COLORADO
Governor Jared Polis

Colorado Greenhouse Gas Pollution Reduction Roadmap

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Public Review Draft

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COLORADO
Department of Agriculture

COLORADO
Department of Natural Resources

COLORADO
Department of Public Health & Environment

COLORADO
Department of Transportation

COLORADO
Energy Office

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Frequently Used Abbreviations and Acronyms

APCD	Air Pollution Control Division of Colorado Department of Public Health and Environment
ACRE3	Advancing Colorado's Renewable Energy and Energy Efficiency Program
AQCC	Air Quality Control Commission
CH4	Methane
CO2	Carbon Dioxide
CO2$_e$	Carbon Dioxide Equivalent
CEP	Clean Energy Plan
CDPHE	Colorado Department of Health and Environment
CDA	Colorado Department of Agriculture
CDOT	Colorado Department of Transportation
CEO	Colorado Energy Office
COGCC	Colorado Oil and Gas Conservation Commission
CSG	Community Solar Garden
EERS	Energy Efficiency Resource Standard
ERP	Electric Resource Plan
EV	Electric Vehicle
DER	Distributed Energy Resource
DNR	Colorado Department of Natural Resources
IPCC	Intergovernmental Panel on Climate Change

LDAR	Leak Detection and Repair
MHD	Medium/Heavy Duty Vehicle
NOAA	National Oceanic and Atmospheric Administration
NWL	Natural and Working Lands
RPS	Renewable Portfolio Standard
SIP	State Implementation Plan
SLB	State Land Board
VMT	Vehicle Miles Traveled
ZEV	Zero Emission Vehicle

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Executive Summary

To address climate change, the Polis Administration has prioritized action on a just and equitable transition to renewable energy and pollution reduction that diversifies and strengthens our economy, creates good-paying, local jobs, and improves the well-being of our communities. This work is motivated by an imperative to protect the health and safety of all Coloradans, as well as the unprecedented opportunity to drive innovation and harness myriad consumer and economic benefits.

Further reducing greenhouse gas (GHG) pollution across our economy to meet the state's science-based goals will be no small task. And while the state has already taken a number of historic steps, we have much work to do to protect the Colorado way of life for generations to come. This work will continue to be multi-faceted and iterative, and it will require the ongoing expertise and engagement of all Coloradans.

In the 2019 legislative session Colorado passed HB19-1261, the *Climate Action Plan to Reduce Pollution* (Climate Action Plan),[1] which included science-based climate targets of reducing statewide GHG pollution 26% by 2025, 50% by 2030, and 90% by 2050 from 2005 levels. To ensure that Colorado is continuing to make progress toward these goals, Governor Polis directed State agencies to develop a comprehensive Roadmap that presents options for near-term actions (the next 1 to 2 years) and assesses the potential for additional policies to make progress toward the mid-term goal in 2030 and the 2050 goal.

The goals of the Roadmap are to assess the sources of the state's greenhouse gas pollution; to identify a series of policy actions and other steps the state can prioritize to further GHG pollution reduction and meet air quality goals by reducing other harmful air pollutants; to cultivate a strong economy; and to develop these solutions with an understanding that climate change affects communities differently and can have a disproportionate social, economic, and health impacts on communities of color and historically disadvantaged communities.

The Roadmap is the work of many state agencies including the Colorado Energy Office and the Departments of Agriculture, Natural Resources, Public Health and Environment, and Transportation. To support the state, Colorado hired Energy + Environmental Economics (E3), a leading national consulting firm with expertise in GHG modeling, to develop a model of the State's economy-wide emissions by sector.

The development of the Roadmap started in late 2019 with a review of Colorado's most recent Greenhouse Gas Inventory and an evaluation of the data used for projecting future GHG emissions in the Environmental Protection Agency (EPA) State Inventory Tool. The State agencies, in consultation with E3 and other outside experts from a Technical Advisory Group (TAG), began gathering updated data and refining modeling methods to establish a more accurate accounting of greenhouse gas emissions in Colorado in 2005— the 2005 baseline. Among other changes, the State agencies revised estimates of 2005 emissions from oil and gas operations upwards from EPA stock assumptions to reflect more recent scientific information about methane emissions. Using E3 modeling tools, the Roadmap team began assessing Colorado's greenhouse gas pollution reduction under a reference case representing the trajectory the state was on prior to the 2019 legislative session. Colorado GHG emissions in 2015 were dominated by electricity generation, transportation, building energy use (especially space heating and water heating) and the oil and gas sector. Electricity generation emissions are predominantly attributed to coal combustion with a small portion from natural gas generators. Emissions from the oil and gas sector include fugitive methane emissions from upstream and downstream operations as well as on-site combustion of fossil fuels in industrial operations. Passenger vehicles are the largest contributor to transportation emissions in the state, followed by large trucks, and air travel. Remaining direct emissions come from manufacturing and other industries, agriculture, waste, refrigerants, and coal mining.

Figure 1: 2015 Sources of Greenhouse Gas Pollution in Colorado

To better understand the impacts of recent policy changes, E3 separately evaluated projected pollution reductions resulting from legislation passed in 2019 and 2020 and from administrative actions to date by the Polis Administration. This evaluation showed that as a result of both previous work and the state's actions in the last two years to address climate change, under current policies and with pre-COVID assumptions, the state is on a trajectory to achieving approximately half the level of emissions reduction needed to meet the 2025 and 2030 reduction goals.

Figure 2: Scenario Projections of Colorado's Potential GHG Emissions
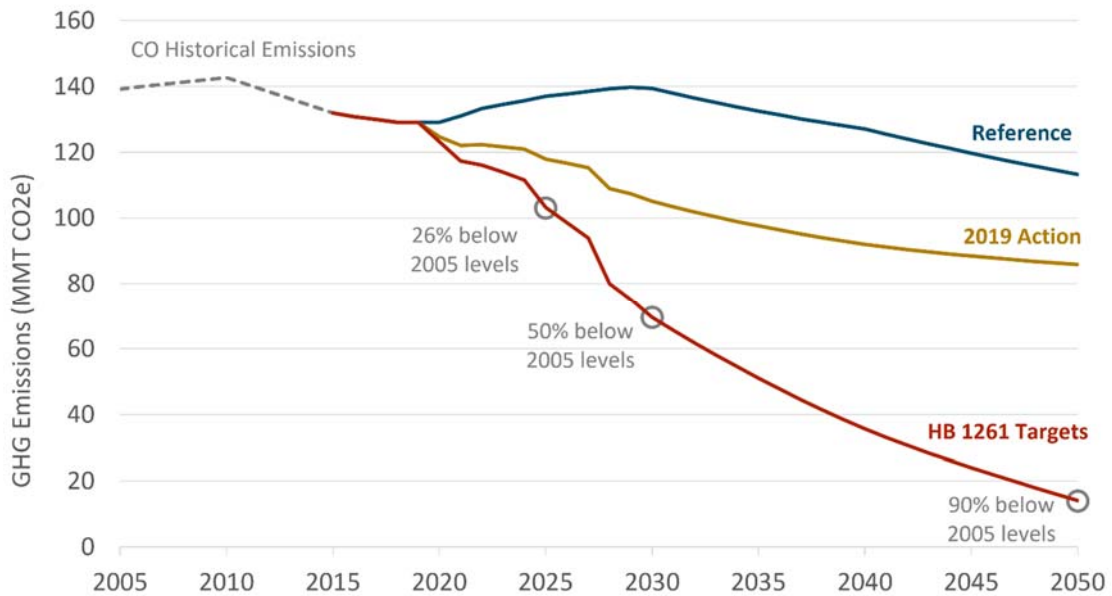
While the state has made significant progress toward meeting the 2025 and 2030 goals, additional actions are needed to get all the way there. The final purpose of the Roadmap is to identify administrative, regulatory, legislative, procurement, incentive-based, and other measures to reduce emissions in different sectors of the state's economy to achieve the 2025 and 2030 goals reduction goals in a cost-effective and equitable way and to ensure that we are on a path to meeting the 2050 GHG goals.

HB1261 Targets Scenario Emissions Reductions (relative to Reference Scenario)

Emissions Mitigation in 2030 by Wedge
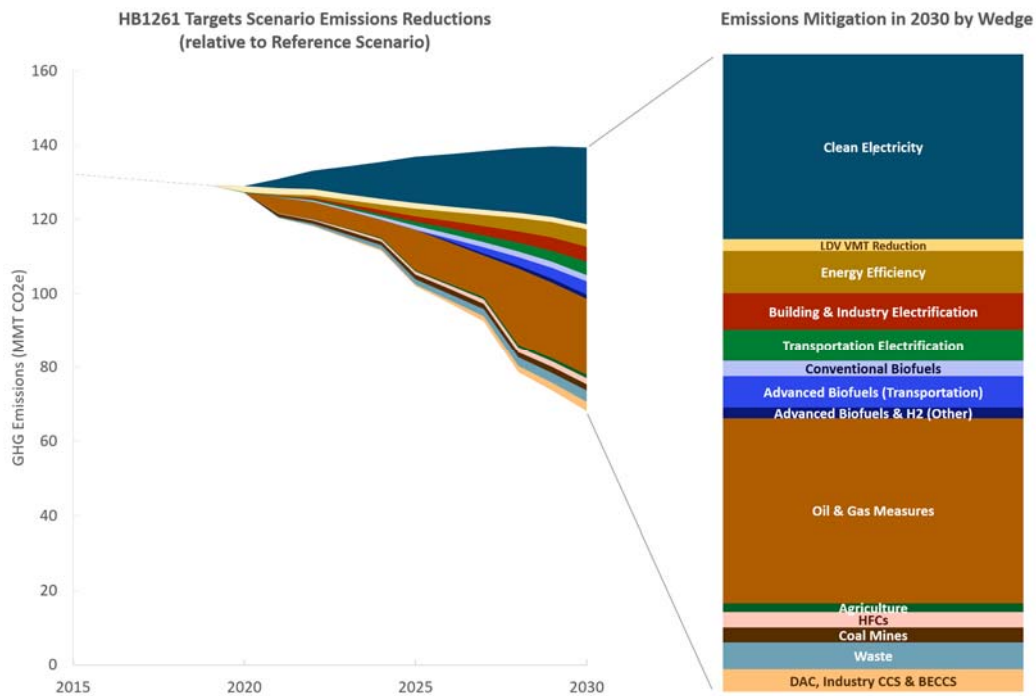
This plan has also been developed to meet the requirements of *Colorado Revised Statute* § 24-20-111, which calls for development of a state climate plan setting forth a strategy to address climate change and reduce greenhouse gas emissions while taking into account previous state actions and efforts.

The GHG Roadmap represents a significant step forward for climate action and pollution reduction planning at the state level, advancing Colorado's policy and programmatic vision for pursuing timely, enduring and equitable strategies. Progressing toward our goals will continue to be iterative and multi-faceted. We look forward to continuing engagement from a diverse set of stakeholders from across the state.

Key findings

- The largest sources of GHG pollution in Colorado are transportation, electricity generation, oil and gas production, and buildings.

- Achieving Colorado's 2025 and 2030 GHG emissions targets is feasible with existing technologies but will require actions and policies beyond those Colorado has taken already.

- Achieving the 2030 goals will rely on deep reductions in pollution from electricity generation by continuing the transition to renewable energy, as well as deep reductions in methane pollution from the oil and gas industry, which makes up the largest source of non-combustion emissions in the state.

- Making changes to transportation planning and infrastructure to reduce growth in driving is an important tool.

- Electrification of end uses in buildings and transportation will play an important role in achieving these targets, with very high levels of electrification needed to achieve the 2050 goals.

- Reducing methane emissions from landfills, sewage plants and other sources is also necessary, especially to reach emissions targets after 2030.

- All sectors have an important role to play in emissions reductions if the state is to reach 90% reductions by 2050.

Table 1: Policy Transitions

Sector	Policy Transition
Electricity	• 80% pollution reduction by 2030 through enforceable Clean Energy Plans, Regional Haze rules and other provisions • Xcel Energy and Tri-State meet energy needs with zero-carbon electricity by 2050
Transportation	• Transitioning to close to 100% electric cars on the road by 2050 and 100% market share for new vehicle sales of zero emissions trucks and buses by 2050 • Adopting lower carbon fuels including advanced biofuels, renewable natural gas and hydrogen for hard to electrify sectors such as aviation and some heavy trucks • In addition to transitioning to a cleaner fleet, expanding efforts in public transit, transportation demand management and wise land use planning to reduce vehicle miles travelled
Buildings	• Decarbonizing buildings through energy efficiency and electrification • Transitioning to biomethane, hydrogen or other lower carbon fuels
Oil and Gas	• Minimizing methane emissions from the oil and gas industry pursuant to Senate Bill19-181
Industry	• Reducing industrial emissions through efficiency, electrification, and carbon capture

	• Action on HFCs (refrigerants, aerosols, etc.)
Agriculture	• Expanding "Advancing Colorado's Renewable Energy and Energy Efficiency" (ACRE3) program • Improving soil function and carbon sequestration through regenerative farming practices • Increasing participation in Field to Market, Soil Health Partnership and Precision Agriculture programs
Natural and Working Lands	• Reducing greenhouse gas pollution and protecting and enhancing carbon sequestration on natural and working lands
Waste	• Reducing methane emissions from coal mines, landfills, sewage treatment plants, and other sources

Recommended Near-term Actions

Based on the analysis in this Roadmap, in order to achieve the deep decarbonization of the state's economy necessary to make progress towards our science-based goals, the state anticipates the following key transformations will be necessary to make progress towards the 2025 and 2030 goals: achieving at least 80% emission reductions in electricity generation; realizing deep methane emissions reductions from the oil and gas industry; accelerating the adoption of electric cars, trucks and buses; land use and transportation investment decisions that reduce the need for driving; improving building and industrial energy efficiency; beginning the transition to electric space and water heating; and reducing methane emissions from landfills, sewage treatment plants, and other sources. The chart below summarizes in more detail recommendations for near term action to achieve the necessary level of reductions. Appendix D describes the methodology that the state agencies used to model the emissions reductions associated with these actions. The section on

recommended near term actions describes these recommended strategies in greater detail.

Table 2: Proposed Near Term Actions to Reduce GHG Pollution

Sector	Proposed Near Term Actions
Electricity	• Adopt Clean Energy Plans and hold AQCC Regional Haze rulemakings to reach 80% pollution reductions by 2030 • Consider mechanisms such as performance based regulation at the PUC and other tools to incentivize deeper emissions reductions and serve new beneficial electrification load with zero carbon generation
Transportation	• GHG pollution standards for transportation plans • Trip reduction/Transportation Demand Management (TDM) requirements and encouraging telecommuting for large employers • Clean trucking strategy with multiple components including infrastructure investments, incentives for fleet turnover, and evaluation of regulatory options. More details are on page 69 of the report. • New revenue to fund infrastructure and incentives to transition to low and zero emissions cars, trucks and buses • Incentives for land use decisions by local governments that reduce vehicles miles traveled, reduce emissions of GHGs and other pollutants, and support greater access to housing near jobs • Indirect source standards for some types of new development • Expansion of public transit, including setting the stage for front range rail

Buildings and Natural Gas Utilities	• Expand energy efficiency investments from natural gas utilities to support building shell improvements • Set carbon reduction goals, leak reduction targets, and renewable natural gas (RNG) requirements for natural gas utilities • Require existing large commercial buildings to track energy use and make progress toward energy and pollution performance standards • Support adoption of advanced building codes • Require regulated electric utilities to create programs that support customer adoption of electric heat pumps and other forms of beneficial electrification
Oil and Gas and other Industry	• AQCC rulemaking to achieve methane pollution reductions from the oil and gas industry - at least 33% reduction in total emissions by 2025 and 50% by 2030 • AQCC action on industrial energy and emission audits requirements • Additional AQCC rulemaking on HFC reduction (refrigerants, aerosols, etc.)
Agriculture	• Expand "Advancing Colorado's Renewable Energy and Energy Efficiency" (ACRE3) program • Improve soil function and carbon sequestration through regenerative farming practices • Increase participation in Field to Market, Soil Health Partnership and Precision Agriculture programs
Natural and Working Lands	• Develop a comprehensive natural and working lands emissions inventory, reduce greenhouse gas pollution and protect and enhance carbon sequestration on natural and working lands
Waste	• Reduce methane emissions from coal mines, landfills, sewage treatment plants and agriculture through renewable natural gas incentives and potential AQCC rulemaking

Colorado Greenhouse Gas Reduction Roadmap

Introduction

<u>VISION</u>

Since 2004, when Colorado became the first state to pass a voter-approved renewable energy standard, we have been at the forefront of the renewable energy transition. Governor Polis ran on a platform of achieving 100% renewable energy by 2040 and ensuring that Colorado does its part to confront the climate crisis. Fighting climate change and reducing harmful air pollution protects the health, safety, and welfare of all Coloradans, today and for generations to come. The transition to a cleaner, more just economy also provides unprecedented opportunity to drive innovation and harness the myriad consumer and economic benefits.

Over the past year, Colorado and the nation have grappled with a number of profound challenges: the COVID-19 pandemic and ensuing economic impacts, heightened attention to systemic injustices against Black and Brown Americans, and historic fires driven by drought and heat. Despite these challenges, Colorado's commitment to renewable energy, climate action, and clean air has not wavered. The investment it will take to build the clean renewable energy Colorado needs, to shift to cleaner trucks, buses and cars, and to reduce energy use in homes and businesses is critical to building a more just and equitable economy and society, protecting the health and safety of all communities across the state, and safeguarding the Colorado way of life.

