Maximizing the Economic Benefits of Hydraulic Fracturing while Mitigating the Risk to Human Health in Colorado

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Executive Summary: Over the past two decades, hydraulic fracturing, commonly known as 'fracking', in Colorado has increased crude oil and natural gas production exponentially. This growth continues to benefit the Colorado economy and employs hundreds of thousands of residents across the state (U.S. EIA 2020a; Hochman 2019). However, despite these economic benefits, studies over the past ten years demonstrate that fracking presents serious environmental and human health risks, particularly to those who live near wells. Hydraulically fractured wells can release toxic hydrocarbons into the atmosphere as well as contaminate land and water supplies, which puts Colorado residents living within 1 kilometer of these wells at an increased risk for adverse dermal and upper respiratory symptoms (Jackson et al. 2014, 347-348; Rabinowitz et al. 2015, 25). Additionally, people living within ½ mile of a well are at an increased risk for developing cancer (McKenzie et al. 2012, 85). Colorado Senate Bill 19-181 responded to this issue in 2019 by delegating regulation of fracking to local jurisdictions (SB 19-181). However, this legislation attempts to solve a statewide issue at a local level and is therefore an inconsistent and insufficient response. For this reason, I urge the Colorado state government to reclaim the authority to regulate fracking and implement a policy to ban all wells within 3000 feet of residential areas and schools, effective 2 years from date of passage. This measure will reduce residents' exposure to toxic chemicals and their risk of disease while allowing the fracking industry to continue to benefit the Colorado economy and energy sector.

I. Introduction and background

In the modern world, energy is everything. While renewable sources comprise 20% of the energy produced in the United States, most energy comes from non-renewable sources to include coal, natural gas, and nuclear power (U.S. EIA 2020c). Since fossil fuels are a limited resource and crucial to energy production, it is important to maximize the amount that can be extracted from the Earth. Hydraulic fracturing is a drilling technique that allows for the extraction of natural gas and oil from impermeable rocks that previously prevented the extraction of fossil fuels. The fracking process works by injecting a liquid consisting of water and chemical additives, such as lubricants and sand to prop open fractures, approximately 1-3 km into the earth via a vertical well (Bazant et al. 2014, 101010-1). The liquid is then channeled through horizontal boreholes using high-power pumps at the surface. The pressure created by the surface pumps in the horizontal boreholes causes fractures to form in the impermeable rock layer, allowing for the extraction of trapped, previously inaccessible oil and natural gas (Bazant, et al. 2014, 101010-1-101010-2). The combination of horizonal drilling and hydraulic fracturing technology has greatly increased the yield of oil and gas from the Earth's subsurface (U.S. EIA 2020a, U.S. EIA 2020b).

i. History

Fracking originated in the Civil War era, when Col. Edward Roberts discovered that detonating torpedoes in artesian oil wells increased their yield (AOGHS 2020). In the 1940s, the use of high-pressure liquid blasts replaced explosives as the primary

means for fracturing subterranean rock (Denchak 2019). Modern fracking began in the 1990s when Nick Steinsberger utilized a "slick-water frack" for the first time. Steinsberger's liquid consisted of water, sand, and other chemicals that proved to be more effective in extracting fossil fuels (Gold 2018).

ii. Associated hazards

While fracking has increased fossil fuel extraction, it is a controversial technique in the U.S. and around the world due to its effects on the environment and human health (Davis & Fisk 2014, 6-13; Aczel et al. 2018, 431-438; Thomas et al. 2017, 4-13). One primary concern is the release of greenhouse gasses and volatile organic compounds (VOCs) into the atmosphere. The presence of VOCs in the troposphere causes the abundance of ozone, a greenhouse gas, to increase. For this reason, VOCs can be considered an indirect greenhouse gas and thus contribute to climate change (Albritton et al. 2001, 44). Additionally, these substances are generally toxic. High concentrations of VOCs, such as benzene and toluene, were reported less than 500 feet downwind from well pads in an air sampling study conducted in Garfield County, Colorado (Jackson et al. 2014, 347-348). Furthermore, in the oil and gas-rich Denver basin region, 70% of the total VOC emissions stem from approximately 6,000 oil and condensate storage tanks that contain liquid hydrocarbons produced by natural gas wells (Jackson et al. 2014, 348; Snyder et al. 2017, U.S. EIA 2013). These toxic emissions are detrimental to the health of nearby Colorado residents.

