one of our expert interviews: "*If an application is rural and not in a sensitive wildlife receptor habitat the permit will be fairly easy to apply for and receive*." Case in point two of the first permits approved after SB-181 were both smaller rural applications in eastern Colorado."

   The Front Range of northern Colorado is a popular and growing area. Colorado's population grew by nearly 15 percent between 2010 and 2020, according to U.S. Census Bureau data The Denver Metro area has a problem with affordable housing, and the recent loss of almost 1100 residences to the Marshall fire has made the real estate situation in the area worse, so suburban sprawl is inevitable. Metro Denver now the fifth least affordable housing market in the United States.

   If you don't have a single large land owner, like Kerr McGee has with Bronco, then work with your land department to trade and acquire leases to develop a lease hold like Chevron has at Mustang where they can access an eight square mile lease from a single 7.5-acre production pad, with as many as 28-32 horizontal wells. Chevron has two drilling rigs that are capable of drilling 100 wells per year taking only 3-5 days to drill each well. Two and a half mile laterals are now the norm. In some cases, the growth of residential properties will come to the oil patch, not the other way around. The rest of these best design principles will help the operator both when the facility is first commissioned and later when future development may get closer.

2) **Electrification: Using electricity to reduce emissions:** Where possible, invest in infrastructure to power compression engines and drilling rigs using electricity from the power grid. Xcel is the largest public utility in the DJ Basin but there are several regional cooperatives that may provide other options. When an operator can use grid electricity to power a rig, they eliminate 100 percent of nitrous oxides and other ozone precursor emissions from rig operations in summer months and approximately 75 percent in colder months, when operations require the use of boilers for heat. In the Mustang area, Chevron has drilled 56

wells using utility electric power since 2019.

While access to public grid power is not always possible or affordable, electrification solutions should be evaluated. The drivers for electrification are reduced costs, higher reliability, higher returns and environmental sustainability. Where feasible, electrification can lead to more efficient unmanned operations, automation and condition-based maintenance and prognostic health monitoring of critical equipment.

It isn't just greenhouse gases that are a concern. On December 16, 2019, the U.S. Environmental Protection Agency (EPA) announced a final rule to reclassify the Denver Metro/North Front Range ozone nonattainment area from Moderate to Serious nonattainment under the Clean Air Act. The area covered embraces all of Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties as well as the southern portions of Larimer and Weld counties.

Under the Clean Air Act, areas that do not attain national ozone standards in a timely manner are reclassified to a higher nonattainment status. The Denver Metro/North Front Range area has been classified as a 'Moderate' nonattainment area for the 2008 ozone 8-hour National Ambient Air Quality Standard since 2016. The reclassification to 'Serious' is based on an evaluation of air quality data collected between 2015 and 2017. Colorado must now revise its State Implementation Plan (SIP) for ozone with enforceable rules and programs to achieve compliance with the national air quality standard for ozone including a lower threshold for permitting large sources. The formation of ozone is a completely different process than methane emissions but it will become another factor to deal with.
https://www.spencerfane.com/publication/new-ozone-classification-will-impact-permitting- along-the-front-range-in colorado/#:~:text=New%20%E2%80%9CSerious%E2%80%9D%20Classification%20for%20Nonattainment%20For%20Ozone%20On,to%20Serious%20nonattainment%20under%20the%20Clean%20Air%20Act.

3) **Tankless facilities reduce emissions and surface footprint:** Many operators are committed to using tankless production facilities, which reduce emissions and surface footprint. The industry's newest facilities enable them to eliminate more than 90 percent of greenhouse gas emissions compared to older facility designs. In the Mustang CDP area for Chevron, it now takes only about 7.5 surface acres to deliver the same production volume that previously required 400 surface acres — reducing their surface footprint by more than 95 percent. In addition, they have eliminated more than 152 million miles of truck traffic and associated emissions by transporting oil and natural gas from their Mustang CDP by pipeline instead of trucks. They have gone from 95% of product carried off lease by truck to 95% of oil, natural gas and produced water carried off lease by pipeline. In many communities truck travel is named as their number one concern.

However, tankless is not the only option. Smaller operators like Bayswater have successful developed sites with tanks that are designed not to vent. Bayswater was the first operator to receive a permit under the new 2019 rules. Sealed tanks, reprocessing of gas that comes out of the storage tanks back into the processing stream are also successful techniques that meet or

exceed state requirements.

There is huge potential for emissions reductions with these newer centralized facilities. Occidental has also been championing these kinds of facilities even before the 2019 change in state regulations. These should be the models for development elsewhere. Occidental and Chevron are starting to transfer their DJ Basin lessons learned to their larger operations in the Permian Basin.

Large operators have a distinct advantage in this realm. They have capital and longer-term plans that allow this upfront spending / planning to design bigger centralized facilities. Smaller operators will need to find ways to partner with larger operators to simply tie into these bigger systems. With the Title V permit requirements and pending severe ozone non-attainment status any pad larger than ~4 wells will have difficulty operating under Title V thresholds without mitigation. The complexity and expense of operating under Title V will become very onerous for these smaller operators to manage.

4) **Operations control center:** The impact of automation is another key design element. Operations Control Centers are the nerve center for production operations across northern Colorado. It allows automated oil and natural gas facilities to be monitored and controlled remotely, in real time, 24 hours a day, seven days a week. For Chevron currently, more than 90 percent of their operations in Colorado are automated and monitored. Occidental Petroleum has a similar integrated operations hub in Platteville, Colorado.