To better plan for and mobilize what Colorado can do to meet these goals, State agencies were directed to work together to produce a Roadmap to greenhouse gas pollution reduction. Like any good map, the Roadmap starts with where we are, with an assessment of the sources of Colorado's greenhouse gas pollution. The Roadmap then identifies policy actions and other steps the state can prioritize to meet state GHG pollution and air quality goals by reducing harmful air pollutants while cultivating a strong economy and developing these solutions with an understanding that climate change affects communities differently and can have a

disproportionate social, economic, and health impacts on communities of color and historically disadvantaged communities.

State government cannot do this work alone. It is going to take the commitment, expertise, and engagement of Coloradans from diverse perspectives and from across the state to further refine, mobilize and implement key actions identified in this Roadmap.

BACKGROUND ON CLIMATE SCIENCE

Climate change results from certain gases, including carbon dioxide (CO_2) and methane (CH_4), absorbing energy from the infrared radiation emitted by the Earth and trapping heat. This heat trapping effect, the "greenhouse gas effect," causes atmospheric warming.[2] The scientific consensus concludes that human caused emissions of those gases, primarily from the burning of fossil fuels, is causing atmospheric warming.

Figure 4 shows the changes in average global air temperature (the thick black line) which has increased since the 19th Century, with the steepest increases coming over the last half-century. The chart also shows that average monthly temperatures are warmer (in red) and warmer by increasing amounts over that same period.

Figure 4: Global Air Temperature. Source: University of East Anglia
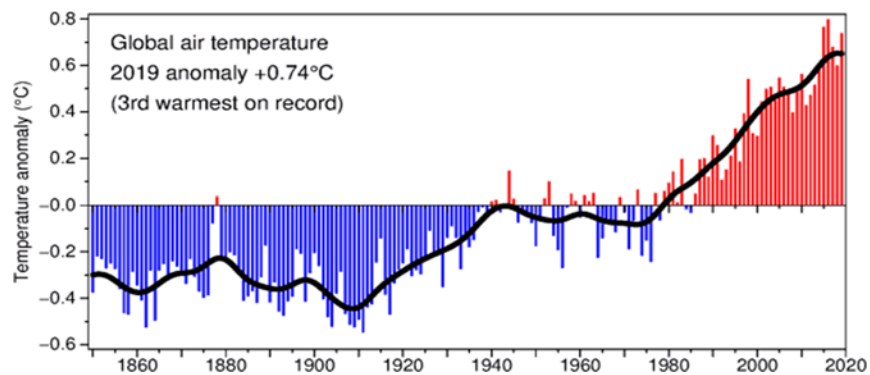
Similar results of warming are shown in Figure 5, which represents the changes in global surface temperature compared to the average temperatures from 1951-1980. Figure 5 also shows that with the exception of 1998, 19 of the 20 warmest years all have occurred since 2001.

Figure 5: Change in Global Surface Temperature. Source: NASA
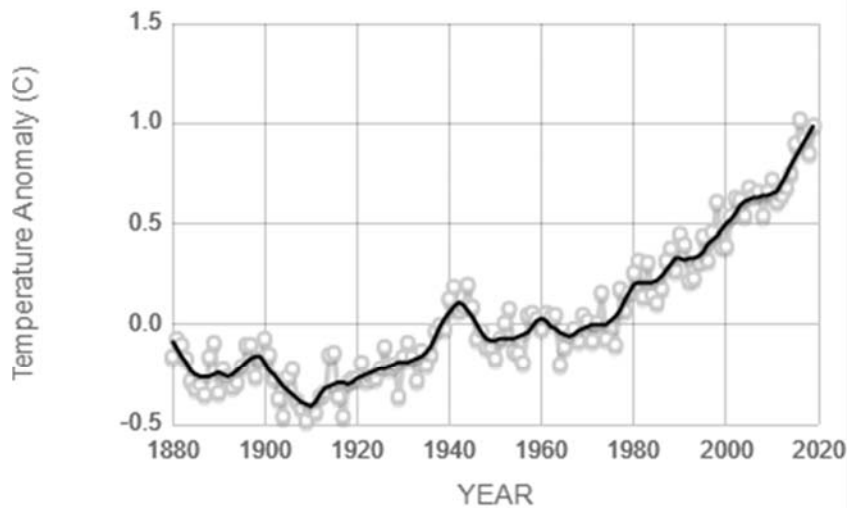
Source: climate.nasa.gov

The United Nations Intergovernmental Panel on Climate Change (IPCC), *Special Report on the Impact of Global Warming of 1.5°C* concludes that human activity is estimated to have already caused global temperatures to have increased by 1.0 degree Celsius above pre-industrial levels. The IPCC report notes that climate-related risks to health, livelihoods, food security, water supply, and economic growth are projected to increase with global warming of 1.5°C and increase further with warming to 2°C. According to the report, disadvantaged and vulnerable populations, indigenous peoples, and

GHG Pollution, Air Quality, and Climate Justice

Reducing GHG emissions also will help improve Colorado's air quality because many sources of pollution that contribute to climate change are also responsible for local and regional air pollution that is damaging to public health.

Transportation is the top source of GHGs and nitrogen oxides, one of the precursors to ground level ozone. Transportation is also a major source of particulate matter, a damaging pollutant and contributor to ozone, concentrated in places like North Denver and Commerce City. Oil and gas production is the leading source of volatile organic compounds (another ozone precursor) and a top source of methane, a potent greenhouse gas. Emissions from the oil and gas production in Denver-Julesburg basin is a key driver of ozone across the Front Range

The impacts of climate change also contribute directly to increased severity of air pollution. For example, the formation of ground level ozone in part is caused by hot weather. Forecasts project that climate change will dramatically increase the number of days over 90 degrees on Colorado's front range, likely exacerbating ozone problems.

While this dual-threat presents significant challenges for the state, it also provides an opportunity. Actions Colorado can take in key emitting areas- such as power plants, cars and trucks, and oil and gas operations, - will reduce GHG emissions and reduced local air pollution.

communities that are dependent on agriculture are at a disproportionately higher risk of adverse consequences from warming. The IPCC report explains that lowering the levels of carbon-dioxide and other greenhouse gases starting immediately improves the chance that global warming can be limited to 1.5°C. The report finds that delayed action to reduce greenhouse gas pollution increases the challenge and cost of meeting the goal and by not investing in lower-emitting technologies, risks locking-in a carbon-emitting infrastructure.

CLIMATE CHANGE IN COLORADO

Colorado's climate is changing. The state has warmed 2°F on average in the last 30 years and 2.5°F in the last 50 years.[11] Data from the Colorado Climate Center (Figure 6) shows that over the last 30 years Colorado has experienced an increased frequency of hotter than average days as represented by the red bars on the graph. The National Oceanic and Atmospheric Administration (NOAA) states that, "Average annual temperatures for Colorado have remained consistently higher than the long-term average (1895–2015) over the past two decades."[3]

Figure 6 Colorado Statewide Temperature Anomalies. Source: Colorado Climate Center

Colorado statewide annual temperature anomaly (deg F), with respect to 1901-2000 average

Data source: NOAA/NCEI
Graphic by Russ Schumacher/Colorado Climate Center
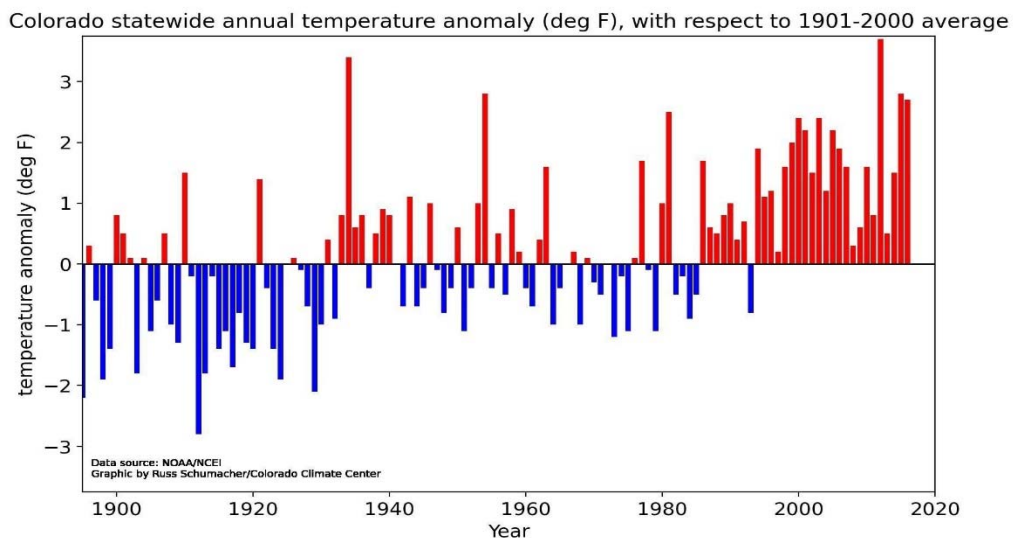
In addition, recent data from NOAA's Center for Environmental Information shows that Colorado's summer temperatures over the last three decades are the highest on record (Figure 7). The data also shows that Colorado's recent average

summer temperatures are even higher than the extreme heat of the 1930s Dust Bowl
era.[4]

Observed Summer Temperature
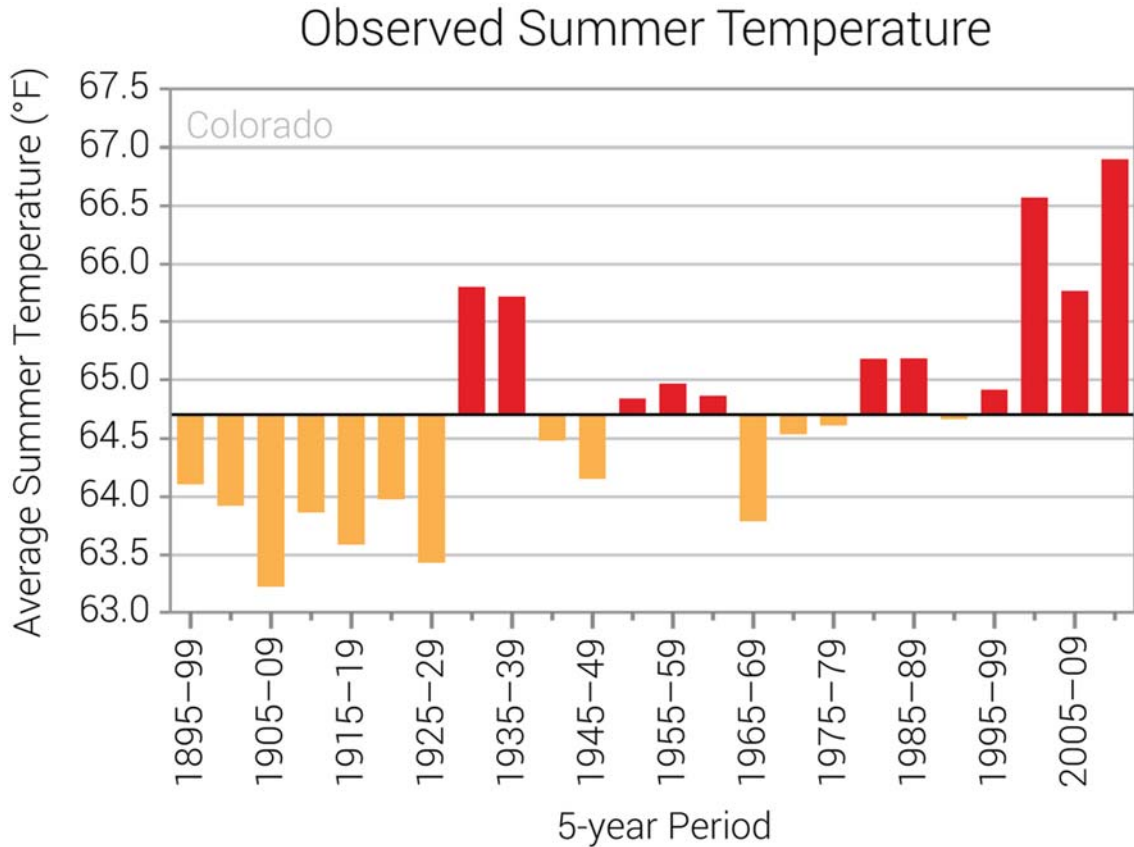
Data shows that not only are average days getting hotter, but that Colorado is
experiencing an increasing number of extreme heat days. NOAA defines "very hot
days" as having a temperature above 95°F. While NOAA notes that temperatures vary
across the state, it concludes that "The number of very hot days has been above
average since 2000"[5] as reflected in Figure 8.

Observed Number of Very Hot Days

Colorado

Y-axis: Number of Days with Maximum Temperature Above 95°F

X-axis: 5-year Period (1900–04, 1910–14, 1920–24, 1930–34, 1940–44, 1950–54, 1960–64, 1970–74, 1980–84, 1990–94, 2000–04, 2010–14)
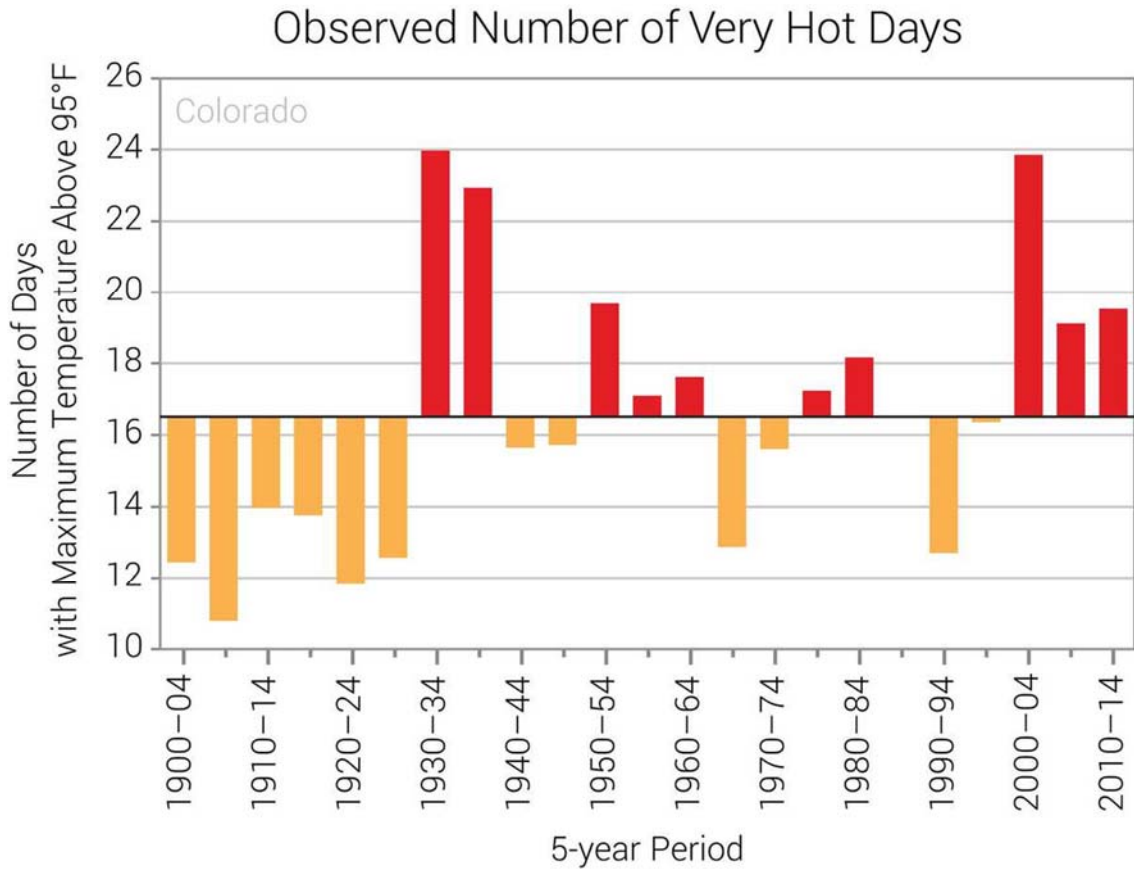
Changes to Colorado's climate resulting from this warming has resulted in an increasing trend of heat waves, droughts (see Figure 9), and more frequent and severe floods. In addition, the warming, along with other factors, has led to peak runoff coming 1 to 4 weeks earlier. This is increasing ecosystem stress through reduced stream flows, high evapotranspiration rates, drier soils, and increasing disease prevalence. Warming temperatures and dryer soils increase the likelihood of large wildfires like those that Colorado has experienced in recent summers.