The other major issue with fracking is its potential to contaminate groundwater. When exposed to high pressure, wells can release contaminated fracking liquids into local groundwater sources (John 2020, 3). Furthermore, the chemical additives that allow the water-based solution to be effective for fracturing shale are toxic and will contaminate groundwater if they are not filtered out (Kharaka et al. 2013, 420-421). Wells with poor integrity due to hydraulic fracturing and poor cement casings also have the potential to leak gaseous toxins and hazardous chemicals into groundwater sources (Jackson et al. 2014, 337-338). This potential leakage is hazardous to Colorado residents who rely on local water wells for drinking water.

Finally, hydraulic fracturing requires millions of gallons of freshwater, straining limited water resources in the western U.S. (Goodwin et al. 2014, 5993-5995). To exploit the benefits of fracking while mitigating the risks, evidence-based, scientifically-sound policies are necessary.

II. Analysis

i. Current regulation

Fracking regulation in Colorado is administered primarily by the Colorado Oil & Gas Conservation Commission (COGCC). Recently, Colorado Senate Bill 19-181 rebranded the COGCC as the chief state agency in regulating oil and natural gas production with the intent of protecting public health and the environment. SB 19-181 also delegated more authority to local jurisdictions, allowing them to place additional regulations on the surface impacts of drilling (SB 19-181). Some potential restrictions that could be imposed by local governments include increased setback distances for surface drilling, more stringent inspection standards, higher inspection fees, drilling moratoriums, and an increased authority to withhold or delay drilling permits (Little & Prulhiere 2019, 120-121; Avery 2019). SB 19-181 is controversial since Colorado oil production accounts for over 89,000 jobs and adds more than $13.5 billion to the state GDP and the law is viewed by some as a threat to the oil and gas sector of the state economy (Orlando 2019, 12, 14; Clark 2019).

ii. Oil and natural gas sector growth

In 2008, Colorado began to employ shale oil extraction, allowing drillers to extract oil trapped in shale reserves, to include Mancos Shale in the Piceance Basin, the second-largest deposit in the U.S. (Orlando 2019, 9-10; Loris & Tubb 2016). The yearly production of crude oil since 2005 follows an exponential trendline, as depicted in Fig. 1 (U.S. EIA 2020a). Since fracking is generally used to extract shale oil and gas, this exponential growth can be attributed to the growing prevalence of fracking in Colorado (Rosa et al. 2018, 745). If the current growth trend continues, Colorado will produce approximately 316,000 barrels of oil in 2022, a 66% increase from 2019 (U.S. EIA 2020a). Therefore, any substantial restriction on fracking would inhibit oil production and adversely affect employment and energy production revenue. Additionally, restrictions on fracking could prevent natural gas production, which has grown steadily over the past 15 years and

accounts for over 120,000 jobs and $17 billion in Colorado (Hochman 2019).

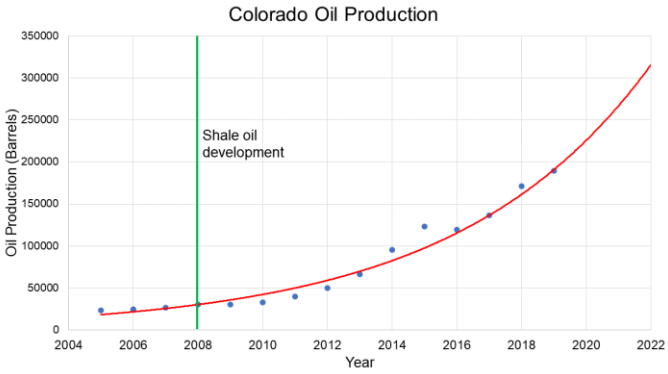

Figure. 1. Crude oil production in Colorado since 2005. The trendline depicts exponential growth in the number of barrels of crude oil produced during the corresponding year in Colorado. This growth is likely due to the development of shale oil extraction in 2008 (U.S. EIA 2020).