   Technologies such as IIoT (Industrial Internet of Things), wearables, and digital twin can strengthen an oil and gas company regardless of the circumstances but the foundation rests with traditional SCADA (supervisory control and data acquisition) instrumentation and control systems. Reliable, secure and robust field to office communications networks are now as critical as pipelines. Now, the industry doesn't need a crisis to understand that remote technology is here to stay. Its value covers two aspects:

   a. Improved people management and working conditions for employees
   b. Improved awareness and decision-making for managers and domain experts

   But greater automation brings about the concern of cybersecurity. The good news is that field operations, control centers and headquarters are getting better connected with near real time data transparency and the capability of applying new advanced analytical techniques to develop better prediction models and gain new insights into operations. The not-so-good-news is that the connectivity brings with it the vulnerability of hackers gaining access to these networks. Process control systems are not invulnerable to hacking and malware. There networks bring a lot of potential value but they must be reliable and secure.

5) **Long Horizon planning phase with predictable and efficient permitting process**
   The concept of a comprehensive development plan (CDP) or a comprehensive area plan (CAP) for a large area allows a longer-term planning horizon for operators to innovate and redesign production facilities and to allocate the capital for infrastructure investment like pipelines and electrical power. However, this assumes some predictability in the permitting process. Operators can't commit to multi-year capital investment unless they certain that

permits will be granted when it comes time to drill and complete wells. The longer planning phase allows the opportunity to engage with community (implied consent process) and with regulators. The permitting phase should be efficient and consistent based on best practices and innovative design that come out of the planning phase.

6) **Environmental Monitoring and proactively address abandoned well inventory** Operators like Civitas and Chevron have committed to proactively address abandoned well inventory with modern plugging and reclaiming standards, regardless of the historical ownership of the abandoned well. Chevron has 17 rigs running for P&A (plug and abandon) work and properly abandoned up to 600 legacy wells per year (at $60k per well for a budget of $50m annually) at its Mustang property near Greeley. COGA have estimated that between 2015 and present, the industry has actually plugged and reclaimed more wells than it has drilled. The Wellbore Integrity Rules negotiated between operators, service contractors and the state (approved on June 10, 2020) also ensure that wells in the future will be less likely to become environmental problems. https://www.naturalgasintel.com/colorado-adopts-nations-strongest-wellbore-integrity-rules-to-protect-groundwater/

There is only one direction for regulations, and that is they will get tougher. So, operators must be proactive and get ahead of the curve even if that means a little more investment in early phases. Environmental monitoring of air and water quality not only keeps up with new regulations but provides the operators with data to identify, locate and mitigate fugitive emissions and to quantify emissions for regulators and community activists. Working with a data driven understanding will help with better design solutions. Whatever layer (or layers) of the Digital Canopy an operator chooses to deploy, environmental monitoring combined with SCADA process automation and field maintenance practices will significantly transform the environmental impact of next generation oil and natural gas production facilities. Operators can also work with third party certification schemes to have an extra set of eyes on the impact of their operations and possibly turn their investments into a market return with Responsible Gas.

7) Engage with all Stakeholders, not just your production engineers

Operators have to figure a way to engage with the local community and state expectations (i.e. community hotlines and website with more transparent reporting of emissions, etc.). With newer facility designs and public influence at the "front-end" of the regulations ruling process rather than being order-takes at the "back-end" O&G operators can build effective partnerships with all stakeholders. One example of this collaboration was the February 2021 rule making on pneumatics controllers. An effort between operators, service companies and NGOs over several months led to a short (one-hour) but successful hearing on a new ruling that everyone could buy- into from a starting proposal that wasn't workable. https://co-lsen.org/2021/03/15/colorado-passed-the-nations-first-regulations-on-pneumatic-controllers/

This will require staff commitment (and a lot of meetings) and the willingness to share best operational practices with regulatory staff. One concern expressed in our interviews was that the same faces seem to be at the numerous hearings. While the process is open, are we really hearing from the general public and do they have the time and interest to fully participate?

The last several years were the era of the drilling and completions engineers developing ways to contact more tight reservoir rock through horizontal drilling and more intense completion practices. Now it is the turn of the facilities engineers to create acceptable "minimum" surface designs.

Collaboration within the industry is a must. The role of trade groups (like COGA and API) can serve as a way to moderate internal criticism about some leading operators "raising the bar" to make it harder for others to get leases, traditional approach of priority of subsurface mineral rights (sue the county or landowners to gain access if they opposed development) won't get you to where you need to go. A company needs to prepare for a long negotiation (a change from the 90 days to get a permit to well over a year in some disputed permits) and have the mindset that the result won't end up in court. Start first with satisfying local demands and end up keeping ahead of new regulations not worrying so much about the cost of compliance.

Other issues (the journey never ends)

Third Party Certification

Concerns about the oil and gas industry and the severity of methane emissions from oil and gas drilling and production from ESG investors, buyers, governments, and producers alike have created an interest in a differentiated gas market, driven by verified environmental attributes that are priced into different quality grades of natural gas. A key dimension of these environmental attributes is the methane emissions from production to delivery. One approach to allowing the market to price these differentiated attributes is through third-party certification, and several certification organizations have arisen in the oil and gas sector to serve this role.

https://www.projectcanary.com/services/responsibly-sourced-gas/#:~:text=Responsibly-Sourced%20Gas%20%28RSG%29%20is%20natural%20gas%20that%20has,practices%20around%20minimizing%20other%20environmental%20and%20community%20impacts .

Beyond certification, other firms and organizations have begun developing alternative frameworks for differentiated gas, such as the Gas Technology Institute's (GTI) Veritas initiative, S&P Global Platts and Xpansiv's Methane Performance Certificates, Rocky Mountain Institute and Spherical Analytics' Climate Action Engine, and Cheniere Energy's quantification, measurement, reporting, and verification (QMRV) initiative. Although these are not official certifications, they represent partnerships between stakeholders to facilitate transactions of low emissions gas.