Colorado Palmer Drought Severity Index
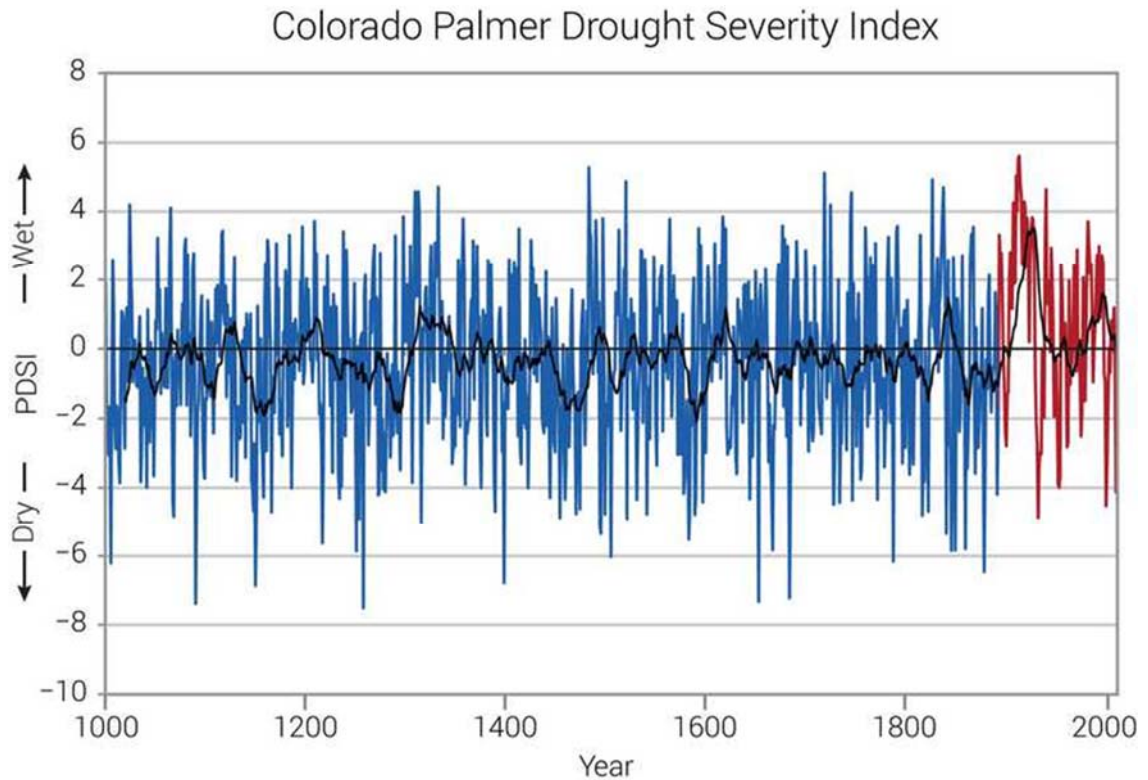
Future estimates project that temperatures could rise an additional 2.5 to 5°F by 2050.[6] As a result of continued warming, Colorado is projected to become more arid, increasing the severity of droughts and wildfires. However, projections also indicate an increase in extreme precipitation events because of increases in the atmospheric water vapor in the oceanic water vapor source regions (due to rising sea surface temperatures), which could further increase flooding in the state.[7]

Rising temperatures and a changing climate will impact key natural resources and environments in the state and industries that depend on them such as farming, ranching and outdoor recreation.

Agriculture is a key driver of Colorado's economy. According to a 2015 study, agriculture in Colorado is a $40-billion industry that employs 170,000 people. With more than 35,000 farms operating on more than 52 million acres, the success of the state's farms and ranches is tied to the health of Colorado's climate and land.[8] As Colorado's climate changes, Colorado's farmers and ranchers could face increasing

challenges. Projected earlier spring snowmelt will result in decreased instream flows through what are projected to be warmer and drier summer. Hotter days and warmer nights will increase soil dryness. Together, the changes that result from a warmer, dryer climate in Colorado could reduce crop yields, force ranchers to reduce herd size, and increase incidences of weeds and pests. In addition, these impacts could result in more and larger wildfires. The 2015 *Colorado Climate Plan* concluded "the Colorado of the future is unlikely to look like that of the past."[9]

Figure 10: Trends in April Snowpack in the Western United States. Source:

Trends in April Snowpack in the Western United States, 1955–2016

Percent change:

| < -80 | -60 to -80 | -40 to -60 | -20 to -40 | 0 to -20 | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | > 80 |
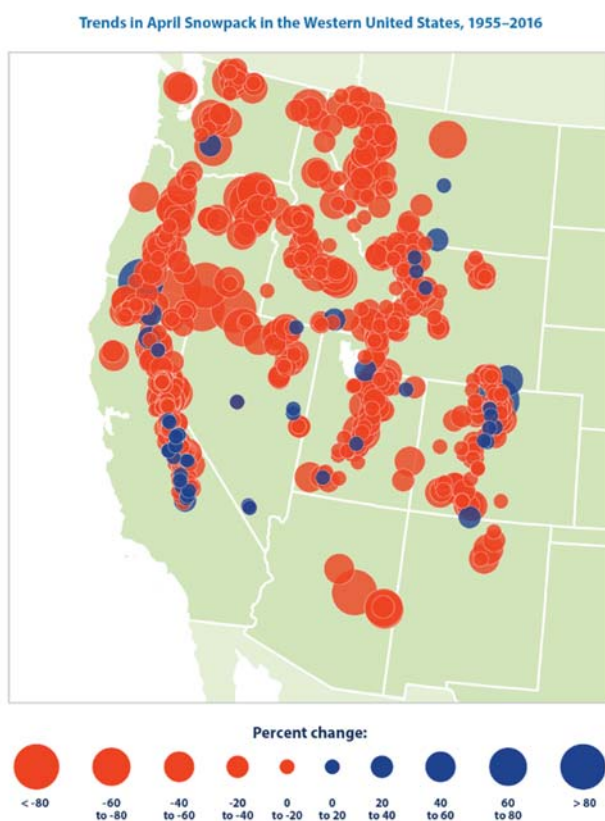
Data source: Mote, P.W., and D. Sharp. 2016 update to data originally published in: Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmaier. 2005. Declining mountain snowpack in Western North America. B. Am. Meteorol. Soc. 86(1):39–49.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

The state's mountains and rivers are not only a symbol of Colorado, but the ski resorts, parks, and gold-medal fishing waters are a leading source of tourism and revenue for the state. According to a 2018 report from Colorado Parks and Wildlife[10], outdoor recreation resulted in $62.5 billion in spending, contributing $35 billion to the state's Gross Domestic Product. The more than 500,000 jobs in outdoor recreation represent 18.7% of the state's employment. But Colorado's skiing is vulnerable to decreased snowpack and early melt, reducing the number of skiable days. Figure 10 (above) shows that Colorado's spring snowpack is declining, which means fewer ski days and fewer mountain visits. In addition, lower instream flow can increase water temperatures impacting signature fish species and impacting gold-medal fishing areas. In short, Colorado's outdoor recreation industries are vulnerable to the warming temperatures resulting from the changing climate.

Table 3 summarizes key changes to Colorado's natural resources from climate change and some of the impacts that those changes will have.

Table 3: Impacts of Climate Change in Colorado

Water	- Decreased snowpack and earlier runoff - Less water availability - Lower water quality - Risks of increased flooding
Agriculture	- Increased drought and drier soil - Decrease crop yields - Smaller herd size
Forest Health and Wildfires	- Increased insect, disease, and drought impacts on trees - Increased risk of wildfires - Increased area burned
Public Health	- Summer heat-related health risks - Health impacts from higher ozone levels due to hot summer days - Increased risk of asthma and other respiratory diseases - Increased risk of vector-borne diseases
Wildlife	- Heat, drought, and reduced snowpack impact wildlife populations - Increases in invasive species

DISPROPORTIONATE IMPACTS OF CLIMATE AND AIR POLLUTION IN COLORADO

The impacts of air pollution and climate change on human health, safety, and economic prosperity do not affect all people equally. People of color, Colorado's sovereign Tribes, lower-income individuals, historically underrepresented groups, and those experiencing multiple environmental burdens and social factors, such as systemic racism, are often most severely impacted.

Studies show that lower-income individuals and people of color experience increased health impacts and premature death due to exposure to particulate matter in the air.[11] Individuals and families who may already be dealing with chronic health conditions, inadequate healthcare or insurance, or a lack of access to trustworthy information may also be more vulnerable to the impacts from air pollution and climate change[12]. In communities that face disparate impacts from pollution – often including the confluence of industrial facilities, highways, and other sources of air pollution - there is greater frequency of more intense exposure to pollution, and a correlation to higher frequency of upper respiratory and other dangerous health impacts. These factors often overlay with compounding factors like homes with poor ventilation and, in the current environment, factors that increase risks associated with COVID-19 such as more crowded living conditions, and frequency of essential work that cannot be done remotely. In communities where infrastructure is inadequate or poorly maintained, with less access to air conditioning, and where more people count on public transit to get around, air quality and climate impacts such as high-ozone days, high levels of particulate pollution, natural disasters, and very hot days can be dangerous or even deadly.

Greenhouse gas reduction policies and programs must be developed with direct input and consideration from disproportionately impacted communities, as well as significant analysis to improve understanding of those disparities. Climate action and air quality improvement strategies that are informed by community concerns and priorities, creative solutions, and are designed to promote equity and enhance quality of life will encourage buy-in and result in lasting change.

RESILIENCE PLANNING IN COLORADO

As outlined previously, Climate change poses one of the biggest threats to Colorado's resiliency to future shock events and long-term stressors. With prolonged and more-intense drought, more frequent and severe wildfires, and more frequent and intense flooding, climate change will continue to disrupt every part of our communities if left unaddressed.

Colorado continues to plan for how to address these and other climate-related threats. As a central part of this work, the Colorado Resiliency Office (CRO) is updating the Colorado Resiliency Framework (Framework) in 2020.

With the release of the Framework in 2015, Colorado led the nation as the first state in the U.S. to develop and implement a framework for holistically addressing risks and vulnerabilities to acute shock events (like a wildfire or pandemic) and long-term stressors (like climate change, housing affordability or aging infrastructure), particularly those related to natural hazards including wildfire, drought, and flooding. With the five-year update the state is conducting now, the Framework will provide priority strategies that address climate change, risks from natural and other hazards, social equity and unique community needs, and economic vibrancy and diversity in each of the Framework's six resiliency sectors: Community Economy, Health and Social, Housing, Infrastructure, and Watersheds and Natural Resources. These strategies will enable State departments and partners to address the Framework's priority focus areas on community capacity, housing, food security, adaptive buildings and infrastructure, natural hazards risk reduction, jobs, and adaptive economy so that the state can:

- Identify and mitigate risk to Colorado communities
- Enhance resiliency planning and capacity in Colorado communities through equitable engagement and regional collaboration
- Develop, align, and streamline policies to empower resiliency
- Create a culture of inclusivity that fosters resiliency, equity, and holistic solutions, and an inherent sense of responsibility to one's community
- Ingrain equity and resiliency into investments in Colorado

The Roadmap: Purpose and Process

In the 2019 session, the Colorado General Assembly passed 14 pieces of legislation aimed at advancing clean energy and reducing the state's greenhouse pollution. In one of those pieces of legislation, the Climate Action Plan to Reduce Pollution (Climate Action Plan),[13] the legislature concluded:

> Colorado is already experiencing harmful climate impacts, including declining snowpack, prolonged drought, more extreme heat, elevated wildfire risk and risk to first responders, widespread beetle infestation decimating forests, increased risk of vector-borne disease, more frequent and severe flooding, more severe ground-level ozone pollution causing respiratory damage and loss of life, decreased economic activity from outdoor recreation and agriculture, and diminished quality of life. Many of these impacts disproportionately affect rural communities, communities of color, youth and older adults and working families. Reducing statewide greenhouse gas pollution as outlined in this subsection (2) will protect these frontline communities, first responders, and all Colorado residents from these and other climate impacts.

To reduce the potential that the state will see more severe impacts from climate change, Colorado's Climate Action Plan set science-based targets for GHG pollution reductions of 26% by 2025, 50% by 2030, and 90% by 2050 from a 2005 baseline.

<u>2019 Colorado Legislative Action Addressing Climate Change</u>

Climate Policy

Senate Bill 19-096: Collect Long-term Climate Change Data
> Requires the AQCC to collect and report on GHG pollution, forecast future emissions, and adopt a state-wide GHG reporting rule by June 1, 2020 and to begin proposing rules to address emissions by July 1, 2020.

House Bill 19-1261: Climate Action Plan to Reduce Pollution
> Establishes GHG pollution reduction goals of 26% by 2025, 50% by 2030 and 50% and 2050 from 2005 level. The bill allows the AQCC to consider other actions, including other statutes, administrative or regulatory policies, local plans and rules, and voluntary efforts as it promulgates rules to reduce pollution and ensure an equitable distribution of benefits.

Energy Efficiency

House Bill 19-1231: New Appliance and Water Efficiency Standards
> Updates and adopts energy efficiency and water efficiency standards for certain appliances and plumbing fixtures.

House Bill 19-1260: Building Energy Code
> Requires cities or counties to adopt one of the 3 most recent energy conservation codes when they update building codes.

Electric Vehicles

Senate Bill 19-077: PUC Electric Vehicle Infrastructure Programs
> Starting in 2020, requires regulated electric utilities to file a plan every three years to invest in electric vehicle infrastructure and to support customers' investments in electric vehicles.

Senate Bill 19-239: Address Impacts of Transportation Changes
> Required CDOT to convene and consult with a stakeholder group to examine impacts of new transportation technologies and business models, identify means of addressing impacts, and report findings and make recommendations to the general assembly (completed in 2019).

House Bill 19-1159: Modification to EV Tax Credits
> Extends the tax credits for purchase of an EV or hydrogen fuel cell vehicle through 2025.

House Bill 19-1198: EV Grant Fund
> Allows CEO to provide grants for and to offset operating costs for charging stations.

Modernizing Utilities and Oil and Gas Development

Senate Bill 19-181: Protect Public Welfare Oil and Gas Operations
> Changes authority over surface impacts of oil and gas development and directs adoption of rules to minimize air pollution from oil and gas operation and strengthen protections for health, safety and the environment.

Senate Bill 19-236: Public Utilities Commission (PUC)
> Directs the PUC to use a social cost of carbon in utility resource planning, to investigate utility rates, utility regulatory models, and the impacts of joining an organized electricity market. Requires the PUC to promulgate rules addressing utility resource and distribution system planning. Requires utilities to submit a workforce transition plan when proposing retirement of a coal-fired power plant. Requires Xcel Energy to file a plan to reduce carbon emissions by at least 80% by 2030 and permits other utilities to file plans to meet that target.

House Bill 19-1003: Community Solar Gardens Modernization Act
> Increases the size of an individual community solar garden (CSG) to 5 megawatts and removes certain location restrictions.

House Bill 19-1272: Housing Authority and New Energy Improvements
> Clarifies that housing authorities may use the Colorado Commercial Property Assessed Clean Energy(C-PACE) program to finance energy improvements.

House Bill 19-1314: Just Transition from Coal-Based Energy Economy
> Creates the Just Transition Office, provides support to coal workers, provides grants for communities impacted by the coal transition, and requires electric utilities that propose to retire a coal-fired power plant to file a workforce transition plan with the Just Transition Office.

Legislation enacted in 2019 also directs the Air Quality Control Commission to conduct enhanced and more frequent collection of greenhouse gas pollution data from sectors across the state's economy and to report that data to the public. The data reporting is to include not only historic emissions but will include an improved forecast of future emissions.[14] The ongoing tracking and reporting of emissions, including projections of potential future emissions, will help ensure that Colorado remains on track to meeting its goals.

After the passage of this legislation, Governor Polis directed State agencies to work together to develop a Roadmap for pollution reduction that would inform progress towards emission targets in the Colorado Climate Plan. The intent of the Roadmap is to more accurately assess the sources of the state's greenhouse gas pollution and to identify policy actions and other steps the state can prioritize to reduce greenhouse gas emissions, while also achieving state goals to reduce other air pollutants, cultivate a strong economy, and address inequities in economic and health outcomes.

State agencies, including the Colorado Energy Office and the Departments of Public Health and Environment, Agriculture, Natural Resources, and Transportation, with additional support from other agencies, worked in concert to develop the Roadmap. In addition, Colorado hired Energy + Environmental Economics (E3), a leading national consulting firm, to support the analysis behind the GHG Roadmap. E3 used the PATHWAYS modeling tool, which looks at economy-wide scenarios for emissions based on technologies and energy use, to explore options to meet Colorado pollution reduction targets. To model a cost-effective carbon-free electricity generation portfolio for the state, E3 used the RESOLVE model.

While the process of developing the Roadmap and the policy recommendations was not a straight line, there were roughly three steps the Roadmap team took. As represented in Figure 11, the development of the Roadmap included (i) an assessment of the 2005 baseline, (ii) the modeling of different emissions scenarios, and (iii) the

development of policies Colorado can implement with a focus on early action to address the 2025 and 2030 GHG reduction goals.

Figure 11: Process for Developing Colorado's GHG Pollution Reduction Roadmap

Assessment of 2005 Baseline
- Update to oil & gas emissions
- Evaluation for SIT tool
- Modeling of Colorado emissions by E3

Analysis of Emissions Scenarios
- Reference case
- 2019 Action scenario
- 1261 Target Scenario
- COVID-19 Sensitivities

Development of Policy
- Review of sector based policies
- consideration of stakeholder feedback on policy analysis
- revision to policy planning
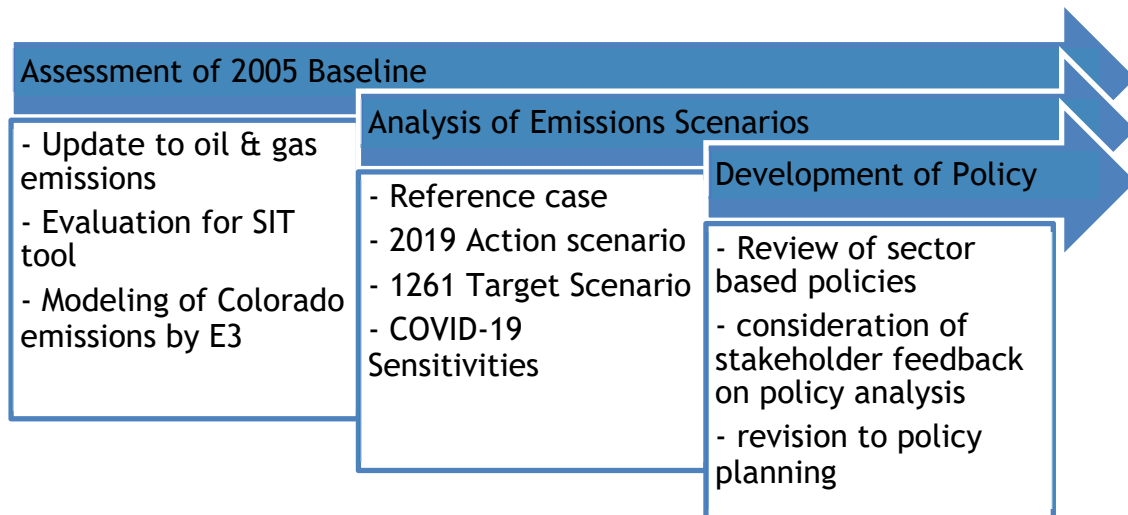
This evaluation shows that as a result of prior policies as well as legislative, regulatory and other actions during the last two years, Colorado is on a path to a 13% reduction in 2025. The state is also making substantial progress toward the 2030 target. The evaluation also shows that additional actions are needed and the Roadmap identifies administrative, regulatory, legislative, procurement, incentive-based, and other measures to progress towards the 2025, 2030, and 2050 GHG reduction goals in an equitable and cost-effective way.