ii. Human health risks

Despite the potential detrimental economic consequences of limiting fracking, increased regulation may be warranted due to the harmful effects it can have on the environment and the health of people that live near wells. According to a 2015 study, people living less than 1 kilometer, or approximately 3000 feet, from a fracking well are four times as likely to show adverse dermal symptoms, such as rashes and dermatitis, and three times as likely to show adverse upper respiratory symptoms than those living more than 2 kilometers from a well (Rabinowitz et al. 2015, 25). Furthermore, people living within ½ a mile of a well are 66% more likely to be diagnosed with cancer due to the increased concentration of harmful hydrocarbons released into the atmosphere by fracking wells (McKenzie et al. 2012, 85). This is likely because 75% of the chemicals identified in natural gas operations can affect the skin and respiratory system and 25% are carcinogens (Colborn et al. 2011, 1039, 1046). In addition to negative health implications, fracking has also been shown to cause an increased crime rate in communities surrounding wells, likely associated with a rise in young male laborers (Bartik et al. 2019, 134). For these reasons, policymakers must weigh the consequences to human health and the environment against the economic benefits of fracking.

III. Courses of action

It is important to note that all three presented options would replace Colorado SB 181-19, returning jurisdiction over fracking to the state government.

i. Option 1: Ban hydraulic fracturing in Colorado

The first course of action to address fracking in Colorado is a statewide ban and mandated plugging of all wells due to the potential health and environmental risks. This option has several benefits. First, it eliminates the human health risks associated with fracking. Over 255,000 Colorado residents live within 3000 feet of a fracking well and are thus at an increased risk for health issues (Czolowski et al. 2017, Table S3). By banning fracking, residents would no longer be subject to harmful pollutants or the increased crime rate in their communities correlated with the presence of fracking wells (Bartik et al. 2019, 134). Moreover, the plugging of all wells would greatly reduce methane emissions in Colorado (Marcacci 2018).

One enormous cost associated with this option is the loss of fracking employment, which would put hundreds of thousands of Colorado residents out of work and therefore negatively impact the economic well-being of their communities. Colorado produces over two times as much energy as consumed annually, 91% of which comes from oil and natural gas (U.S. EIA 2020b). As fracking is the main source of these natural resources, banning the technology would prevent Colorado from being energy independent and force the state to import natural resources to meet their energy needs. Mitigating these effects would require a massive investment in alternative energy sources.

ii. Option 2: Increase crack density of hydraulically fractured wells

The second option is a law to mandate that drillers increase the density of cracks within hydraulically fractured wells while decreasing the size of the cracks. Creating a "densely fractured volume with many narrow cracks" as opposed to fewer wide cracks reduces the contaminated water flowback (Bazant et al. 2014, 101010-9). This course of action would reduce the amount of contaminated water flowback resulting from hydraulic fracturing while also decreasing the likelihood that contaminated water and hazardous gases would reach groundwater sources via subsurface cracks. One cost of this option

is the need to restructure fracking wells. Without government aid, this cost would fall on fracking companies, thus inhibiting their growth. This option could also be detrimental to the environment as it would require the use of more contaminated water to refracture existing wells. Finally, this option does little to address gas emissions and their effects on the health of nearby residents.

iii. Option 3: Increase surface setback distance requirement for hydraulically fractured wells

The third option is a law mandating that all fracking wells be set back at least 3000 feet from residential areas and schools, effective 2 years from passage of the legislation. Additionally, this option would enact an immediate ban on wells within 1000 feet of residential areas and schools and mandate that all abandoned wells be plugged. Like the first proposed action, this option reduces the risk of health problems due to fracking for over 255,000 Colorado residents (Czolowski et al. 2017, Table S3). However, this law would not dismantle the fracking industry. Instead, it would allow drillers to construct new wells away from residential areas while allotting 2 years for existing close-proximity wells between 1000 and 3000 feet from residential areas and schools to continue operation before being shut down. Therefore, local economies could continue to take advantage of the economic benefits of fracking, enabling Colorado to maintain a large degree of energy independence.