Abandoned and Orphan Wells

Most responsible operators try to take care of their own wells when it comes time to call out the cementing unit and plug and abandoned (P&A) and reclaim a well that has reached its economic limit. But many wells have been abandoned and forgotten since Edwin Drake in 1859 drilled the first commercial oil well along the banks of Oil Creek in Pennsylvania, by many operators who ran out of cash and just walked away. Others did the best job they could using then current standard practices and technologies but some of these approaches haven't stood the test of time and have started creating problems for the current land owners. While state governments and environmental groups have worked on their own to fill wells, the process can take years and there is rarely enough money in the

budget to take care of the wells on their lists, with residents struggling to get wells filled in their own backyards.

The **Texas Rail Road Commission** has said that plugging orphaned wells is a critical component of its mission to protect public safety and the environment. The State Managed Plugging Program, which has exceeded legislative goals for five consecutive years, has the goal of plugging another 1,000 orphaned wells in fiscal year 2023 using state appropriations funded with revenue from the oil and gas industry. FY 2023 also will include an infusion of federal infrastructure funding that should result in the plugging of up to an additional 800 orphaned wells.

The issue may just be a piece of rusting pipe or equipment that needs to be removed or a collapsed hole is creating a hazard for grazing cattle that needs to be filled in. There is rarely a geyser of salt water coming from the old wellbore, but that can happen to. The salt water creates a difficult to remediate zone around the spill which is expensive to restore and there is always the problem of methane emissions. So, the feds are lending a helping hand.

This issue in Colorado is more manageable. In Colorado, the industry points out that with almost every new well, dozens of old and potentially leaking wells are plugged. Between 2015 and 2020, 8,104 wells were drilled in Colorado and 9,902 were plugged, according to industry statistics. Occidental Petroleum, the state's biggest oil and gas producer, spent more than $100 million between 2017 and 2020 to plug and abandon 2,224 wells, while drilling 937, according to a filing with the COGCC. Civitas announced in January it would even plug 42 wells near its operations identified by the state as abandoned and orphaned oil wells, at an estimated cost of $4 million. Since 2014, PDC has plugged and reclaimed almost 2,100 well sites.

The COGCC has an "orphan well" program and keeps an inventory of wells that need attention, has a prioritization process for addressing these wells and a professional project management and inspection staff to implement projects according to its budget. That budget is currently being enhanced with federal funds from the Infrastructure Bill. Colorado is now receiving $79 million to clean up the wells in this state. The COGCC has a team set up already to get to work. The COGCC's most recent report identified 528 orphaned wells and 981 associated sites across Colorado. **https://www.iea.org/policies/13504-colorado-executive-order-d-2018-12-orphan-well-program**

As governor of Colorado, Hickenlooper directed a working group in 2018 to recommend regulations for orphaned oil and gas wells and issued an executive order (D 2018-12) allocating $5 million annually to speed up the closure and cleanup of the sites. The action followed a warning from a former director of the oil and gas commission that the state would need at least six times more money than companies had provided in bonds. As part of the overhaul of state oil and gas rules mandated by a 2019 law, the commission earlier this year approved new requirements for the bonds that companies must provide to ensure wells will be taken care of. In June, the commission-imposed a per-well fee on companies to generate roughly $10 million annually for a new fund. Including the $25 million in federal dollars, the agency expects the fund to total $100 million to $115 million over the next five years.

https://www.denverpost.com/2022/08/27/colorado-gets-money-orphan-wells/?utm_email=74F9A49EB486B4AFD570D4E97D&g2i_eui=bQ1FKDDxs2MvIPEncwWSaxx244SQ7x%2fN&g2i_source=newsletter&active=no&lctg=74F9A49EB486B4AFD570D4E97D&utm_source=listrak&utm_medium=email&utm_term=https%3a%2f%2fwww.denverpost.com%2f2022%2f08%2f27%2fcolorado

-gets-money-orphan-wells%2f&utm_campaign=denver-evening-post&utm_content=automated

A major effort to combat climate change by reducing methane emissions is now underway as $1.15 billion flows to states to help properly abandoned forgotten oil and gas wells that release salt water and greenhouse gases. The funds stem from the **Bipartisan Infrastructure Law**, which in total allocated $4.7 billion over nine years for a new federal program to address orphan wells. This is the first funding phase. There are over 130,000 orphaned wells across the country (as currently documented but there are likely many more), according to a preliminary analysis from the Department of the Interior.

The new funding focuses specifically on orphaned wells, a subset of the estimated two to three million abandoned wells in the United States that, combined, release greenhouse gases equal to 1.5 to four million cars annually, according to the EPA Greenhouse Gas Equivalencies Calculator. They are the nation's 10th-largest methane emitters, according to a study conducted at McGill University. Various groups are working with states to find unidentified orphaned wells through multiple processes, including using drones. The funding from the infrastructure bill only addresses already-identified wells.

In the next fiscal year, the Texas Railroad Commission said it expects to analyze flaring data. Colorado and other states have been doing this for years and flaring doesn't seem to be an issue at all for the DJ Basin. The resulting study will evaluate additional measures the agency can take on flaring and clarify any data discrepancies. Findings, including any recommendations for regulatory or statutory changes, will be shared with the state legislature and the public. On a state-by-state basis these issues facing oil and gas producers are very different. That argues that Colorado may not be an example of other states as they have to go through their own journey but the state may be a trendsetter.

The cost of a well abandonment depends on a number of factors; the primary ones being depth of the well, condition of the casing and whether the wellhead is present and needs to be pulled. Aquifers need to be protected by properly cemented casing. Access to the well site can be an issue. Estimated range from $20,000 to $40,000 per well to several million dollars to remediate an abandoned well site.