In addition to proposing near-term actions Colorado can take to meet its GHG reduction goals, the Roadmap has also been developed to meet the requirements of Colorado Revised Statute § 24-20-111, which calls for development of a state climate plan setting forth a strategy to address climate change and reduce greenhouse gas emissions while taking into account previous state actions and efforts.

PHASE I - DEVELOPING THE 2005 BASELINE

The Colorado Climate Action Plan sets targets for GHG pollution reductions measured relative to 2005 levels. The 2019 *Colorado Greenhouse Gas Inventory Update Including Projections to 2020 & 2030*, which reassessed the state's 2005 emissions, identified that "There is still considerable uncertainty in much of the activity data, the emission factors, and many calculation methods" of the approach used in the modeling.[15] To provide a refinement to those approaches and to harmonize E3's modeling with the state inventory, the development of the Roadmap began in December 2019 when the State agencies and E3 began gathering data and reassessing the 2005 baseline greenhouse gas emissions inventory for Colorado. The Roadmap team worked with a Technical Advisory Group of Colorado-based experts (see sidebar) to assess the design of the study and process for developing the early model inputs and assumptions, in addition to ensuring that the process and data met with best practices. Among other changes, the Roadmap team adjusted baseline inventories of oil and gas methane emissions upwards to better reflect current scientific understanding of emissions. The state also met with other stakeholders conducting emissions modeling exercises to understand the similarities and differences in the respective efforts.

Technical Advisor Group

Early in the process, the State sought input and feedback from a Technical Advisory Group:

Dr. Morgan D. Bazilian - Director, Payne Institute, Colorado School of Mines

Jill Cooper - Senior Principal, Geosyntech

Dr. Bryan Hannegan - President and CEO, Holy Cross Energy

Jeffrey Lyng - Director of Energy and Environmental Policy, Xcel Energy

Dr. Keith Paustian - Distinguished Professor Department of Soil and Crop Sciences, Colorado State University

Dr. Gabrielle Petron - Research Scientist NOAA ESRL Global Monitoring Division

Tracy Winfree - Senior Program Manager CDR

Lee White - Managing Director Stifel Public Finance

PHASE II - BUILDING THE BASELINE AND EARLY POLICY DEVELOPMENT

In early 2020, E3 began modeling the trajectory of Colorado's greenhouse gas pollution under a Reference Case Scenario. This scenario included earlier actions that have reduced GHG pollution including the voter approved Renewable Portfolio

Standard, the legislatively adopted energy efficiency resource standard, and the effects of the Clean Air, Clean Jobs Act. Separately, E3 modeled the 2019 Action Scenario to show the impacts of utility commitments, legislation, and administrative efforts since January 2019. This evaluation showed that Colorado is on a path to 13% reduction in GHG pollution by 2025 and nearly half way to the 2030 target of a 50% reduction. Because the analysis showed that Colorado needs to take additional actions to meet its goals, the state asked E3 to model an illustrative target scenario that showed a possible set of changes and reduction that would meet the targets established in the *Colorado Climate Plan* (1261 Target Scenario).

Table 3: Key Assumptions in the Reference and 2019 Action Scenarios

Sector	Measure	Reference Scenario	2019 Action Scenario
Buildings and Industry	Energy Efficiency	Utility efficiency programs; appliance standards	2019 New Appliance Standards (HB 1231)
Transportation	CAFE Standards	Extended through 2026	
	Zero-Emission Vehicles (ZEVs)	Economic adoption (EIA), 9% sales by 2030	Navigant modeled scenario, 42% sales by 2030
Electricity Generation	Coal Retirements	Planned retirements (pre-2019 announcements)	Recent announcements (Craig 2 and 3)
	Distributed Solar	Projected trends in rooftop solar adoption	
	Carbon Targets	N/A	80% GHG Reductions by 2030, Tri-State and Xcel targets by 2050, SB 236
Oil & Gas	Control regulations	Post 2018 regulation impacts not currently modeled	
Waste and Refrigerants	Total Emissions	Grow with population, no measures	
Ag. and Coal Mine Methane	Total Emissions	Remain constant, no measures	

The Roadmap team continued meeting with members of the Technical Advisory Group to discuss the on-going modeling efforts. In February, the State agencies also provided the first of a series of regular updates on the status of the Roadmap to the AQCC. These updates included a discussion of any revisions to methodological assumptions, key findings, and potential policies the state might evaluate for early action. Time was provided for public comment on the Roadmap at each AQCC monthly meeting where the Roadmap team provided an update.

During this phase, the Roadmap project team began holding meetings with groups of stakeholders to hear feedback on the Roadmap. Over the course of the development of the project there were more than 40 meetings with groups representing local governments, the Southern Ute leadership and environmental program staff, the Ute Mountain Ute environmental program staff, the business community, environmental advocacy organizations, the outdoor recreation industry, utilities, the oil and gas industry, mining, farmers and ranchers, and organizations serving disproportionately impacted communities.[16] These meetings provided an opportunity to learn from the groups about their concerns and to hear what policies or technologies the state should consider including in the Roadmap.

Feedback from these meetings led to several changes in the report. First, as the COVID-19 pandemic began to take hold, the Roadmap team heard from many stakeholders that the modeling needed to reassess certain assumptions in light of changes to oil and gas development, driving habits, and the state' economy from COVID-19. As described in the next section, E3 and the Roadmap team evaluated the impacts of certain modeling inputs and included sensitivity analyses designed to show a reasonable potential of the impacts of the COVID-19 pandemic on the state's overall emission trajectory. Also in response to feedback, the Roadmap team conducted further review of the baseline emissions from oil and gas development, ultimately revising the numbers to align with best current information and practices.

While the Roadmap was intended to provide an initial framework for a subsequent assessment of targeted policies, additional feedback the team heard was

that the Roadmap needed to include a more targeted assessment of pollution reduction from any policies that state was considering for early action to demonstrate that those policies would close the gap to the 2025 and 2030 goals. That analysis is now included in this report and referred to throughout as the state modeling or Colorado modeling.[17]

<u>PHASE III - REFINEMENT OF POLICY ALTERNATIVES</u>

During the course of summer 2020, E3 and State agency staff began the third phase of the project. While continuing to update modeling inputs and assumptions as needed, the E3 team and state staff began working on modeling potential emissions reductions across sectors of Colorado's economy that would enable the state to make progress toward meeting the Climate Action Plan goals. Simultaneously the state team began to assess potential additional administrative, regulatory, legislative, procurement, incentive-based, and other measures to advance toward the 2025, 2030, and 2050 GHG reduction goals in an equitable and cost-effective way.

Through the summer months the agencies continued providing updates to an AQCC subcommittee and meeting with interested groups. The agencies held a virtual, online public listening session in August 2020. More than 300 Coloradans joined the two-hour event, which was hosted in Spanish and English.

Throughout the process, the Roadmap has been developed to help inform policy making and to ensure progress toward meeting the emissions targets in the Colorado Climate Action Plan. Making progress toward these emission targets will be a total state effort involving agencies and departments across state government. It will also be iterative and multi-faceted in nature and require a broad portfolio of investments, incentives, and regulatory and legislative strategies. Because the state government cannot do it alone, we intend to partner with a diverse array of local governments and public and private partners.

The GHG Roadmap represents a significant step forward for climate action and pollution reduction planning at the state level, advancing Colorado's policy and programmatic vision for pursuing timely, enduring and equitable strategies.

Progressing towards our goals will continue to be iterative and multi-faceted, and we look forward to continued engagement from a diverse set of stakeholders from across the state.

Key findings

- Making progress towards Colorado's ambitious GHG emissions targets is feasible with existing technologies but will require actions and policies beyond those Colorado has taken already.

- Making progress towards the 2030 goals will rely on rapidly reducing carbon pollution from electricity generation by continuing the transition to renewable electricity generation; dramatically reducing methane emissions from oil and gas production; accelerating the transition to electric cars, trucks and buses; making changes to transportation planning and infrastructure to reduce growth in driving; accelerating improvements to building efficiency and electrification of buildings; and reducing methane emissions from landfills, sewage plants and agriculture.

- All sectors have an important role to play in emissions reductions if the state is to reach 90% reductions by 2050.

- Electrification of end uses in buildings and transportation will play an important role in achieving these targets, with very high levels of electrification needed to achieve the 2050 goals.

- Reducing methane emissions from the oil and gas industry is essential to achieving the state's goals, as these make up the largest source of non-combustion emissions in the state.

Colorado's Roadmap to Greenhouse Gas Pollution Reduction

Progress to date

Because of early actions and commitments to addressing the climate crisis, Colorado has made significant progress on a transition to renewable energy and GHG pollution reduction. This work would not have been possible without a strong partnership among the General Assembly, public interest groups, private sector leaders, and the public.

EARLIER CLIMATE PLANS

In 2007 Governor Bill Ritter Jr. released the *Colorado Climate Action Plan: A Strategy to Address Global Warming*. The plan concluded that the scientific evidence for human-caused climate was clear. Governor Ritter called global warming "our generation's greatest environmental challenge."[18] The plan also described three principal roles for state government: enacting bridge strategies that immediately reduce greenhouse gas pollution while we pursue technologies to generate cleaner energy; providing leadership to ensure that long-term solutions, such as renewable energy, are fully developed and broadly implemented; and preparing the state to adapt to those climate changes that cannot be avoided. The plan established a goal of an 80% reduction in greenhouse gas pollution by 2050 from 2005 levels.

The 2007 plan established a goal of increasing renewable energy and reducing GHG pollution from electric utilities by 20 percent by 2020. The plan also called on State agencies to partner with research institutions and industry to develop ways to prevent methane leakage from natural gas drilling; established goals for diverting waste from landfills; directed state governments to reduce energy consumption in state buildings and vehicles; and sought to develop a workforce that would make Colorado a leader in the emerging new energy economy.

In 2014, Governor Hickenlooper released a Colorado Climate Plan that identified a number of opportunities to reduce greenhouse gas emissions at the agency level, and recommended a number of actions to help improve Colorado's ability to adapt to future climate change impacts and increase Colorado's State

agencies' levels of preparedness. In 2017, Governor Hickenlooper signed an executive order committing the state to further climate action, including reducing statewide greenhouse gas emissions 26% by 2025 from 2005 levels. Governor Hickenlooper issued an updated Climate Plan in 2018, which included the recently enacted emission reduction goals for the State of Colorado, in addition to identifying opportunities to mitigate greenhouse gas emissions and promoting state policy recommendations and actions that increase Colorado's level of preparedness for impacts of a changing climate.

EARLIER CLEAN ENERGY AND ENERGY EFFICIENCY LEGISLATION AND REGULATORY ACTION

In 2004, Colorado voters passed Amendment 37, the first-ever voter-approved Renewable Portfolio Standard ("RPS"), which set a renewable energy target of 10% by 2020 for investor-owned utilities. The legislature has amended the RPS several times including adopting changes that expanded the requirement for behind the meter generation, increased to 30% percent by 2020 the amount of renewable energy that investor-owned utilities must provide, and established renewable energy targets for rural electric cooperatives and municipal utilities.[19]

Colorado adopted legislation in 2007 that created an energy efficiency resource standard (EERS) by requiring the Public Utilities Commission (PUC) to establish energy and demand savings goals for regulated gas and electric utilities. In 2017 the law was extended to require regulated utilities to offer electric efficiency programs through 2028. As part of the update to the EERS the PUC is required to set goals of at least 5% peak demand reduction and 5% energy savings by 2028.

In 2010, the state adopted the Clean Air Clean Jobs Act, which required regulated utilities to file with the PUC plans to reduce emissions from coal-fired power plants. Xcel energy filed a plan addressing 900 megawatts (MW) of coal-fired generation and the PUC ultimately approved a plan to retire 597 MW of coal-fired generation.[20]

In 2014, Colorado became the first state to adopt regulations to reduce methane emissions from both new and existing oil and gas well operations. The

regulations have served as a model for subsequent federal and state regulations in the sector. In 2018, the Colorado Air Pollution Control Division determined that the number of methane leaks had fallen by 52% after the regulations were implemented, in the timeframe of 2015 to 2017.

In 2014, as part of the settlement of litigation around a State Implementation Plan to reduce Regional Haze, the owners of the Nucla coal-fired power plant agreed to accelerate the retirement date for the plant to 2022. The agreement was later amended to include the early retirement of a second coal-fired plant, Craig 1 in 2025. The updated plan was approved by the state Air Quality Control Commission on December 15, 2016 and approved by the Environmental Protection Agency on July 5, 2018. Ultimately, the Nucla plant was then closed early, more than two years in advance of the date set out in the settlement.

In 2016, Xcel Energy filed an electric resource plan with the PUC. During the proceeding, Xcel and more than 20 different groups joined together to present the PUC with the Colorado Energy Plan- an agreement that proposed to retire two coal-fired power plants and replace them with 1,100 MW of new wind generation and 700 MW of solar, while saving customers a projected $200 million. The Colorado Energy Plan proposed to retire Comanche unit 1 (325 MW) in 2022, 11 years ahead of schedule. Comanche unit 2 (335 MW) was proposed to retire in 2025, a decade ahead of its prior retirement date. According to analysis submitted with the plan, Xcel Energy would cut its carbon emissions from electricity generation by 60% by late 2025 from 2005 levels. The plan was also projected to create nearly 2,000 jobs and add $203.6 million in GDP statewide. The PUC approved the plan in 2018.

In 2018, the AQCC adopted the Colorado Low Emission Automobile Regulation (CLEAR) in response to efforts at the federal level to roll back vehicle emission standards. CLEAR established low-emission vehicle standards for light-duty and medium-duty vehicles in Colorado beginning with the 2022 model year. CLEAR is projected to reduce GHG pollution by more than 30 million tons cumulatively between 2022 and 2031, compared to a scenario where federal standards are relaxed,

and, due to greater vehicle efficiency, provide net savings to Colorado drivers through reduced fuel costs.

Progress under the Polis Administration

RENEWABLES ROADMAP

In June of 2019, Governor Polis released the *Roadmap to 100% Renewable Energy by 2040 and Bold Climate Action*, which included a number of key priorities and strategies, including: growing green jobs and saving consumers money; modernizing the Public Utilities Commission; promoting Energy Efficiency; putting more zero emission vehicles and commuting options on Colorado roads; moving toward zero emission buildings; supporting local commitment to 100% renewable energy; and, ensuring a Just and Equitable Transition for all of Colorado. Since the release of the 2019 Roadmap, the state has taken a number of important steps towards the identified priorities and this Roadmap builds on that work.

RECENT LEGISLATION

In 2019, Governor Polis signed into law 14 pieces of clean energy and climate legislation, including the Climate Action Plan, which established GHG pollution reduction goals. Other legislation required local jurisdictions to adopt one of the three most recent versions of the International Energy Conservation Code (IECC); created pathways for electric utilities to invest in clean energy; modernized the Public Utilities Commission; adopted new energy efficiency standards for appliances; and required investor-owned utilities to invest in electrifying transportation.

ELECTRICITY

Electricity has historically been the largest single source of greenhouse gas pollution in Colorado, driven primarily by emissions from coal power plants. A smaller portion of emissions come from natural gas power plants. However, pollution from electricity has been trending downwards for the last 15 years, driven by public policy and by changes in technology and economics. As wind and solar have been deployed on a large scale, their cost has come down dramatically through a combination of technical improvements, economies of scale, and advances in forecasting and the

ability to cost effectively integrate into the grid. This has led to new wind and solar often being less expensive than continuing to operate existing coal-fired generating plants. Governor Polis campaigned on a platform of 100% renewable electricity by 2040, in order to realize the benefits of cheaper power, lower emissions, and local economic development that can come with this transition.