Additionally, the 2,556 active wells within 1000 feet of schools and residential areas make up less than 7% of Colorado hydraulically fractured wells and ceasing their operation would result in only a 1% subsurface resource loss (Finley 2019, FracTracker 2020, Ericson et al. 2019, 6-7). Given that these close-proximity wells pose the greatest risk to human health, the immediate ban on them would be worth the minimal resource loss. The main cost associated with this law is the large proportion of the subsurface that would become inaccessible, thus limiting producers' ability to extract oil and gas (Ericson et al. 2019). However, by increasing the subsurface horizontal drilling distance of wells to three miles, the estimated resource loss is only 25% (Ericson et al. 2019, Appendix Figure S3). This resource loss could be further mitigated by increasing the horizontal drilling distance beyond three miles as there is no current regulatory limit on subsurface drilling. The subsurface extension of wells is a viable option that has the potential to yield oil and natural gas safely as some horizontal boreholes are several kilometers long (Bazant 2014, 101010-1). Nevertheless, after the 2-year transition period expires, oil and gas production could decrease and cause the Colorado economy to shrink.

IV. Policy recommendation

The most advantageous solution to the issue of fracking in Colorado is a policy that would reclaim the Colorado state government's jurisdiction over fracking and implement a ban on all fracking within 3000 feet of schools and residential areas, fully effective 2 years after its passage. The law would also prohibit wells within 1000 feet of residential areas and schools, effective immediately and ensure that all abandoned wells are plugged. This policy is beneficial for several reasons. First, and most importantly, it addresses the human health risks posed by fracking. For people living more than 3000 feet from a fracking well, there is no statistically significant relationship between well proximity and an increase in dermal, respiratory, cardiac, gastrointestinal, or neurological symptoms (Rabinowitz et al. 2015, 25). Therefore, by mandating a well setback distance of 3000 feet from schools and residential areas, 255,000 Colorado residents would be at a lower risk for various health conditions. Furthermore, it would mitigate this risk while appealing to those who oppose increased fracking regulation and without sacrificing the economic benefits.

Banning wells within 1000 feet of residential areas and schools immediately is an acceptable loss as the ban would protect those at highest risk of inhaling toxic hydrocarbons. The policy would also alleviate a potentially significant disruption to the oil and natural gas industries resulting from a sudden ban on all wells within 3000 feet of residential areas. Instead, it will allow companies 2 years to increase the subsurface horizontal drilling distance in their wells to compensate for the resources lost from their close-proximity wells. Finally, this policy would likely gain a substantial level of public support, as a 2020 survey showed that 70% of Colorado residents believe that the effect of drilling on local land, air, and water is at least a "somewhat serious" problem (Colorado College 2020).

V. Conclusion

Fracking and the extent to which the technology is regulated presents a complex issue in Colorado. The energy industry is an important part of Colorado's economic welfare, and arguable 'overregulation' of fracking would be detrimental to economic growth. In 2019, oil and gas production in Colorado contributed over $30 billion to the state GDP and accounted for over 200,000 jobs (Hochman 2019). As depicted in Fig. 2, the onset of the 2020 COVID-19 pandemic caused crude oil prices to plummet. This sudden decrease, however, is likely only a temporary roadblock for the Colorado oil and natural gas industry, which is projected to rebound in the next 1-2 years and thrive for decades to come (Collins 2020).