Colorado estimates it costs on average $82,500 to plug and reclaim an orphan well, although environmental organizations contend it can cost well above $100,000. Every site is its own challenge. Currently states require operators to post a surety bond in case they are not around at the end of the well life to carry out the abandonment work. Big companies pay less as they are more likely to still be there and have deeper pockets while smaller operators will have to pay more upfront.

Summary and Conclusions: Avoidance, Minimization & Mitigation

Oil and Gas industry is going through an enormous transition after the recent collapse of commodity prices due to COVID 19 in 2020. Consolidation in the industry (mergers and acquisitions) will inevitably lead to cost control but the industry still needs new capital to maintain or grow its businesses and provide energy security to the world's economy. Capital markets' desire to support the Oil and Gas industry has changed dramatically as well. Some in the investment community have lost faith in industry's capability of generating returns and with the concerns over the climate change taking center stage, there is strong demand for capital programs that can sustain and grow businesses with golden ESG standards in mind.

The demise of the oil and gas industry in Colorado predicted after the passage of legislation and regulations focused on protecting public health, safety and the environment does not appear to be imminent. The O&G industry has adapted and is learning how to work with the new regulations. Plans for nearly 1,900 new oil and gas wells are before the Colorado Oil and Gas Conservation Commission in 2022, some already approved and others in various states of review.

The industry seems to have found a way to work within the new (and changing) regulatory framework and community expectations. It takes more work to get a permit, it takes the ability to be nimble and include community voices in the discussion and in the facilities and drilling plans but the industry has found a way to continue operating in the DJ Basin
https://coloradosun.com/2022/07/06/colorado-oil-gas-laws-new-drilling-permits/?pico=clean&utm_source=The+Colorado+Sun+Newsletters&utm_campaign=SUNRISER_202207 06&utm_medium=email

It will be more difficult to permit many new projects in Colorado due to the number of aspects that are perceived as controversial and the ability of local governments and citizens to directly engage the COGCC in protest of an application. But ultimately, many pads and wells will get approved, it is just a long and more complex process. The length of the process and uncertainty is easier for larger companies to endure. Smaller companies will be at a disadvantage due to the amount of up-front costs needed to invest in a pad sitting and design before it even gets approved.

We have suggested a seven-step plan or tool kit, for the future of onshore oil and gas production facilities, including legacy production sites, for the unconventional basins in the United States. This begins with by future-proofing the facility design and selecting locations that will avoid if possible and minimize by design their environmental and community footprint. By designing emissions out, operators can gain community support, regulatory approval and an efficient production site.

The upstream has no option not to do track/monitor/estimate/measure the amounts of emissions (Scope 1 and 2) from the fields operating in Colorado. Scope 1 is already required, and this will be expanded into areas that are currently not well captured by United States EPA Subpart W. Monitoring will likely be expanded and Scope 2 will start to be included in the ESG company reports. As far as

estimates versus measurements, it looks like the industry will continue to do some of both through a measurement informed inventory approach. With preference moving towards monitoring and ultimately quantification.

The impact on smaller operators will depend on what phase the smaller operator is in with well development. New pads can be developed using newer technology and would allow even small operators to have the best BMPs (best management practices) in place where possible. Probably the biggest factor for all operators is access to line power (electrification). With line power access small and large operators can achieve emissions reductions on new facilities in a fairly cost-effective manner. Other operators that have ongoing operations with declining well volumes will be hard pressed to make any changes that can reduce emissions, but they have to try. The Lease Operating Expense will be very high in relation to production, so it may cause some wells to become non-economic if the issue is enforced by regulations.

Many analysts believe there is a limited future for oil and gas in Colorado for new drilling. The production activity won't end when we run out of economically producible crude oil and natural gas but when it becomes too expensive to address the increasingly difficult regulations and community demands. While commodity prices are cyclical, it is a one-way street for tougher regulations. There will likely be some limited drilling locations left in the DJ Basin after the next 20 years, but most will be drilled out in the next ten years. Of course, these forecasts all are price dependent. At sub $80 oil there is not a whole lot of inventory left. At crude oil near $100/bbl. and natural gas over $7/mcf, the future could be more optimistic depending on how long these prices stay at this level.