In the first two years of the Administration, this transition has accelerated. Xcel Energy, the largest utility in the state, made a voluntary commitment to reduce GHG pollution by 80% below 2005 levels by 2030; Senate Bill 19-236 built on this voluntary commitment by requiring Xcel to submit a Clean Energy Plan to the PUC that will achieve an 80% carbon reduction by 2030. Xcel is required to file its Clean Energy Plan March of 2021. This plan will build on an approved plan that will retire the Comanche 1 and 2 coal units (totaling 660 MW) in Pueblo roughly a decade early and replace them with a combination of wind, solar, and storage. As part of its transition to a clean electricity generation, Xcel Energy agreed with the Evraz steel mill to construct a 250 MW solar plant on the mill's grounds–the largest behind the meter project in the country. This project will provide low cost, clean electricity at a reliable price, which enabled Evraz to announce a $480 million improvement to the Pueblo mill, including a guarantee of 1,000 jobs.[21]

Xcel also signed a settlement agreement with the City of Boulder to end a 10-year dispute over whether Boulder will form a municipal electric utility. The agreement still needs to be approved by Boulder voters. If it is approved, it sets pre-2030 GHG emissions targets, committing Xcel to greenhouse gas pollution reductions of 52% by 2022, 61% by 2024 and 67% by 2027.

The combination of Senate Bill 19-236 and House Bill 19-1261 creates strong incentives for other utilities to reduce their pollution. Under part of Senate Bill 19-236, any utility is permitted to file with the PUC a Clean Energy Plan (CEP) that reduces carbon emissions by 80% by 2030. If a utility's CEP meets this reduction target and is approved by the PUC, the utility is granted a "safe harbor" from additional regulation by the AQCC of the utility's carbon emissions through 2030. The

administration has encouraged utilities to voluntarily adopt energy plans that will achieve these goals and to file CEPs as a mechanism to achieve deep pollution reductions and a quick transition to renewables.

The state's other electric utilities with coal plants have announced plans to retire coal-fired generation and replace it with renewable energy and storage. The state's second largest utility, Tri-State Generation and Transmission (Tri-State), historically has been reliant on coal-fired generation including the Nucla plant and three coal-fired units located in Craig, Colorado. The three Craig Station units total 1,285 MW. Prior to 2019, Tri-State did not submit its resource plans to the PUC for approval. With the passage and signing of Senate Bill 19-236, Tri-State must now get approval of its Integrated Resource Plan (IRP) from the PUC. While Craig Unit 1 (427 MW) was scheduled for retirement in 2025, Craig unit 2 (410 MW) was anticipated to stay in operation through 2039 and Craig unit 3 (448 MW) was projected to run through 2044.[22] In 2019 new leadership at Tri-State worked with the administration and a variety of stakeholders to develop a new "Responsible Energy Plan," which commits to closing all Colorado coal-fired generation by 2030, and commits to closing the mines associated with those plants. As a result of the closures, the plan reduces emissions from generation located in Colorado by 90% and emissions from generation serving Colorado load by 70% (this reflects the fact that some electricity used in Colorado comes from coal generation in Wyoming). At the time the plan was announced, Tri-State's CEO described the "green dividend," in which low cost solar and wind would allow the company to make these changes without negatively impacting ratepayers. Tri-State also selected developers to add 1000 MW of wind and solar in five locations across the state. Tri-State will submit an IRP to the PUC in December 2020.

Colorado Springs Utilities, the state's third largest utility, which serves Colorado Springs and is governed by the city, is also making voluntary efforts to reduce its reliance on coal-fired generation. In June 2020, the City Council, acting as the utility board, voted to retire the Drake coal-fired unit by 2023, roughly 12 years ahead of schedule, and to retire the Ray Nixon plant by 2030. The plan presented to

the board calls for 500 MW of wind power generation capacity, 150 MW of solar, and more than 400 MW of battery storage, reducing GHG pollution by 80% by 2030.

The Platte River Power Authority (PRPA), the fourth largest utility in the state, provides power to the municipal utilities serving Estes Park, Longmont, Loveland, and Fort Collins. This summer PRPA announced plans to retire their coal plant, the Rawhide plant north of Fort Collins, by 2030. While PRPA is still in the process of adopting a full electric resource plan, the scenarios that they have evaluated that include retiring Rawhide both achieve a minimum of 90% pollution reductions by 2030. PRPA has also indicated that it intends to file a Clean Energy Plan before the Public Utilities Commission.

In the fall of 2019, Black Hills Energy filed voluntarily with the PUC to amend its current electric resource plan. In its filing, Black Hills stated that its goal was to add up to 200 MW of new renewable resources while saving money for its customers by avoiding burning natural gas. At the time the Roadmap was developed the case was still before the PUC.

The administration's strategy for the electricity sector has been to focus on achieving deep reductions in pollution (at least 80% by 2030) enabled by declining cost for wind, solar, and storage, while using the expertise of utility boards and the PUC to ensure this transition is accomplished in a way that maintains reasonably priced electricity and reliability of the system. While some of these plans are voluntary, a variety of state regulatory structures will allow these plans to be made enforceable, including placing announced coal plant retirements into enforceable State Implementation Plans (SIPs) for reducing regional haze or through the Clean Energy Plan approval processes.

In addition to the work the state is doing with utilities to reach deep pollution reduction, the State Land Board (SLB) provides opportunities for renewable energy development on state lands. The SLB has signed renewable energy leases for projects that will increase installed production capacity on State Trust Land to 520 MW,

enough energy to power 150,000 homes in Colorado, and generating revenue for Colorado's public schools.

One important benefit flowing from the rapid transition towards clean electricity is that it magnifies the pollution reduction, public health, and other benefits of electrification in other sectors, such as cars and buildings.

TRANSPORTATION

In 2020, transportation overtook electricity generation as the largest source of greenhouse gas pollution in Colorado, consistent with the trend nationwide. That is why the state is working to develop policies and strategies that will reduce emissions in this sector by making cars, trucks, and buses cleaner, by reducing the number of miles traveled, and by helping local governments invest infrastructure to reduce transportation related emissions.

Shortly after taking office, one of Governor Polis' first executive orders, (Executive Order B 2019-002) "Supporting a Transition to Zero-Emission Vehicles", committed the state to a large-scale transition to zero-emission vehicles and identified several key initiatives in support of this goal. The order directed CDPHE to develop a rule to establish a zero-emission vehicle program under Section 177 of the Clean Air Act, including proposing the rule to the AQCC by May 2019 and requiring consideration of adoption by October 30, 2019. It also required CDPHE and its partner agencies to revise the state's Volkswagen Settlement Beneficiary Mitigation Plan (BMP) to direct all remaining funds to transportation electrification projects, a process that was completed by September of 2019. Finally, Executive Order B 2019-002 laid the foundation for a number of subsequent bills and initiatives over the course of 2019 and 2020 in support of greater transportation electrification.

The AQCC adopted Low Emission Vehicle (LEV) Standards on November 16, 2018. In August 2019, the AQCC subsequently adopted Zero Emission Vehicle (ZEV) Standards. With that decision, Colorado became the first state in nearly a decade to adopt a ZEV regulation and the first ever to do so with support of automakers. State agencies negotiated an approach that created incentives for early deployment of

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ZEVs, which resulted in the associations representing 99% of auto sales supporting the proposed rule. These regulations start with model years 2022 and 2023 vehicles, respectively, and will allow Colorado to continue making progress on improving the sustainability of its transportation system in spite of federal government inaction and the roll back of nationwide emissions standards. In particular, the ZEV standard will require auto manufacturers to make a greater number and variety of clean vehicles available to Colorado consumers. Colorado's program also contains a provision that allows manufacturers to earn early action credit against their requirement by making EVs available as early as the 2021 model year. The early action credit could result in Colorado being one of the first states to receive electrified SUVs and trucks. Finally, Colorado's ZEV program also establishes a process for tracking and increasing the percentage of ZEVs on the road in the years to come.

Colorado's EV Plan

In 2020, the Colorado Energy Office updated the state's EV plan. The plan presents a framework for transitioning vehicles in Colorado, setting a goal of increasing the number of light-duty cars and trucks to 940,000 by 2030. In support of the goal, the plan also calls for transitioning medium-duty (MDV) and heavy-duty (HDV) vehicles to zero emission vehicles; undertaking a gap analysis to identify the type and number of charging stations needed across the state to meet the state's vehicle electrification goals; and for state government agencies lead by example.

A ZEV program is just one strategy needed to help the state reach its goal of 940,000 EVs by 2030. A 2019 analysis by Navigant looked at three different EV growth scenarios and found that while the ZEV program is critical to ensuring increased model availability, achievement of the state's goal will also require a significant and long term utility investment in charging infrastructure and a multi-year consumer education and awareness campaign would be needed. The analysis also stated that continuation of the Innovative Motor Vehicle Credit, albeit at a lower level, would be needed through at least 2025 to achieve the State's 2030 goal.

The Colorado Legislature passed several new laws in 2019 that support transportation electrification. The actions taken under these statutes will reinforce one another and the goals and strategies of the Colorado Department of Transportation's Clean Transportation Plan and the updated *Colorado Electric Vehicle*

*Plan 202*0. CDOT has enhanced its focus on electrification of transit fleets and is supporting zero emission vehicle adoption throughout the state through consumer education, investment in charging infrastructure programs, and additional measures to reduce emissions. CDOT is also working to expand multimodal options through its intercity bus service, Bustang, as well as the continued development and construction of mobility hubs– transportation centers that emphasize multimodal options and continuing to support local transit agencies across the state.

Senate Bill 19-077 is one of the bills passed in the 2019 legislative session that supports vehicle electrification for Colorado homes and business, including vehicle and transportation fleets. The statute requires Colorado's two investor-owned electric utilities, Black Hills and Xcel Energy, to file plans with the Public Utilities Commission for how they will invest in vehicle electrification and requires utilities to include in those plans investments that serve historically disadvantaged communities. The statute authorizes the utilities to provide electric vehicle (EV) charging as a service to customers, allows the utilities to provide incentives to customers, and to support customers' investments in charging infrastructure. To ensure that there is competition in the EV charging marketplace, the law requires the utilities to apply to the Public Utilities Commission to build facilities to support EVs. Furthermore, utilities are required to submit Transportation Electrification Plans to the PUC.

In May 2020, Xcel Energy and Black Hills Energy submitted their first Transportation Electrification Plans to the PUC. Xcel Energy's 3-year $101.5 million proposal includes a wide range of offerings to residential customers in single-family and multi-family homes as well as programs for small and large businesses. If approved, customers will have access to rebates and other programs that support installation of charging stations as well as turnkey charging station offerings. Xcel Energy's proposal also allocates funding for advisory services and research and innovation for projects such as electrification of shared mobility, optimization solutions for fleets, and electrification of school buses. The Black Hills Energy Ready EV plan would offer rebates for installation of charging stations to its single and multifamily residences, businesses, governments, and nonprofits. Black Hills Energy

also proposes customer and auto dealership outreach and education. Both Xcel Energy and Black Hills Energy have proposed expanded offerings for income eligible customers.

Other supporting measures passed in 2019 included House Bill 19-1159, which extended existing income tax credits for the purchase or lease of alternative fuel vehicles (including EVs) through 2025 while ratcheting them down over time. House Bill 19-1159 also allows Transportation Network Companies (TNCs) like Lyft and Uber that offer leased EVs to their drivers under short term rental programs to claim the full tax credit. This last provision helped lead to Lyft deploying 200 Kia Niro EVs in Denver in November 2019, the single largest EV deployment made by a TNC to date. Concurrently, House Bill 19-1198 modified the statute governing the electric vehicle grant fund to allow fees collected on EV registrations to be used for administrative costs associated with making charging station grants and to offset charging station operating costs. House Bill 19-1298 established penalties and signing procedures for non-charging vehicles parked in designated EV charging spots to encourage greater access to public charging infrastructure, including those EV stations funded using the grant funds addressed above.

Finally, Senate Bill 19-239 directed CDOT to examine the environmental, congestion, and social impacts of technological and business model changes related to commercial vehicles and convene a stakeholder working group to develop recommendations on how best to mitigate these impacts, including via a potential fee structure. CDOT released its findings in fall 2019, which sets the stage for future efforts aimed at electrifying these emerging commercial vehicle types before they produce negative air quality and GHG impacts over the long-term.

In 2020, the General Assembly passed Senate Bill 20-167, which allows manufacturers who make only EVs and have no franchised dealers to sell directly to customers. This will help to increase the availability of new all-electric cars and trucks in Colorado and support greater consumer choice in the future.

In July 2020 the state announced the launch of a Colorado Clean Trucking Strategy aimed at formulating a cohesive and comprehensive plan to reduce the air quality and GHG impacts of the Medium and Heavy (MHD) sector. Reducing pollution from MHD vehicles is particularly important because MHD vehicles are major sources of nitrogen oxide pollution, which contributes to ozone formation and because the particulate emissions from diesel vehicles have serious health impacts, especially in disproportionately impacted communities. Transitioning to much cleaner and zero emissions trucks in one of the most important strategies to simultaneously address GHG pollution and local air pollution.

To advance the Clean Trucking Strategy, Colorado is working in partnership with the Colorado Motor Carriers Association and vehicle manufacturers, electric utilities, environmental advocacy groups, environmental justice communities, and local governments. The state is pursuing a wide-ranging strategy that will include evaluating a potential ZEV regulation for medium and heavy duty vehicles, potential new regulations of nitrogen oxide emissions from trucks, voluntary vehicle efficiency improvements, utility infrastructure investments, integration of electrification considerations in highway infrastructure improvements, incentives for cleaner trucks, ZEV workforce development, and state government leadership by example. At the same time that Colorado launched this internal state effort, it also signed on to a Memorandum of Understanding with 14 other states and the District of Columbia committing to work collaboratively to advance and accelerate the market for electric MHD vehicles, including large pickup trucks and vans, delivery trucks, box trucks, school and transit buses, and long-haul delivery trucks (big-rigs). The goal is to ensure that 100 percent of all new MHD vehicle sales be zero emission vehicles by 2050 with an interim target of 30 percent zero emission vehicle sales by 2030.

Finally, the state has made progress in ensuring Coloradans can drive anywhere in Colorado in an EV and find a place to "fill-up" their battery. In April 2019, CEO issued a $10.33 million grant to ChargePoint to build high-speed charging stations in 34 communities along Colorado's interstates as well as state and US highways. ChargePoint has partnered with a variety of public and private site hosts all over

Colorado, with each location selected for its proximity to amenities and ability to ensure quick, convenient charging. Each site will allow two-to-four cars to charge at a time, and each site will be built so that as more EVs come on the roads, the number of vehicles that can charge and the charging speed can be expanded in a cost-effective way. In 2020, stations will open in Dinosaur, Salida, and Pagosa Springs as well as nine other locations. Twenty-two more stations are projected to come online by spring 2021. In addition, through the Charge Ahead Colorado grant program, the state has made awards for installation of more than one thousand community-based Level 2 and DC fast-charging stations at workplaces, multi-family housing, commercial facilities, and public parking lots and garages.

Outside of the vehicle electrification space, the state is also moving towards a strategy of better accounting and mitigation for the pollution impacts of infrastructure itself, and towards an approach that focuses on providing more options to travelers. For example, as the state begins its community input process for the reconstruction of I-270, a highly trafficked thoroughfare that traverses Commerce City – an important environmental justice community – CDOT is pursuing a range of new strategies, previously unprecedented in the agency's approach, to better measure air quality impacts at the outset as a baseline for mitigation, and to work with the community to identify advanced mitigation options to incorporate into the project. This builds on lessons learned from evaluation of the Central 70 project through Denver, and CDOT intends to carry these practices into other capacity projects moving forward.

In another example, CDOT and the Denver Regional Council of Governments (DRCOG) have collaborated on a new model for making funding available to make urban arterial roadways into "safer main streets" for all modes of transportation including walking, transit, and biking – including through an allocation of more than $75 million dollars of current road and multimodal funds that are in the process of

being awarded competitively through this program. This is one of the highest priorities included in CDOT's 10-year infrastructure plan, "Your Transportation Plan."

Importantly, CDOT is also working closely with the Front Range Rail Commission to accelerate completion of program options and a surface development plan for Front Range Rail, in conjunction with work to build demand and make "anchor investments" in transit along the I-25 corridor through a network of multimodal "hubs" along the corridor, a number of which are already funded and others of which would be funded as part of CDOT's 10-year plan, which will service rapid bus service as plans for Front Range Rail Continue.

BUILDINGS

While Colorado's electricity and transportation sectors are the top two sources of climate warming pollution, fuel use in residential, commercial, and industrial buildings is not far behind. Achieving the state's pollution reduction goals will require significant reductions in this sector. Integrating more energy efficiency with the expanded use of clean electricity as an alternative to burning fossil fuels in buildings could bring consumer cost savings, enhanced electric grid operations, and reduced emissions. The state has taken a number of steps to advance building efficiency and is actively engaging in a variety of programs and strategies to decarbonize the built environment.

The state passed legislation in 2019 to expand the number of products covered under appliance efficiency standards (House Bill 19-1231) and updated the building energy code statute (House Bill 19-1260) to require local building codes to be at least as strong as one of the three most recent versions of the International Energy Conservation Code (IECC). The state supports local governments in adopting these codes by providing no-cost technical assistance and training to county and municipal building departments through CEO. In addition, to increase education and awareness of the benefits of newer energy codes, CEO created an Energy Code Adoption Toolkit that details significant changes and provides a cost comparison between code editions, has examples of advanced codes, and includes code compliance checklists.

The state also supported the adoption of the 2021 IECC, which achieves 10% greater efficiency than the prior code and includes requirements that buildings be pre-wired for future installation of electric appliances and EV charging infrastructure. The 2021 IECC will be the first code in several cycles that has achieved this level of energy savings and puts codes on a path toward increasing efficiency and performance standards, setting the stage for future codes to enable new buildings to produce net zero emissions.