While the increase in oil and natural gas production due to fracking benefits workers and the Colorado economy, the health risks that it poses are detrimental to hundreds of thousands of Colorado residents. Recent studies have determined that people living within 3000 feet of a hydraulically fractured well are at a much higher risk for adverse dermal and upper respiratory symptoms (Rabinowitz et al. 2015, 25). Living in proximity to wells has also been linked to an increased risk of cancer (McKenzie et al. 2012, 85). For these reasons, the Colorado state government should move swiftly to reclaim its authority to regulate fracking and implement a ban on fracking wells within 3000 feet of residential areas and schools. This policy will allow the oil and natural gas industry to continue to prosper while protecting the health and welfare of all Colorado citizens.

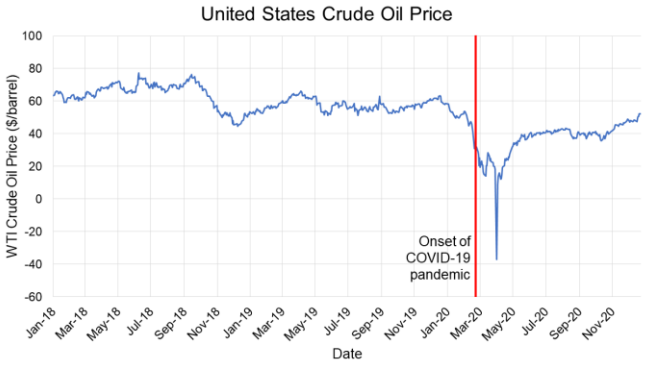

Figure 2. West Texas Intermediate (WTI) crude oil price since 2018. The price declined sharply following the onset of the COVID-19 pandemic but has since begun to recover as the demand for crude oil continues to increase with the opening of the worldwide economy (U.S. EIA 2021).

References

Aczel, Miriam R., Karen E. Makuch, and Manel Chibane. "How much is enough? Approaches to public participation in shale gas regulation across England, France, and Algeria." *The Extractive Industries and Society* 5, no. 4 (November 2018): 427-440. https://doi.org/10.1016/j.exis.2018.10.003.

Albritton, Daniel L., Myles R. Allen, Alfons P. M. Baede, John A. Church, Ulrich Cubasch, Dai Xiaosu, Ding Yihui et al. *Climate Change 2001: The Scientific Basis*. Cambridge: Cambridge University Press, 2001. Accessed January 18, 2021. https://www.ipcc.ch/site/assets/uploads/2018/03/WGI_TAR_full_report.pdf.

American Oil & Gas Historical Society. "Shooters – A "Fracking" History." Last modified April 20, 2020. https://aoghs.org/technology/hydraulic-fracturing/.

Avery, Greg. "Colorado oil and gas well permitting cut in half by drilling reforms." *Denver Business Journal*, November 8, 2019. https://www.bizjournals.com/denver/news/2019/11/08/colorado-oil-and-gas-well-permitting-post-reform.html.

Bartik, Alexander W., Janet Currie, Michael Greenstone, and Christopher R. Knittel. "The Local Economic and Welfare Consequences of Hydraulic Fracturing." *American Economic Journal: Applied Economics* 11, no. 4 (October 2019): 105-155. https://www.aeaweb.org/articles?id=10.1257/app.20170487.

Bazant, Zdenek P., Marco Salviato, Viet T. Chau, Hari Viswanathan, and Aleksander Zubelewicz. "Why Fracking Works." *Journal of Applied Mechanics* 81, no. 10 (October 2014): 101010-1-101010-10. https://doi.org/10.1115/1.4028192.

Clark, Douglas. "Organizations oppose Colorado SB 19-181." *Daily Energy Insider*, March 21, 2019. https://dailyenergyinsider.com/news/18315-organizations-oppose-colorado-sb-19-181/.

Colborn, Theo, Carol Kwiatkowski, Kim Schultz, and Mary Bachran. "Natural Gas Operations from a Public Health Perspective." *Human and Ecological Risk Assessment* 17, no. 5 (September/October 2011): 1039-1056. https://doi.org/10.1080/10807039.2011.605662.

Collins, Vicky. "Colorado oil and gas industries in COVID slump, likely won't recover until mid-2021." *Empowering Colorado*, December 14, 2020. https://empoweringcolorado.org/2020/12/14/oil-and-gas-workforce/.