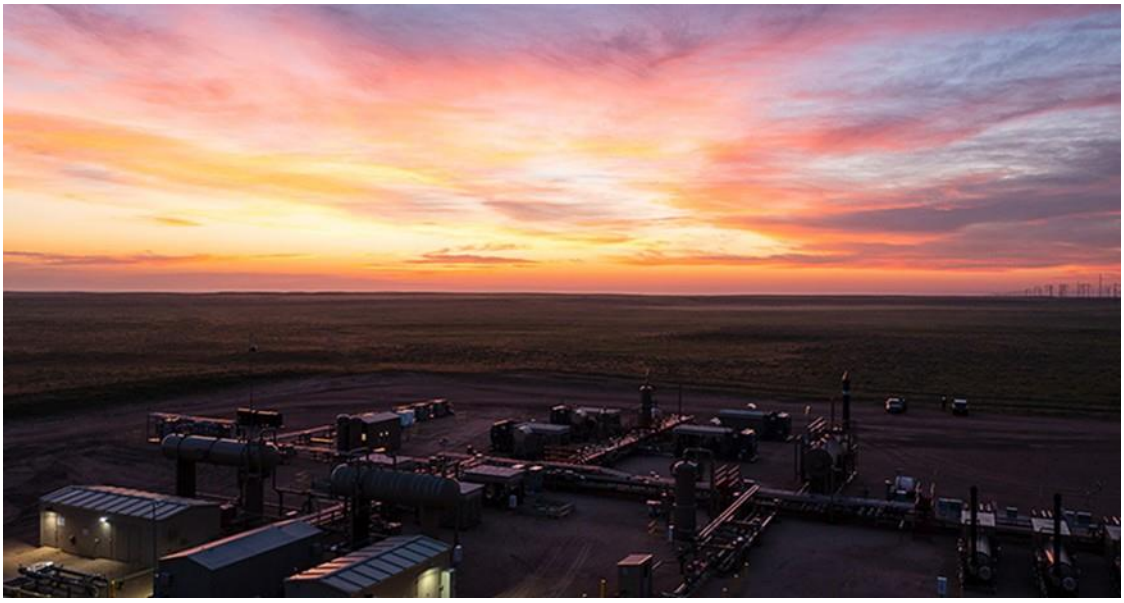
The trend in Colorado as in other basins is for operators to merge in order to decrease overhead costs. A lot of that contraction has already occurred. For operators outside of the big Five (Occidental, Chevron, Civitas, PDC and Bayswater), it is very attractive to target basins outside of Colorado due to less regulatory requirements, better ability to get permits, and in many cases better rock to work with for now. Investment in new wells will migrate even more so to the Permian, Marcellus, Haynesville, etc. plays. Wyoming is one of the most attractive states to drill in, but unless price stays high these basins have difficulty competing against others. Colorado will be a producer for a long time and mergers and acquisitions will continue. But oil and gas producers must look at more than just regulations to make long-term capital decisions.

The oil and natural gas industry must continue to embrace community engagement, emissions reductions and the energy transition. The industry can still operate, but do it properly decarbonization must be done at an affordable cost and achievable pace. Ensure that whatever production is added will be the most environmentally benign in history as well as the highest rate of return.

Chevron claims that their Mustang facilities can reduce emissions from an estimated 50 kg CO2e per barrel of oil produced down to only five-six kg CO2e per barrel produced with a 97% uptime. The next generation oil and gas producing facility will be one that has taken the time to design emissions out, rather than spend money at the back end to mitigate past practices.

Operator must bring emerging emissions reduction technologies and monitoring and measurement systems along for the ride, and help these emerging technologies to mature, many are still in proof-of-concept stage currently. Use the operations and air quality data to be transparent to the local community and keep listening to their issues and concerns. As one interviewee said, "*visit every household, listen to their concerns, explain in everyday language, build trust and you just might leave with a half dozen newly picked tomatoes,*

a new neighbor and even a friend."



The question is whether this is a sunrise or sunset for the oil and gas industry in the DJ Basin? The answer may surprise you.

Acknowledgements

The observations and recommendations from this paper are solely the responsibility of the authors but we would like to thank all those who took time from their busy schedules to share their experiences and expertise with us. Our perspective on this challenge started off in a very pessimistic place but by learning more and listening carefully to everyone's view, the Colorado story turns out to be a very positive one. We feel other states can learn from the experiences of the operators, regulators and community stakeholders in creating a win-win collaborative solution for oil and gas development in areas where rapid population growth and potential oil and gas production collide. We have learned the collision doesn't always have to be a competitive one.

DJ BASIN NIOBRARA TIMELINE:
THE COLORADO STORY

Regulations	Industry	WTI Price
Colorado became the first U.S. state to create a renewable portfolio standard (RPS) by ballot initiative when voters approved Amendment 37 in November 2004. The original version of Colorado's RPS required utilities serving 40,000 or more customers to generate or purchase enough renewable energy to supply 10% of their retail electric sales by 2015.	**2004**	
	2009	
	EOG Resources kicked off the trend toward horizontal drilling in the Niobrara DJ in October 2009, with its Jake well at the Hereford Ranch Field in Weld County. The #2-01H Jake had initial potential (IP) rates of 1,700 BOE per day.	$37.28
		$66.94 ↑
	2010	
	Noble Energy Inc. completed what it considers to be "the best well ever drilled" in Wattenberg Field, reported IHS Inc. About two miles southwest of LaSalle, Colorado, and next to U.S. Highway 85 in Wattenberg Field, Noble reported that #01-99HZ Gemini-K produced 100,000 barrels of oil in its first four months online, and 60,000 barrels of oil equivalent (BOE) in its first 60 days.	$74.71 ↑
		$79.30 ↑
The United States Environmental Protection Agency (EPA) began regulating greenhouse gases (GHGs) under the Clean Air Act from mobile and stationary sources of air pollution for the first time on January 2, 2011. FracFocus was created in 2011 with a single purpose in mind: to simplify the search for chemicals used in hydraulic fracturing operations by location.	**2011**	
	Much of the horizontal drilling for the Niobrara and the Codell that has occurred since has been in the Wattenberg Field in Weld County, Colorado, and, to a lesser extent in and around the Silo Field in Southeast Wyoming. These have been the most heavily targeted areas in part because many companies already held acreage in those areas, and also because those regions have existing infrastructure.	$91.54 ↑
Colorado -Hydraulic Fracturing Disclosure Rulemaking requires comprehensive public disclosure of the chemicals used in hydraulic fracturing treatments.	Liberty Energy was founded. Liberty is a leading North American oilfield services firm that offers one of the most innovative suites of completion services and technologies to onshore oil and natural gas exploration and production companies. CEO is Chris Wright.	
John Hickenlooper elected govenor.		$98.05 ↑
	2012	
		$99.60 ↑
Matt Lapore named as director of COGCC.		$83.91 ↓
	According to the COGCC oil production exceeded 48 million barrels in 2012, a 49 percent increase over 2010 levels. The 2012 oil production levels are the highest since 1961 and are an increase of 24 percent over 2011	

2013

DCP Midstream opens O'Conner gas processing plant near Kersey in Oct 2013 at an investment of $270 million.