The Colorado Energy Office and the Division of Housing within the Colorado Department of Local Affairs worked with the Colorado Housing and Finance Authority (CHFA) to modify the 2020 Qualified Allocation Plan (QAP), which outlines criteria for awarding tax credits to developers and investors for affordable housing projects in Colorado. The updated criteria encourage developers to design housing that meets higher efficiency standards such as the U.S. Department of Energy's Zero Energy Ready Home or Passive House certifications. The update also includes electric vehicle ready parking space requirements, mandates energy-use intensity reporting, and adds criteria to assess the future retrofit needs of the building, ongoing utility costs, and housing density.

In 2020, the Colorado Energy Office funded a beneficial electrification (BE) potential study that estimates the technical, economic, and achievable potentials for BE in buildings in Colorado over the next ten years. The research identifies key technologies and sectors that can benefit from this transition. The report also analyzes market barriers that will impede electrification efforts and provides policy and program recommendations to accelerate the adoption of BE technologies. The report is available on the Colorado Energy Office website.

The Colorado Energy Office is also in the process of launching a commercial building benchmarking program. The program, when fully developed, will enable building owners to report energy use data to a statewide database. The program will work to modernize utility data protocols to improve customer access to building level energy data. Making whole building energy use data more transparent will also help

identify cost-effective opportunities for energy efficiency and beneficial electrification upgrades.

OIL AND GAS

Colorado has a significant amount of oil and natural gas production and has experienced sustained growth in production in the last decade. Despite the substantial growth in production, methane emissions from oil and gas operations are estimated to have generally remained flat between 2005 and 2015 due to increased regulatory requirements adopted by the AQCC that have led to a declining leak rate from the sector. Colorado has been a leader in developing environmental regulations for the oil and gas sector dating back to 2005 when the first system-wide tank regulations were enacted.

Since adoption of that first set of regulatory requirements, Colorado has engaged in a series of rulemakings to reduce emissions from the oil and gas sector. With rulemakings in 2006, 2008, 2014, 2016 and 2017, Colorado has adopted increasingly more stringent requirements on the oil and gas sector aimed at a wide range of sources including: oil storage tanks, glycol dehydrators, engines, gas-driven pneumatic devices, component leaks, and well-unloadings. In 2014, Colorado became the first state in the nation to directly regulate methane from oil and gas operations. During that same 2014 rulemaking Colorado developed a new leak detection and repair (LDAR) program using optical gas imaging technology, which has since formed the basis for federal LDAR requirements for the oil and gas industry.

In 2019 the Colorado State Legislature passed Senate Bill 19-181, which strengthened the state's commitment to regulating emissions from the oil and gas industry by creating a statutory requirement for the AQCC to obtain emissions data from oil and gas operators and to minimize emissions in the sector. The AQCC promulgated the first in a planned series of regulations in December 2019, which included a requirement for annual GHG emissions reporting from the sector. The AQCC promulgated further regulations in September 2020 to require monitoring at all new wells and tightened emissions requirements for pre-production activities.

Regulations stemming from additional AQCC rulemakings are expected to result in lower leak rates and declining emissions totals from the sector.

Senate Bill 19-181 also changed the mission of the Colorado Oil and Gas Conservation Commission (COGCC). The statute directs the COGCC to regulate the development and production of oil and gas in a manner that protects public health, safety, and welfare, including protection of the environment and wildlife resources. In November 2020 the COGCC is expected to have completed a series of rule changes to implement the updated priorities of the commission under the statute, which will also deepen AQCC and COGCC coordination to pursue emissions reductions moving forward.

NATURAL AND WORKING LANDS (NWL)

Colorado's natural and working lands include our vast forests, grasslands, croplands, rangelands, wetlands, riparian areas and urban greenspaces. Natural and working lands are both sources of GHG pollution, including emissions from wildfires and agricultural fertilizer use, and serve as carbon sinks (holding or sequestering carbon in the plants and soils). Natural climate solutions aim to reduce emissions from natural and working lands and protect and enhance their ability to sequester carbon. Natural climate solutions present a unique opportunity to jointly address climate change mitigation and adaptation, and generate ecosystem benefits, while also sustaining working farms, forests and ranches through the generation of potential ecosystem market and supply-chain opportunities.

In 2018 Colorado signed on to the U.S. Climate Alliance's Natural and Working Lands Challenge. Colorado commits to managing natural and working lands to be resilient carbon sinks and to protect the communities, economies and ecosystems that depend on them.[23] In 2020 state staff established an interagency Natural and Working Lands (NWL) Task Force to address Colorado's commitment to improving inventory methods for land-based carbon flux; identify opportunities to reduce GHG pollution and increase resilient carbon sequestration; and advance programs, policies, and

incentives to promote natural climate solutions. In partnership with The Nature Conservancy, state staff are currently conducting a technical analysis to quantify the potential for specific strategies to contribute to ambitious greenhouse gas reduction goals by 2050. This effort will be completed in Summer 2021 and will identify priority pathways for land management and inform strategic development of NWL policies, programs, and research agendas.

AGRICULTURE

Beginning in 2020, Colorado Department of Agriculture (CDA) has led a soil health initiative in coordination with stakeholders and State agencies including the Colorado Collaborative for Healthy Soils (CCHS), the Department of Natural Resources (DNR), the Natural and Working Lands Task Force, and Colorado Energy Office. The initiative has built the foundation for the Soil Health Program that will start in Fall 2020 and will provide technical assistance and grants to producers to implement soil health practices that benefit the environment while supporting farmers and ranchers' bottom lines. The new program aligns with a growing number of public and private efforts throughout the United States and other parts of the world to mitigate climate change through the voluntary implementation of improved agricultural stewardship practices that simultaneously help mitigate risk and expand revenue opportunities for producers.

Through increased awareness in private market opportunities and industry influences to transition to sustainable practices, Colorado producers will be able to enhance their participation in national programs such as Field to Market, Soil Health Partnership, and the Ecosystems Market Consortium. CDA is aligning these tools through traditional pathways like the conservation districts and new routes such as carbon markets.

The ACRE3 program provides funding and technical assistance to help Colorado agricultural producers reduce or offset their on-farm energy costs by installing high efficiency or renewable energy equipment within their operations. The program collaborates extensively with the Colorado Energy Office (CEO) and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) to

partner on competitive cost-share energy projects throughout the state. The program consists of two initiatives: the Agricultural Energy Efficiency (AgEE) program and the Irrigation Hydropower Partnership.

Through the AgEE program, ACRE3 funds qualifying energy efficiency projects recommended through vetted energy audit reports, provided at no cost by the CEO. In addition to the efficiency projects, ACRE3 provides technical assistance and project funding for solar electric, solar thermal, and geo-exchange projects. These projects significantly reduce the burden of energy costs for energy-intensive agricultural operations such as dairies. The Irrigation Hydropower Partnership is an innovative initiative and partnership with the USDA-NRCS to modernize on-farm irrigation infrastructure, incorporating energy-recovery hydropower. The hydropower initiative prioritizes water-use efficiency improvements and water quality improvements in each of its projects. The hydropower initiative also allows farmers to install center pivot irrigation systems in remote, off-grid applications when the right combination of resources is available. Going forward, the ACRE3 program has identified three strategic priorities: (i) agricultural energy efficiency and photovoltaics, which focuses on reducing energy costs in energy-intensive operations, such as dairies, pumped irrigation, and greenhouses; (ii) agricultural hydropower, which focuses on energy-recovery hydropower and water resources conservation in irrigated fields and irrigation canals and ditches; and (iii) renewable thermal technologies, which focuses on solar water heating, solar space heating, and ground-source heat pumps in agricultural applications

JUST TRANSITION

Coal has played an important role in Colorado's economy, but with price declines, technological advances, and environmental and public health imperatives, the move away from coal toward cleaner energy resources is already taking place and will only accelerate. While the transition to cleaner, lower-cost resources brings economic benefits to the state, the transition away from coal carries significant implications for Coloradans who work in the coal industry and the communities

supported by the mines and those who work in them. As we embrace the renewable-energy future, Colorado must remain committed to partnering with and supporting these workers and communities. They powered Colorado's growth in the past and they should continue to share in its future prosperity.

In 2019, the Colorado General Assembly passed and the Governor signed House Bill 19-1314, focused on providing support and resources to both communities and workers impacted by the energy system's transition away from coal. The bill established the nation's first State Office of Just Transition (OJT) and a Just Transition Advisory Committee (JTAC) to develop a Colorado Just Transition Plan.

The JTAC-comprised of a diverse set of representatives ranging from impacted workers and communities, disproportionately impacted communities, economic development experts, elected officials, electric utilities, and state officials, submitted a Draft Just Transition Plan in August of 2020. Following evaluation of the draft plan and an extensive public input process, executive leadership from the Department of Labor and Employment and the Department of Local Affairs will submit a final Just Transition Plan to the Governor and General Assembly by December 31, 2020.

CLIMATE EQUITY FRAMEWORK

The state is developing a Climate Equity Framework to help ensure that Colorado's response to climate change is guided by principles of racial equity and economic justice. The framework outlines the state's plan to identify and meaningfully engage with communities who are disproportionately impacted by climate change, including: people of color; Tribes; indigenous persons; lower-income people; historically underrepresented groups, like rural and linguistically isolated communities; and those experiencing multiple environmental burdens. The framework lays out data mapping strategies to identify disproportionately impacted communities and provides best practices for equitable and authentic community engagement. It also outlines key opportunities for evaluating potential impacts of policies on disproportionately impacted communities, striving to reduce burdens and maximize benefits.

Informed by an advisory committee made up of equity, environmental justice, and community engagement experts and focus groups with members of disproportionately impacted communities, the Climate Equity Framework will inform long-term state outreach programs and shape how the state, with community input, develops and implements specific greenhouse gas reduction policies, rules, and regulations. The success of the framework depends, in part, on strong partnerships with community leaders and organizations across the state. The state recognizes that these important steps to help rebuild a more just and inclusive system will take time. This change requires a lasting commitment to constantly reexamine policies and processes, connect with and listen to community input and ideas, and elevate voices that have been underrepresented for far too long.

GREENING GOVERNMENT

In December 2019, Governor Polis signed an executive order (Executive Order D 2019 016) focused on the state's commitment to reducing greenhouse gas pollution and making government operations more energy efficient and sustainable. This executive order builds on the state's prior greening government efforts and establishes new goals and directives for all State agencies and departments that will save taxpayer money and reduce the impact of state operations on the environment and public health. The executive order's goals center on reducing greenhouse gas emissions across state government by at least 10 percent below 2014-15 levels by 2022-23. The executive order also highlights directives in several areas including utility and fleet fuels management; energy efficiency and renewable energy; state fleet vehicle fuel efficiency and zero emission fleet vehicles; agency and department staffing and training Directives; and, leased facilities. To accomplish some of the goals in the order it establishes more targeted efforts in energy efficiency and energy conservation, increased telecommuting, renewable energy, and fleet management, including:

- Reducing energy consumption per square foot by 15 percent by the end of FY 2022-2023

- Increasing the percentage of renewable electricity consumed or purchased by state facilities to five percent by the end of FY 2022-2023

- Reducing greenhouse gas emissions from state fleet vehicles by 15 percent by the end of FY 2022-2023

LOCAL GOVERNMENT ACTIVITIES

In addition to state actions, numerous local governments throughout Colorado are implementing strategies to address climate change and its adverse impacts in their communities or are initiating planning to address the climate crisis. These communities range from the largest metropolitan centers to small mountain counties and represent the diverse economic and geographic aspects of Colorado. While the individual programs vary in size and scope, collectively they form a foundation that can be built on through continued collaboration and dedication to a common goal.

The City of Fort Collins Climate Action Plan tracks annual GHG emissions using 2005 as its baseline year. The community aims to reduce carbon dioxide emissions by 20% below 2005 levels by 2020 and 80% by 2030 with the goal of being carbon neutral by 2050. As of 2018, the community had reduced emissions 14%.

In 2018 Boulder County completed a *Greenhouse Gas Inventory and Emissions Reductions Strategies Report* with an updated inventory and new long-term emission reduction goals to reduce community GHG emissions 45% below 2005 levels by 2030 and 90% below 2005 levels by 2050. The City of Boulder set a 100% renewable energy goal by 2030, and 100 megawatts of renewable energy generation by the same year. They have also set the target of reaching 80% community greenhouse gas emission reduction by 2050.

The City and County of Denver adopted the *80X50 Climate Action Plan* with a goal of reducing greenhouse gas emissions 45% by 2030 and 80% by 2050 through the decarbonization of transportation, buildings, and the electricity grid. To reach those goals, the plan calls for reducing total community-wide greenhouse gas emissions 30 percent by 2025, making all new buildings net-zero by 2035 and achieving 100 percent renewable electricity in municipal facilities by 2025 and community-wide by 2030.

Summit County has a plan to reduce communitywide emissions 50% by 2030 and 80% by 2050. Many cities and counties throughout the state including Carbondale, Adams County, and Gunnison County have adopted similar plans with substantive goals on energy efficiency and renewable energy, sustainability measures, multi-modal transportation programs, energy efficient building codes, and waste reduction.

A $12 million Renewable and Clean Energy Challenge was launched in 2019 by the Department of Local Affairs to help spark efforts to reach Colorado's 2040 100% renewable energy goal. That challenge resulted in $1,175,456 in renewable planning projects and another $4,416,704 in renewable implementation awards across Colorado. Funds that remain from the Challenge are specifically earmarked for ongoing renewable and clean energy projects. Projects must include renewable energy, energy efficiency, and energy conservation efforts, support innovations in renewable energy, achieve multiple objectives and/or serve those with the greatest need, develop plans, studies, and policies that further long-term, large-scale renewable energy generation and energy conservation.

Scenario Analysis

Identifying pathways to making progress towards House Bill 19-1261's ambitious targets requires a comprehensive analysis of GHG reduction measures across all sectors of Colorado's economy. The Colorado Energy Office hired Energy + Environmental Economics (E3) to conduct an analysis of measures and actions to reach the state's ambitious goals. This analysis evaluated the emission reduction impacts of existing policies through the 2019 legislative session as well as additional measures needed to meet House Bill19-1261's targets. This analysis provides an initial foundation for Colorado to assess various decarbonization options, identify areas for additional analysis, and consider concrete next steps in making progress towards its 2025, 2030 and 2050 targets.

Colorado's Emissions

Colorado GHG emissions in 2015 were dominated by electricity generation, transportation, and the oil and gas sector. Electricity generation emissions are predominantly attributed to coal combustion with a small portion from natural gas generators. Emissions from the oil and gas sector include fugitive methane emissions from upstream and downstream operations as well as on-site combustion of fossil fuels in industrial operations. Passenger vehicles are the largest contributor to transportation emissions in the state, followed by large trucks and air travel. Remaining direct emissions come from manufacturing and other industries, building energy use (especially space heating and water heating), agriculture, waste, refrigerants, and coal mining.[24]

Model Framework

This analysis uses E3's PATHWAYS model to create distinct scenarios of future energy demand and GHG pollution in Colorado. The model is built using a "bottom-up" accounting of all energy-consuming devices and their pollution for key sectors of the economy along with a more general accounting of all energy demand and pollution for sectors where device-level data are not readily available. Scenarios are designed to test "what-if" questions and to provide a comparison of emissions reductions under a range of mitigation measures.

PATHWAYS also captures interactions between demand and supply-side variables (e.g. electrification of space heating leads to a reduction in natural gas demand and emissions in buildings and an increase in electricity supply and potentially emissions), with constraints and assumptions informed by existing analyses of resource availability, technology performance, and cost.

For key sectors like buildings and transportation, PATHWAYS uses a bottom-up stock rollover approach primarily based on data from the EIA National Energy Modeling System (NEMS) that is validated through benchmarking to historical "top-down" energy consumption data for Colorado. For certain sectors like industry or off-road transportation where equipment stock data are not readily available, we benchmark directly to historical energy consumption data. Non-combustion emissions from sources like agricultural methane, industrial processes, and oil and gas extraction are benchmarked to a combination of federal and state data sources.

The E3 modeling approach also incorporates a detailed representation of the electric sector using E3's RESOLVE model. RESOLVE is used to develop least-cost electricity generation portfolios that achieve Colorado's policy goals, including an 80% by 2030 emissions reduction, while maintaining reliability. Finally, we calculate potential bioenergy supply from a variety of feedstock as well as emissions reduction potential for a variety of negative emissions technologies, including carbon capture and storage (CCS) for industrial process emissions and direct air capture (DAC) of CO_2. Figure 13 illustrates the relationship between the different modules of the analysis.

Figure 13: E3 Modeling Framework
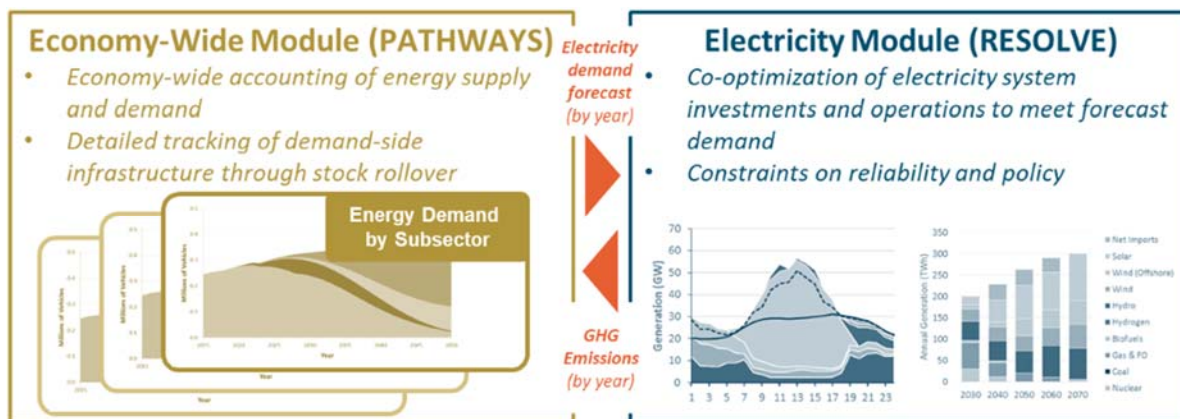
More detail on modeling approach and assumptions is available in Technical Appendix C.