Colorado College. "The 10th Annual Survey of Voters in the Rocky Mountain West." Last modified December 17, 2020. Accessed January 16, 2021. https://www.coloradocollege.edu/other/stateoftherockies/conservationinthewest/.

Czolowski, Eliza D., Renee L. Santoro, Tanja Srebotnjak, and Seth B. C. Shonkoff. "Toward Consistent Methodology to Quantify Populations in Proximity to Oil and Gas Development: A National Spatial Analysis and Review." *Environmental Health Perspectives* 125, no. 8 (August 2017): 086004-1 – 086004-11. https://doi.org/10.1289/EHP1535.

Davis, Charles, Jonathan M. Fisk. "Energy Abundance or Environmental Worries? Analyzing Public Support for Fracking in the United States." *Review of Policy Research* 31, no. 1 (January 2014): 1-16. https://doi.org/10.1111/ropr.12048.

Denchak, Melissa. "Fracking 101." Natural Resources Defense Council. Last modified April 19, 2019. Accessed November 13, 2020. https://www.nrdc.org/stories/fracking-101.

Ericson, Sean J., Daniel T. Kaffine, and Peter Malinoff. 2019. "Costs of increasing oil and gas setbacks are initially modest but rise sharply." Colorado School of Mines Working Paper 2019-06, Division of Economics and Business, Golden, CO. https://doi.org/10/1016/j.enpol.2020.111749.

Finley, Bruce. "Colorado to tighten oversight of oil and gas sites near homes in wake of study finding possible short-term health effects." *The Denver Post*, October 17, 2019. https://www.denverpost.com/2019/10/17/colorado-oil-gas-health-risks-study/.

FracTracker. "Colorado Oil and Gas Activity." Last modified August 12, 2020. Accessed November 13, 2020. https://www.fractracker.org/map/us/colorado/.

Gold, Russell. "The Texas Well That Started the Fracking Revolution." *The Wall Street Journal*, June 29, 2018. https://www.wsj.com/articles/the-texas-well-that-started-a-revolution-1530270010.

Goodwin, Stephen, Ken Carlson, Ken Knox, Caleb Douglas, and Luke Rein. "Water Intensity Assessment of Shale Gas Resources in the Wattenberg Field in Northeastern Colorado." *Environmental Science & Technology* 48, no. 10 (2014): 5991-5995. https://doi.org/10.1021/es404675h.

Hochman, Nate. "Colorado's Anti-Fracking Law Illustrates the State's Growing Divide." *National Review*, July 24, 2019. https://www.nationalreview.com/2019/07/colorados-anti-fracking-law-illustrates-the-states-growing-divide/.

Jackson, Robert B., Avner Vengosh, J. William Carey, Richard J. Davies, Thomas H. Darrah, Francis O'Sullivan, and Gabrielle Petron. "The Environmental Costs and Benefits of Fracking." *Annual Review of Environment and Resources* 39 (2014): 327-362. https://doi.org/10.1146/annurev-environ-031113-144051.

John, Zira Quaghe. "Fracking in Colorado: Evidence, politics and policy change." *Cambridge Journal of Science & Policy* 1, no. 2 (2020): 1-9. https://core.ac.uk/download/pdf/322485779.pdf.

Kharaka, Y. K., J. J. Thordsen, C. H. Conway, and R. B. Thomas. "The Energy-Water Nexus: Potential Groundwater-Quality Degradation Associated with Production of Shale Gas." *Procedia Earth and Planetary Science* 7 (2013): 417-422. https://doi.org/10.1016/j.proeps.2013.03.132.

Little, David R. and Diana S. Prulhiere. "Colorado." *Oil and Gas, Natural Resources, and Energy Journal* 5, no. 2 (2019): 117-127. https://digitalcommons.law.ou.edu/cgi/viewcontent.cgi?article=1210&context=onej.