$95.89 ↑

September 11: Big Thompson River flood causes significant damage to production facilities in flood plains including 10 dead and $80 million in damage. This was a repeat of the July 31, 1976 Big Thompson River flood which took 144 lives and $35 million in damage.

$106.00 ↑

Members of the Colorado oil and natural gas community formed CRED on September 5, 2013 to combat the growing amount of misinformation about fracking.

June 4: The Boulder City Council adopted Ordinance 7907 prohibiting the city manager and city staff from accepting or processing any application for oil and gas exploration permits on City of Boulder Open Space properties.

Colorado - Setback Rulemaking, created a uniform 500-foot statewide setback, applicable in both rural and urban areas and a 1,000-foot setback from high occupancy buildings such as schools, nursing homes and hospitals.

Colorado - Baseline Water Quality Sampling Rulemaking, Rigorous mandatory groundwater sampling and monitoring rules, Wildlife Map Update Rulemaking. Keeping maps updated provides state regulators with information to ensure that sensitive species are appropriately accounted for during exploration. Spills and Releases Rulemaking, Tightened spill reporting requirements to broaden the definition of what needs to be reported and requires that spills are reported within 24 hours to landowners and local governments.

2014

$95.86 ↓

Operators begin to consolidate leasholds in order to take advantage of longer laterals and pad drilling.

$102.37 ↑

CO first state to pass methane emissions regulations, Air Emissions from Oil and Gas. Colorado's Air Quality Control Commission passed new precedent-setting rules targeting air emissions from the oil and natural gas industry.

2015

$48.98 ↓

April: Encana sells DJ Basin properties for $900 million.

Dan Haley is selected as the President and CEO of the Colorado Oil & Gas Association (COGA). Founded in 1984, the Colorado Oil & Gas Association's mission is to be the unified political and regulatory voice for the oil and natural gas industry in Colorado, and to support their members through advocacy, partnerships, education and stakeholder engagement.

$51.83 ↑

According to Baker Hughes data from early October 2015, drilling activity in the play is down 56% from the first week of December 2014, with active rigs falling from 61 to 27.

Enforcement and Penalty Rulemaking, Fines were increased from $1,000 to $15,000 for each violation and eliminated the $10,000 overall cap for violations.

Flood Lessons Learned Rulemaking, The state updated its regulations to require remote shut-in capabilities and secondary containment areas around tanks. Additional reporting of equipment and wells in existing floodplains also was required.

Complainant Rulemaking, COGCC implements a streamlined process for the public to submit complaints. The new online portal makes the agency's methods for receiving, processing, addressing, closing and communicating complaints more effective and transparent. It includes guidance for making a complaint, what a complainant can expect and the rights of the complainant.

2016

State Implementation Plan (SIP) Strengthened rules to reduce ozone levels for the Denver Metropolitan and North Front Range nonattainment area. Governor's Oil and Gas Task Force Rulemaking The Task Force was comprised of 21 members representing local government, civic organizations, environmental interests, agriculture, and affected industries. They put forward 9 recommendations that empowered local governments in the permitting process and allowed for site specific mitigation as a condition of permit approval.

Leeds School of Business, University of Colorado Boulder issues research report on the economic impact of the oil and gas industry in Colorado and the potential impact of the proposed 2500 foot setpback rule.

$33.87

CSU opens METEC center with ARPA-E funding.

Crestone Peak forms from former Encana properties.

$47.87

September: Colorado Rising formed.

2017

AQCC CTG Rulemaking & Revisions to Reg 7 To further reduce ground-level ozone, improve air quality, and comply with federal requirements, new rules were passed to reduce emissions from oil and natural gas sources.

Extraction Resources and Noble Energy take different approach to public engagement, oil and gas development and facilities designs.

$52.81

Anadarko Petroleum Corporation announced it would close more than 3,000 vertical wells across northeast Colorado as a response to the Firestone explosion. Governor Hickenlooper subsequently issued an order for inspection of wells across Colorado. The order stated flowlines within 1,000 feet of occupied buildings be inspected within 30 days and be tested for integrity within 60 days.

April 17: an explosion at a home in Firestone killes two men (Mark Martinez and Joseph Irwin) and injured two others. Fire investigators determined the explosion was the result of odorless gas leaking from a severed underground pipeline into the home and through French drains and a sump pit in the basement. The abandoned 1-inch-diameter line was connected to an active well that came within 178 feet of the home.

$47.07

Note: Tragic and significant safety accident.

Garry Kaufman named director of Air Quality Division of CDPHE.

2018

Requirements call 811 Underground Facilities (SB 167): This legislation brought Colorado into compliance with new damage prevention enforcement rules issued by the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration in 2015. Flowline Rulemaking: Dozens of new rules pertaining to flowlines and other types of piping systems were approved, along with other regulations increasing transparency in safety and gas leak reporting. School Setback Rulemaking: The definition of a school facility was greatly expanded and broadens the 1,000 foot boundary to include not just the school building, but also surrounding facilities, such as playgrounds, athletic fields, fences, and other outdoor areas.

$61.63

Colorado Supreme Court issued its unanimous decision in Martinez v. Colorado Oil and Gas Conservation Commission, which upheld a decade's worth of rulemaking by the Colorado Oil and Gas Conservation Commission ("COGCC") under the state's prior regulatory regime.

Jun: Extraction obtains permits for Broomfield MOU Livingston pad from COGCC.