For this analysis, E3 developed three distinct scenarios: a Reference Scenario that reflects a "business-as-usual" projection of energy consumption and emissions under existing policies prior to 2019, a 2019 Action scenario that includes the impacts of both legislative and regulatory policies and measures adopted in 2019, and a HB19-1261 Target scenario that is designed to meet the state's goals in 2025, 2030, and 2050.

- **Reference Scenario**: includes existing sector-specific policies adopted before the 2019 legislative session, including the Renewable Portfolio Standard (RPS) for electricity and federal CAFE standards for passenger vehicles.

- **2019 Action Scenario**: includes the impact of key policies adopted during 2019, such as electric sector GHG emissions targets (HB19-1261), the incorporation of the social cost of carbon in electric sector planning (SB19-236), increased efficiency standards for certain appliances (HB10-1231), and the creation of a Zero Emission Vehicle (ZEV) program (EO B 2019 002). Since a number of the pieces of legislation passed in 2019 require regulatory implementation, this scenario includes what we believe are reasonable assumptions about implementation.

- **HB19-1261 Target Scenario**: includes the impact of additional measures needed to reach the 2025 target of reducing greenhouse gas emissions by 26%, reducing 2030 by 50%, and 2050 emissions by 90% from 2005 levels.

Table 5: Key Strategies by Sector in Each Scenario

Strategy	Reference	2019 Action	HB19-1261 Target
Clean Electricity	Existing RPS, announced coal retirements	80% reduction in pollution from Colorado generation by 2030, 95% by 2050 Includes Xcel & Tri-State commitments and HB19 1261	Same as 2019 Action
Building Efficiency	Utility efficiency programs, existing appliance standards	Appliance efficiency standards covered under HB 1231	Appliance efficiency standards for all end-uses, efficient building shell requirements
Building Electrification	None	Same as Reference	High electrification for all end-uses
Transportation Efficiency	CAFE Standards	Same as Reference	CAFE Standards, LDV VMT reductions
Transportation Electrification	EIA AEO 2019 Reference Forecast	ZEV Standard for LDV, state EV Plan target of 940,000 EVs by 2030	Aggressive ZEV sales for all vehicle types
Low-Carbon Fuels	Existing ethanol and biodiesel blends	Same as Reference	Advanced biofuels and hydrogen production
Oil & Gas	Projected oil and gas production	2019 Updates to AQCC Reg. 7	SB19-181, significant reductions in methane emissions
Agriculture	ACRE3	Same as Reference	Soil Health Program

The three core scenarios (Reference, 2019 Action, HB19-1261 Target) modeled in this study are based on pre-COVID conditions and do not take into account impacts from the recent COVID-19 pandemic. To reflect some of the potential impacts from COVID, E3 ran sensitivities on the 2019 Action and HB-1261 Target that included:

- A lower population and household growth rate from 2020 through 2025 to reflect lower migration to Colorado.

- A reduction in vehicle miles traveled (VMT) in 2020 consistent with what has been observed through the first half of this year. Annual VMT slowly increases back to pre-COVID levels by 2027.

- Flat oil and gas production levels from 2020 through 2030, in comparison to the production increase seen over the same period in the three core scenarios.

SCENARIO RESULTS FOR 2025 AND 2030

E3's analysis finds that achieving Colorado's GHG emissions targets is feasible with existing technologies. However, as shown in Figure 14 below, this will require additional measures and policies beyond those that are included in the 2019 Action scenario. The changes needed to achieve the 2030 goals rely primarily on existing mature technologies. Achieving the 2050 goals likely requires innovation to drive costs down and enable large scale deployment of technologies that are less mature. More information on the key transformations needed by 2050 is available later in the report.

Figure 14: E3 GHG Emissions Projections by Scenario Through 2030
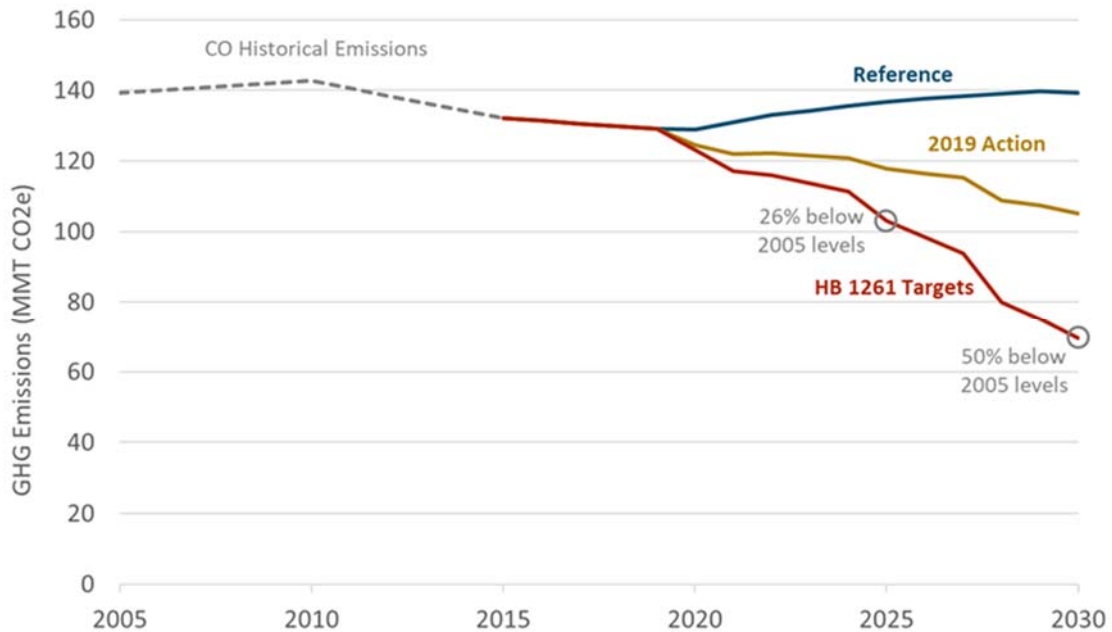
Making progress towards the 2025 and 2030 goals primarily will rely on continuing the transition to renewable electricity generation, reducing methane emissions from oil and gas development and operations, accelerating the transition to electric cars, trucks and buses, making changes to transportation planning and infrastructure to reduce the growth in driving, accelerating improvements to building efficiency and electrification of buildings, and reducing methane emissions from landfills, sewage plants and agriculture.

Impacts of COVID-19 on pollution may be large in the near-term, but long term effects are unknown. The modeled COVID sensitivities show significantly lower emissions in 2025, although this difference is modelled conservatively as smaller by 2030 and essentially gone by 2050. The emissions impact of lower population growth, reduced VMT, and flat oil and gas production is larger in the 2019 Action scenario because of the higher rates of building and vehicle electrification and lower oil and gas methane leak rate in the HB19-1261 Target scenario. It is uncertain what the long-standing effects will be felt after 2030 with respect to how Coloradans live, work, and travel, but these sensitivities indicate that the impacts in 2025 and 2030 may be

50

substantial. And while the state is not relying on COVID sensitivity assumptions for purposes of achieving emission reduction targets, we will continue to evaluate how they impact actual emissions trajectories over time and update relevant modelling accordingly.

Figure 15: E3 GHG Emission Projections by Scenario Through 2050
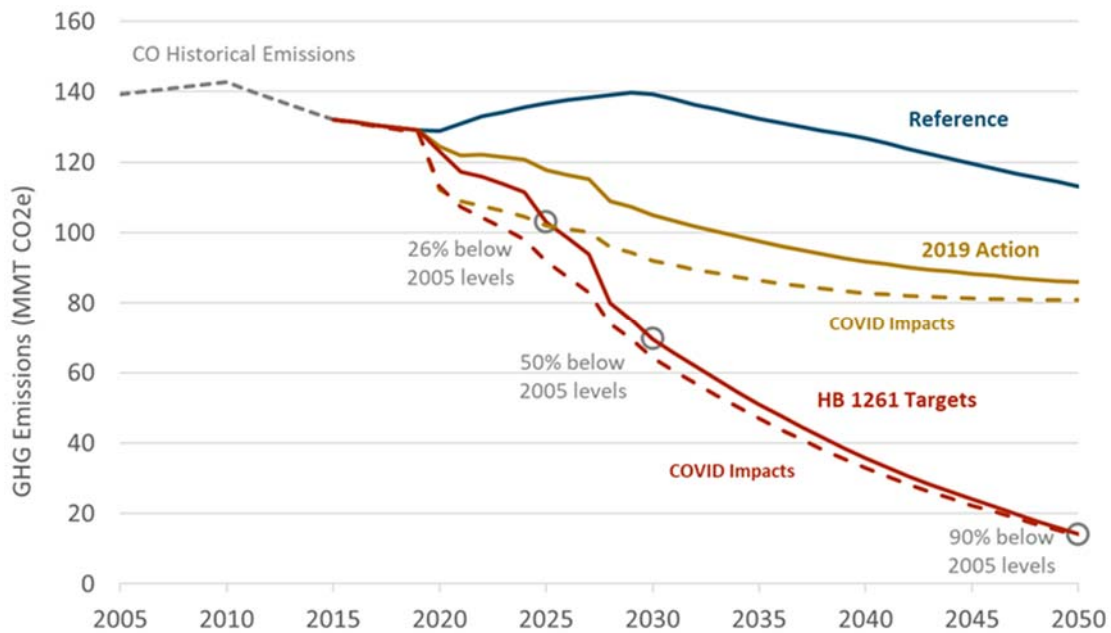
Any deep decarbonization pathway to 2030 and 2050 will require a transformation in energy infrastructure and consumption patterns. The deep decarbonization transition in Colorado will be supported by five pillars: energy efficiency, electrification, low-carbon fuels, decarbonizing electricity supply, and reducing non-combustion emissions. The scale of transformational change needed in each of these categories for the 2050 targets is shown in Figure 16.
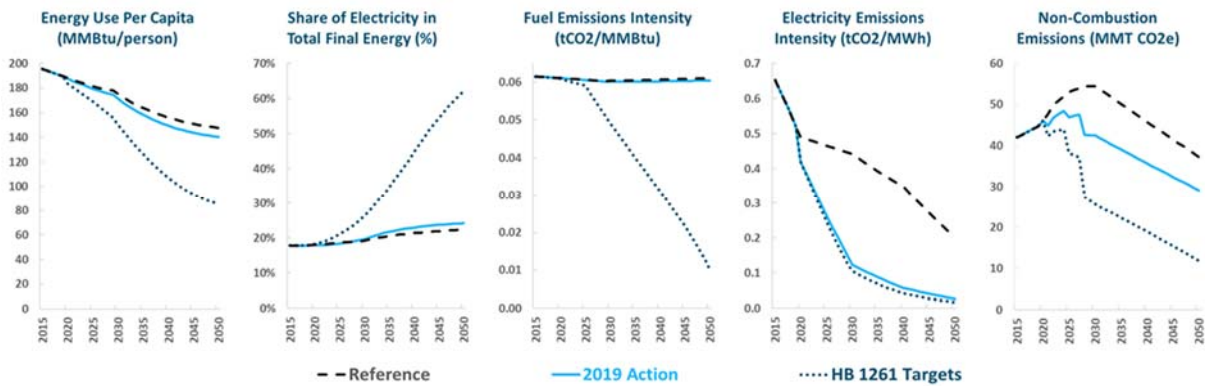
To meet 2025 and 2030 targets, emissions reductions are needed across many sectors. Figure 17 below shows the breakdown of emissions reduction by distinct sets of measures or "wedges" in 2030. The largest near-term gains can be made in electricity generation and oil and gas, but early effort is also needed in buildings, transportation, industry, refrigerants, waste, and coal mine methane.

Figure 17: Emissions Reduction by Measure in 2030
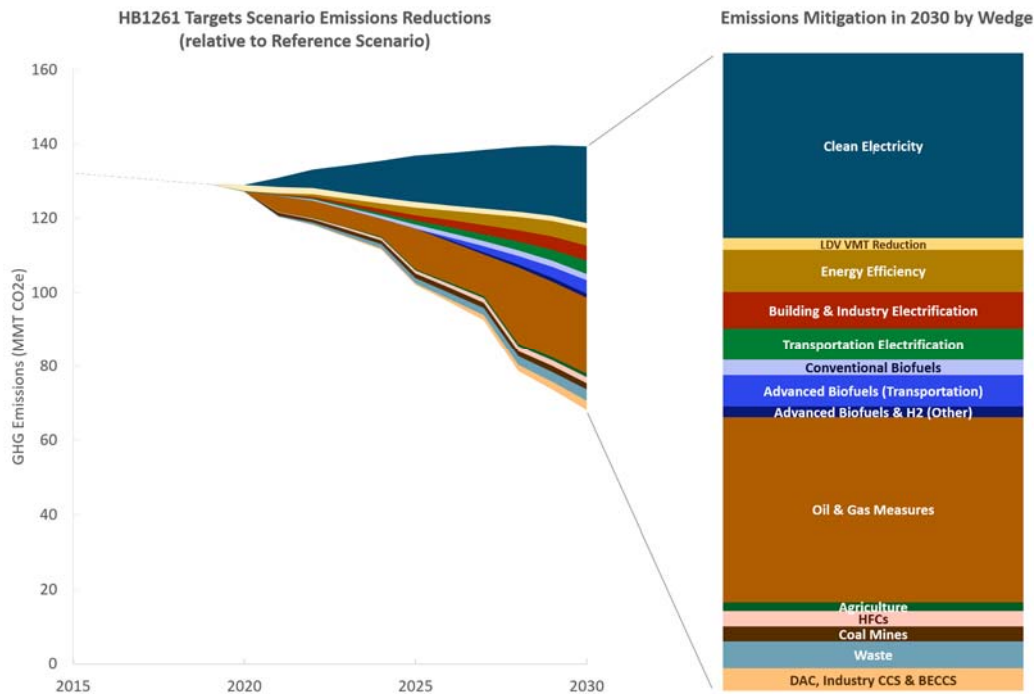
The clean electricity targets set in 2019 as part of House Bill 19-1261, along with additional commitments from Colorado utilities, form the backbone of deep decarbonization by directly reducing electricity generation emissions and indirectly enabling greater emission reductions elsewhere through the electrification of buildings, transportation, and industry. The clean electricity targets modeled by E3 assume that Xcel and Tri-State's share of load is met with carbon-free resources by 2050, while other utilities must meet an emissions reduction of 80% below 2005 levels by 2050. This is likely a conservative assumption; other utilities will also be transitioning towards zero carbon generation.

Figure 18: Electricity Generation through 2030 in 2019 Action Scenario (left) and HB19-1261 Target   Scenario (right)
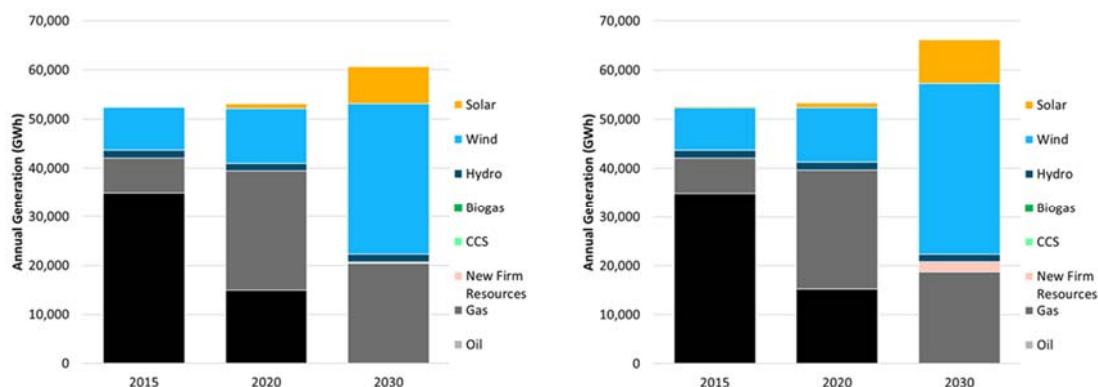
Minimizing the release of methane from the oil and gas industry is essential to achieving the state's goals, as these make up the largest source of non-combustion emissions in the state. Oil and gas production is assumed to be the same between the three scenarios, with emission reductions coming from reducing methane emissions leaks in upstream operations and the downstream distribution system. The forecasts of production and leak rates were set on the high side of potential outcomes for planning purposes. Greater leak rate reductions or less production would drive deeper reductions. Methane is a short-lived but potent climate pollutant, making it a priority for the state to mitigate impacts in the next ten years. Oil and gas measures are estimated to be low cost, approximately $4/tonne CO_2e relative to the Reference

scenario (for comparison, the social cost of damages caused by carbon emissions is over $50/ton).
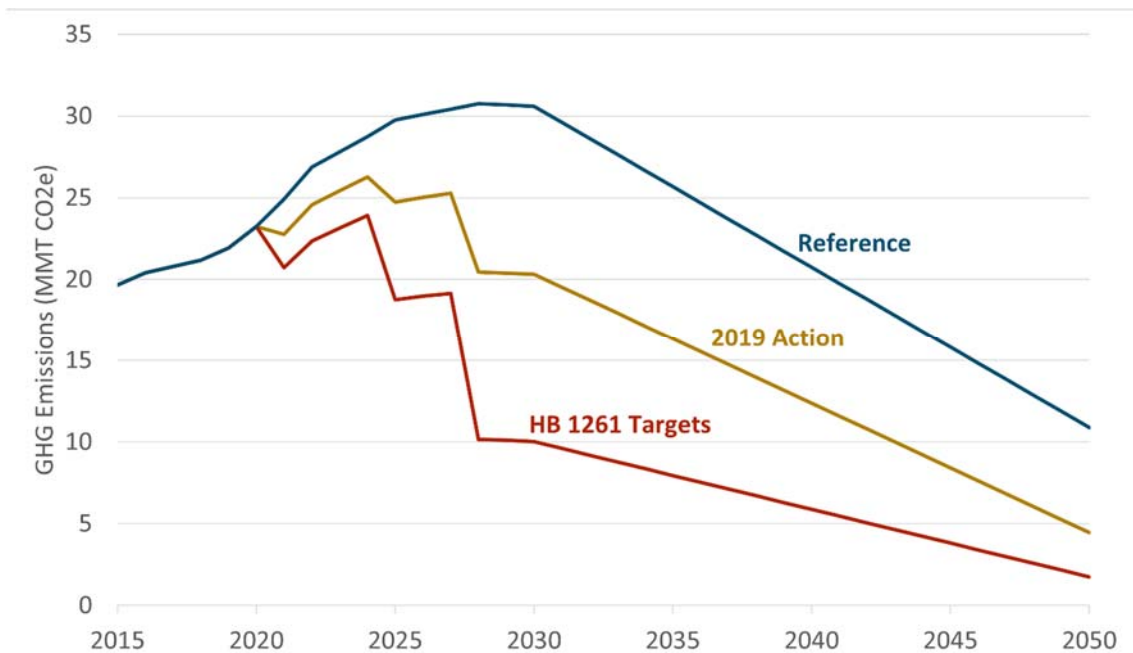
Energy efficiency in residential and commercial buildings is a no-regrets action in the near term. E3's analysis assumes a transition to 100% sales of high efficiency appliances and technologies in buildings, which in turn reduce pollution and costs. Building efficiency measures are estimated to save $54/tonne CO2e (i.e. cost savings) relative to the Reference scenario in 2030.