Loris, Nicolas and Katie Tubb. "Colorado's Discovery of Massive Oil and Gas Reserves: A Case for Local Energy and Environment Policy." *The Heritage Foundation*. October 24, 2016. https://www.heritage.org/environment/report/colorados-discovery-massive-oil-and-gas-reserves-case-local-energy-and#:~:text=The%20discovery%20makes%20Colorado's%20Mancos,barrels%20of%20natural%20gas%20liquids.

Marcacci, Silvio. "Plugging Abandoned Oil Wells Is One 'Green New Deal' Aspect Loved By Both Republicans And Democrats." *Forbes*. September 21, 2020. https://www.forbes.com/sites/energyinnovation/2020/09/21/plugging-abandoned-wells-the-green-new-deal-jobs-plan-republicans-and-democrats-love/?sh=1e59729e2e10.

McKenzie, Lisa M., Roxana Z. Witter, Lee S. Newman, and John L. Adgate. "Human health risk assessment of air emissions from development of unconventional natural gas resources." *Science of the Total Environment* 424 (May 2012): 79-87. https://doi.org/10.1016/j.scitotenv.2012.02.018.

Orlando, Michael J. *Colorado Oil & Gas Industry Economic and Fiscal Contributions, 2017.* Denver: University of Colorado Denver, Business School, 2019. Accessed September 21, 2020. https://www.coga.org/uploads/1/2/2/4/122414962/coga_economic_fiscal_impacts_-_final.pdf.

Rabinowitz, Peter M., Ilya B. Slizovskiy, Vanessa Lamers, Sally J. Trufan, Theodore R. Holford, James D. Dziura, Peter N. Peduzzi, Michael J. Kane, John S. Reif, Theresa R. Weiss, and Meredith H. Stowe. "Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania." *Environmental Health Perspectives* 123, no. 1 (January 2015): 21-26. https://doi.org/10.1289/ehp.1307732.

Rosa, Lorenzo, Maria Cristina Rulli, Kyle Frankel Davis, and Paul D'Odorico. "The Water-Energy Nexus of Hydraulic Fracturing: A Global Hydrologic Analysis for Shale Oil and Gas Extraction." *Earth's Future* 6, no. 5 (May 2018): 745-756. https://doi.org/10.1002/2018EF000809.

Senate Bill 19-181, Colorado Session Law (2019).

Snyder, Jennifer, Regi Oommen, and Mike Pring. "Oil and Gas 101: An Overview of Oil and Gas Upstream Activities and Using EPA's Nonpoint Oil and Gas Emission Estimation Tool for the 2017 NEI." Presentation at 2017 Emission Inventory Conference, Baltimore, MD, August 15, 2017. https://www.epa.gov/sites/production/files/2017-10/documents/oil_and_gas_101_training_8_15_17.pdf.

Thomas, Merryn, Nick Pidgeon, Derrick Evensen, Tristan Partridge, Ariel Hasell, Catherine Enders, Barbara Herr Harthorn and Michael Bradshaw. "Public perceptions of hydraulic fracturing for shale gas and oil in the United States and Canada." *WIREs Climate Change* 8, no. 3 (May/June 2017): 1-19. https://doi.org/10.1002/wcc.450.

U.S. Energy Information Administration. "Colorado Field Production of Crude Oil." Last modified August 31, 2020. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpco1&f=a.

U.S. Energy Information Administration. "Colorado State Profile and Energy Estimates." Accessed October 12, 2020. https://www.eia.gov/state/?sid=CO#tabs-1.

U.S. Energy Information Administration. "Cushing, OK WTI Spot Price FOB." Last modified January 13, 2021. https://www.eia.gov/dnav/pet/hist/RWTCD.htm.

U.S. Energy Information Administration. "EIA's Proposed Definitions for Natural Gas Liquids." Last modified June 14, 2013. https://www.eia.gov/petroleum/workshop/ngl/pdf/definitions061413.pdf.

U.S. Energy Information Administration. "Short-Term Energy Outlook." Last modified August 11, 2020. https://www.eia.gov/outlooks/steo/report/electricity.php.

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