Nov 6: CO Prop 112 fails (2500 foot setback) Executive Order D 2018-12 was signed on July 18, 2018 to improve the environment, public health, and safety of Coloradans by directing the Colorado Oil and Gas Conservation Commission (COGCC) to plug, remediate and reclaim orphaned wells and sites and prevent future orphaned wells and sites. The Executive Order requires COGCC to update its comprehensive list of orphaned wells and sites annually by July 1, and to prioritize the list into low-, medium-, and high-priority categories based on identified risk factors.

Oct: Noble Energy Mustang CDP approved southeast of Greeley in rural Weld County.

$73.94 ↑

Note: The election of this new governor lead to many new regulations in 2019.

Nov 6: Jared Polis (D) elected govenor.

2019

Jan: Jeff Robbins named acting director of COGCC, Jill Ryan named executive director of CDHPE.

$47.09 ↓

April 16: CO sr19-181 bill signed into law (House bill 19-1261) granted local governments power to regulate future oil and gas development within their jurisdictions, including the power to preempt less restrictive statewide regulations promulgated by the COGCC. On May 30, 2019, Governor Polis signed into law the "Climate Action Plan to Reduce Pollution", known as House Bill 19-1261, and codified in the Colorado Air Pollution Prevention and Control Act, largely at §§ 25-7-102 and -105, C.R.S. House Bill 19-1261 established statewide greenhouse gas reduction targets of: 26% by 2025, 50% by 2030, and 90% by 2050.

The Colorado Energy Foundation (was added to COGA) seeks to amplify existing philanthropic efforts of the oil and gas industry in Colorado and develop new community partnerships through strategic investment.

July 8, 2019, the Weld County Oil and Gas Energy Department (OGED) was created to firmly establish the county's local control over mineral resources in unincorporated Weld County.

Project Canary formed in September 2019 by Chris Romer and Will Folles. Merged with IES in September 2020.

$59.43 ↑

500 Series Rulemaking: As directed by SB19-181, this rulemaking enabled the use of administrative law judges and hearing officers to ensure the COGCC is properly processing applications. Flowline Rulemaking: Following the 2018 rule changes, additional public disclosure, inspection, and deactivation requirements were added. AQCC Regulation Number 7 & Regulation Number 3 addresses control of Ozone and control of Volatile Organic Compounds and Nitrogen Oxide emissions. Regulation 3 addresses stationary source permitting and air pollutant emission notice requirements. Regulation 7 includes monthly leak detection and repair at new well production facilities including design alternatives and increased leak detection and repair frequency for existing well production facilities and compressor stations. The Colorado Department of Public Health and Environment created the Climate Change Program in December 2019 to lead an ambitious effort to reduce greenhouse gas emissions to protect a livable climate. The Program is responsible for conducting the statewide Greenhouse Gas Inventory, developing regulations to reduce greenhouse gas emissions, and gathering input from stakeholders and communities to shape an equitable and effective response to climate change in Colorado.

Nov: Occidental acquires Anadarko for $38 Billion, Highest oil and gas production from DJ Basin at 801.5 mbd and 5.8 billion cfgd. Western Midstream - Latham Plant was built. The Latham gas processing plant has two processing trains. The facility was completed in 2019. Latham II was completed in the fourth quarter of 2020.

2020

CDPHE has been engaged in separate rulemaking proceedings through two of its divisions, the Air Quality Control Commission ("AQCC") and the Water Quality Control Commission ("WQCC"). In December 2019, the AQCC adopted rules imposing increased leak detection and repair requirements on producing wells, comprehensive annual emissions reports, and more stringent controls on emissions from storage tanks. AQCC also adopted regulations requiring oil and gas producers to obtain air-quality permits (in addition to the permit to drill required by the COGCC) before they can begin exploration and production activities, eliminating a 90-day grace period under previous rules.

Jan: PDC acquires SRC Resources for $1.7 Billion. Mar Price of WTI crude hits $0/bbl. Occidental Petroleum said it will make its Western Midstream (WES) business a standalone company, shedding $7.8 billion in debt through its separation of the former Anadarko pipeline business.

$63.05 ↑

April: Occidental issued $18.25mm fine for Firestone explosion. Wellbore Integrity Rulemaking: This rule strengthened the groundwater protection requirements for oil and natural gas development. AQCC Regulation Number 22: This rule developed Colorado greenhouse gas reporting and emission reduction requirements. Includes emissions from: Preproduction and production, Methane and CO2 and Industrial Sector and O&G Sector. In addition new requirements for the transfer of assets among operators/owners and intensity plans and required updates.

Extraction Resources declares banruptcy, Whiting Petroleum declares bankruptcy

$13.78

Note: Significantly new low WTI price.

Julie Murphy was appointed director of COGCC on July 1, 2020. On September 30, 2020, State agencies made public the first draft of the Greenhouse Gas Pollution Reduction Roadmap. The GHG Roadmap identified several sectors from which reductions will need to be realized to achieve Colorado's climate goals. Two of these sectors include emissions from the oil and gas industry: the Oil and Gas Fugitive Emissions Sector and the Industrial Sector.

July: Chevron acquires Noble Energy for $5 billion. According to the latest annual tally by the COGCC's Orphaned Wells Program, released on July 1, Colorado has at least 215 orphaned wells and 454 associated sites, which can include well pads, storage tanks, flowline locations and other facilities.

Extraction emerges from bankruptcy. 13,867 producing wells have been drilled in the DJ Basin from Jan 1970 to Dec 2020. In 2020, energy production in the United States fell by record amounts compared with 2019, mostly as a result of decreased economic activity during the COVID-19 pandemic. Wyoming had the largest drop in total energy production among the states mostly due to decreased coal production. Seven states saw their largest annual energy production decline in at least 60 years.

Michael Olgetree named director of Air Quality Division of CDPHE. On October 23, 2020, the Air Quality Control Commission (AQCC) issued the Resolution to Ensure Greenhouse Gas Reduction Goals Are Met in support of the roadmap.

$39.82

2021

First year of Oil and Gas Development Plan (OGDP) approvals after the Mission Change rules went into effect on January 15, 2021, In January 2021, Colorado released its Greenhouse Gas Pollution Reduction Roadmap.

April: Only 9 drilling rigs active in Basin.

$48.45

Rule 903, which made it the second state in the country to prohibit routine venting and flaring of natural gas by upstream operators. On July 2, 2021, Governor Polis signed into law the "Environmental Justice Disproportionate Impacted Community", known as House Bill 21-1266, which is set forth required reductions of greenhouse gas emissions from the oil and gas industry under the O&G Sector and the Industrial Sector.

Merger forms Civitas (Extraction Resources and Bonanza Creek). In June, Civitas acquires Crestone Peak.

Colorado Department of Public Health and Environment (7/16/2021), completed the state's first airborne survey designed to monitor for methane and other emissions at major oil and gas sites in the Denver-Julesburg Basin with Scientific Aviation. Data analysis collaboration also with Carbon Mapper and University of Maryland. The state is funding the aerial surveys with money from a settlement between the Colorado Oil and Gas Conservation Commission (COGCC) and Kerr McGee that was related to the tragic 2017 explosion and resulting loss of lives in Firestone. This survey was the department's first flight — CDPHE will use the flight to both gather data on methane emissions and prepare for a larger concentrated aerial survey efforts.

Whiting Petroleum sells their Redtail properties for $187 million to focus on Williston Basin. Cimarex merges with Cabot Oil & Gas to focus on Permian.

$72.98

Xcel Energy announced that it is aiming to achieve net-zero greenhouse gas emissions from its natural gas business by 2050. In addition to its vision to provide 100% carbon-free electricity to customers by 2050, Xcel Energy is committing to becoming an overall net-zero energy company by 2050, while keeping service reliable and customer bills low. On December 17, 2021, the Air Quality Control Commission adopted revised and new requirements into Regulation 7, Part D and Regulation 22, Part B requires reduction of greenhouse gas and other pollutant emissions from oil and gas industry sources.

According to the 2021 Colorado Greenhouse Gas Inventory report, the inventory shows that Colorado's GHG emissions have decreased 9% between 2005 and 2019 and 16% since 2010 to 126,174 MMTCO2e.

2022

The Colorado Oil and Gas Conservation Commission turned down the Kerr-McGee application to drill a total of 33 wells on two pads (McGavin pad in Longs Peak CDP) in Firestone saying that the company had not shown its plan was protective enough or that there had been an adequate evaluation of alternate sites.

Since 1978 there have been 36,065 wells drilled, with 13,867 active producing wells, by 121 active operators, with a total historic produced volume of almost 1.4B bbls of crude oil, and 9.8Tcf of natural gas.

$75.21

The Environmental Protection Agency (EPA) has moved to reclassify Colorado's northern Front Range as "severe" on the air quality spectrum for not having met the 2008 National Ambient Air Quality Standards (NAAQS) for ground-level ozone.

May: PDC acquires Great Western, Centennial Resources Development Inc. merges with Colgate Energy to focus on Permian, Oil & Gas Industry now occupies 10.6% of downtown Denver office space (down from 50% in the 1980s and 25% as recent as 2015).

June: Colorado drilling rig count rises to 19, Colorado producers still hold more than 1,400 active drilling permits, nearly 1,100 of which lie on private land in the oil-rich Denver-Julesburg Basin in the northeast quarter of the state, according to data from the Colorado Oil and Gas Conservation Commission. U.S. gas prices hit at a 14-year seasonal high as the country battles persistent high temperatures and resultant soaring cooling demand for gas. Henry Hub gas prices rose to $8.99 per MMBtu on July 26, before falling to $8.283 per MMBtu on August 1. Rystad analyst pointed out that, in the west, prolonged droughts and reduced hydro-electric generation had contributed to elevated gas use. At the same time, the U.S. has become the largest LNG exporter, with 42 million tons of LNG exported in the first six months of 2022, about six million tons more compared with the same period last year.

Upcoming Rulemakings/Actions: Summer 2022: Ozone Reclassification; Fall 2022: Ozone SIP rulemaking action; GHG Building Energy Efficiency" Winter 2022: GEMM II; Transportation strategies; Winter 2022: Environmental Justice Action Task Force recommendations; Spring 2023: Advanced Clean Trucks; Environmental Justice in permitting

$118.93 ↑

The Bureau of Land Management has agreed to freeze oil and natural gas leasing on 2.2 million acres of Colorado public land pending a deeper look at the climate change effects of drilling in the area and the impacts on the endangered Gunnison sage-grouse and its habitat. The move is part of a settlement with the Sierra Club and other environmental groups, which argued in a 2020 lawsuit that the agency's current 20-year management plan violates the National Environmental Policy Act. Phillips 66 on Wednesday submitted a proposal to purchase all public shares of DCP Midstream for $7.2 billion after Enbridge, which owned half of DCP's general partner, agreed to cut its stake in the company from 28.3% to 13.2% in exchange for $400 million in cash from Phillips 66. Denver-based Whiting Petroleum merges with Houston-based Oasis Petroleum creating a new company called Chord Energy Corp valued at $6 billion with HQ in Houston.

2023

Rule making for Intensity verification for Air Pollution Control Division of CDPHE

Continual development of state GHG emissions reporting data base

Further data surveys in Western Colorado

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