Vehicle and building electrification are very effective at reducing pollution, but will take time to ramp up in adoption. Electric passenger vehicles and trucks are more efficient at converting energy to miles, and the electricity they use is increasingly clean, so they reduce pollution relative to internal combustion engine vehicles. In the scenario that achieves the House Bill 19-1261 targets, E3 assumes a ramp up in sales of zero emission vehicles to 70% by 2030, which is a significant departure from adoption today. This level of transformation will require continued effort from the state to remove barriers to consumer adoption, install robust EV

charging infrastructure, and plan the electricity grid to accommodate new levels of electrification. Light-duty vehicle electrification is expected to be very affordable by 2030, E3 estimates cost savings of $172/tonne CO2e in 2030 relative to the Reference scenario. Medium- and heavy-duty electrification may take additional time to ramp up - E3's analysis assumes a 40% sales share of zero-emission trucks by 2030. MDV and HDV electrification is currently estimated to be more expensive ($114/tonne CO2e in 2030), which indicates that technology costs may need to decline or operating conditions changed to maximize benefits of truck electrification.

Electric water heaters and space heating can provide an efficient alternative to fossil devices, but are less widespread in Colorado. E3 assumes a 60% sales share of electric heat pumps in space heating and water heating by 2030, which will require moving quickly to identify least-cost early adopters and investments in heat pump technology to bring down costs for a diverse set of buildings. Building electrification is estimated to cost $55/tonne CO2e relative to the Reference scenario.

A robust market for low-carbon fuels will be needed for biofuels and hydrogen to reduce emissions in sectors that are difficult to decarbonize. E3's analysis finds that low-carbon fuels are essential after 2030, but that the role of ethanol, biodiesel, renewable natural gas, advanced biofuels, and hydrogen, will need to start ramping up between 2025 and 2030. Promising near term opportunities in Colorado include renewable natural gas from waste sources in Colorado, ethanol with carbon capture and storage, and renewable diesel for transportation. Low-carbon fuels range in costs ($168 - $395/tonne CO2e) based on feedstock, conversion process, and delivery of fuel.

Natural and working lands play a crucial role in the state's low-carbon future. The total carbon flux between the atmosphere and Colorado's natural and working lands sector is currently unquantified. As a result, with the exception of specific agricultural emissions identified in Appendix C, the natural and working lands sector is not explicitly modeled in PATHWAYS. However, natural and working lands have an important role to play in achieving the state's emission targets. In addition to

identifying near term emission reduction strategies, developing a comprehensive natural and working lands carbon inventory is a key near-term priority for Colorado, because it is critical for monitoring and verifying land management activities, policies, and programs that may increase or decrease carbon sequestration over time.

Recommended Near-term Action Plan

As described above, the Roadmap incorporates and builds on the existing legislation and policy framework. The Roadmap assesses the sources of the state's greenhouse gas pollution and identifies a series of policy actions the state can take to reduce GHG pollution. The report focuses primarily on near-term on actions, meaning action that may be implemented over the next 1 to 2 years to make progress toward Colorado's 2025 and 2030 GHG targets. The Roadmap also considers a range of other actions that help ensure that Colorado is on a pathway to meet its 2050 target of a 90% reduction in GHG pollution from a 2005 level.

The plan presented here was developed with the help of 10-months of conversations with disproportionately impacted communities, community leaders, Colorado's farmers and ranchers, Colorado's sovereign tribes, faith groups, business leaders, environmental organizations, industries affected by the transition, and other Coloradans. State agencies received feedback on a wide array of topics, including recommendations on how to model GHG pollution and what policies should be considered to reduce those emissions.

Making progress towards Colorado's 2025 and 2030 GHG pollution reduction goals is technically feasible though a combined effort to transition to renewable electricity generation, invest in energy efficiency, electrify buildings and industry, expand use of clean fuels such as biomethane, and through reductions in non-combustion GHGs including significant reductions in methane emissions from the oil and gas industry.

As noted above, many actions, including energy efficiency in buildings, efficient cars and trucks, electric vehicle adoption, reducing vehicle miles travelled, and replacing high cost coal generation with lower cost wind and solar, will have net cost savings.

Summary of Near-term Action Recommendations

The chart below summarizes the set of near term action recommendations that our analysis projects to achieve the 2025 and 2030 goals. Appendix C describes the methodology that the State agencies used to model the emissions reductions associated with these actions. The rest of this section describes these recommended actions in greater detail.

Table 7: Proposed Near Term Actions to Reduce GHG Pollution

Sector	Proposed Near Term Actions
Electricity	• Adopt Clean Energy Plans and hold AQCC Regional Haze rulemakings to reach 80% pollution reductions by 2030 • Consider mechanisms such as performance based regulation at the PUC and other tools to incentivize deeper emissions reductions and serve new beneficial electrification load with zero carbon generation
Transportation	• GHG pollution standards for transportation plans • Trip reduction/Transportation Demand Management (TDM) requirements and encouraging telecommuting for large employers • Clean trucking strategy with multiple components including infrastructure investments, incentives for fleet turnover, and evaluation of regulatory options. More details are on page 69 of the report. • New revenue to fund infrastructure and incentives to transition to low and zero emissions cars, trucks and buses • Incentives for land use decisions by local governments that reduce vehicles miles traveled, reduce emissions of GHGs and other pollutants, and support greater access to housing near jobs • Indirect source standards for some types of new development

	• Expansion of public transit, including setting the stage for front range rail
Buildings and Natural Gas Utilities	• Expand energy efficiency investments from natural gas utilities to support building shell improvements • Set carbon reduction goals, leak reduction targets, and renewable natural gas (RNG) requirements for natural gas utilities • Require existing large commercial buildings to track energy use and make progress toward energy and pollution performance standards • Support adoption of advanced building codes • Require regulated electric utilities to create programs that support customer adoption of electric heat pumps and other forms of beneficial electrification

Oil and Gas and other Industry	• AQCC rulemaking to achieve methane pollution reductions from the oil and gas industry - at least 33% reduction in total emissions by 2025 and 50% by 2030
	• AQCC action on industrial energy and emission audits requirements
	• Additional AQCC rulemaking on HFC reduction (refrigerants, aerosols, etc.)
Agriculture	• Expand "Advancing Colorado's Renewable Energy and Energy Efficiency" (ACRE3) program
	• Improve soil function and carbon sequestration through regenerative farming practices
	• Increase participation in Field to Market, Soil Health Partnership and Precision Agriculture programs
Natural and Working Lands	• Develop a comprehensive natural and working lands emissions inventory, reduce greenhouse gas pollution and protect and enhance carbon sequestration on natural and working lands
Waste	• Reduce methane emissions from coal mines, landfills, sewage treatment plants and agriculture through renewable natural gas incentives and potential AQCC rulemaking

Utility Sector

Colorado's utility sector is composed of 54 electric utilities and 12 natural gas utilities that provide the electricity and natural gas that heat our homes and businesses and power the state's economy. Xcel Energy is the state's largest electric and natural gas utility. As shown in Figure 20, Xcel accounts for roughly 52% of the state's electricity sales.

Figure 20: Percent of Total Electric Sales in Colorado by Utility (2018 MWh)
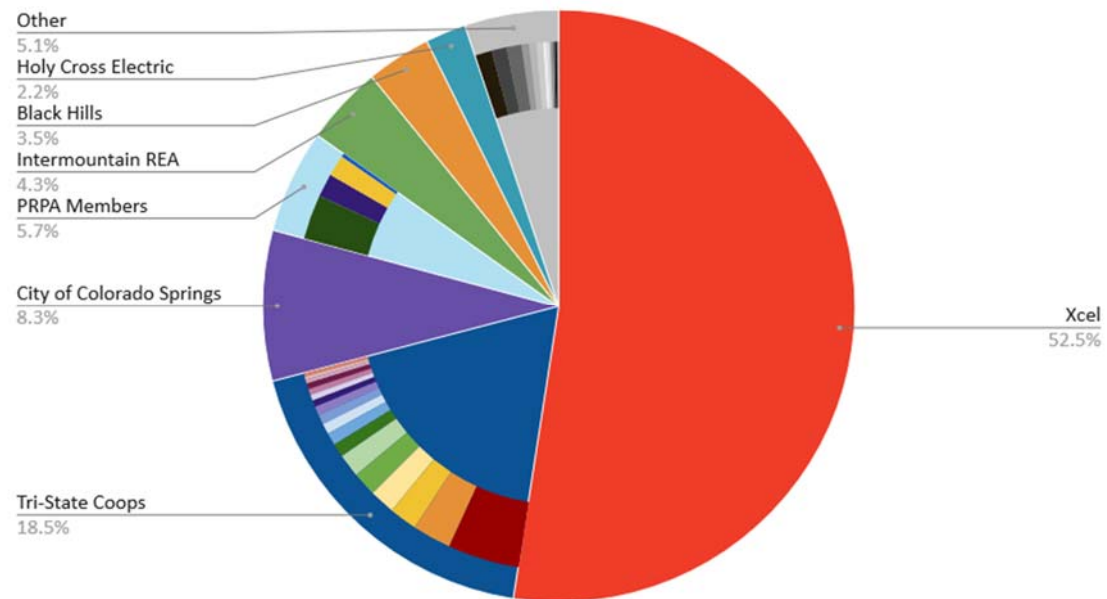
As shown in Figure 21, Colorado has historically depended on coal-fired power plants to provide electricity. Starting in the 1990s, the state saw more investment in natural-gas fired generation. Then, in 2004, with the passage of the Renewable Portfolio Standard, Colorado began to see increasing investment in wind and solar. As investments in wind and solar grew nationally and prices declined, the state saw additional growth in renewable resources. Colorado is positioned to further this process and accelerate the retirement of fossil fuels and achievement of renewable generation goals.

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Source: EIA Electric Monthly Current
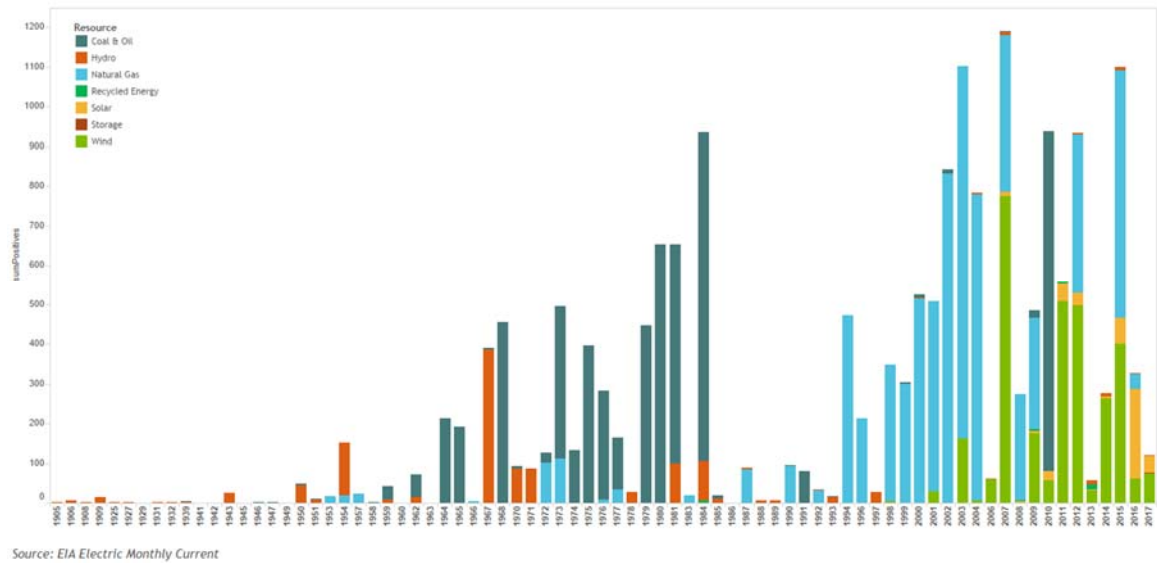
Based on a recent analysis by the Colorado Energy Office, roughly 99% of the fossil fuel generation in the state is operated by only five utilities.

Figure 22: Percent of Fossil Fuel Generation in Colorado by Plant Operator (2019, MWh)

Black Hills
2.2%
PRPA
5.0%
Colorado Springs Utilities
11.0%

Tri-State
21.1%
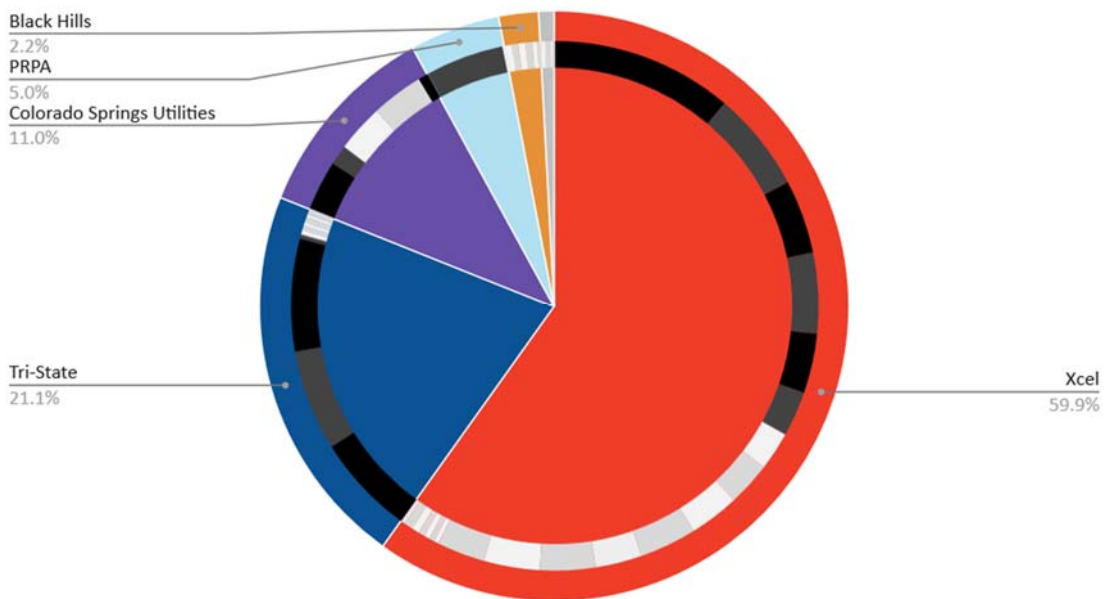
Xcel
59.9%

Senate Bill 19-236 requires Colorado's largest investor owned utility, Xcel Energy to file a Clean Energy Plan (CEP) with the Public Utilities Commission as part of its next Electric Resource Plan (ERP). The PUC ordered Xcel to file its ERP no later than March 31, 2021. Under the requirements of Senate Bill 19-236, any CEP filed with the PUC must demonstrate an 80% reduction in CO_2 emissions associated with the utility's Colorado sales in 2030, as measured from a 2005 baseline. Because it is part of the utility's ERP, the CEP will include resource retirements and acquisition requirements through 2030. Because of legislative changes in 2019, the retirements and acquisitions will be assessed, in part, using a social cost of carbon. The plan can also consider whether it is economically beneficial to retire fossil-fired power plants ahead of schedule.

The combination of Senate Bill 19-236 and House Bill 19-1261 create a mechanism for utilities in addition to Xcel to reduce their pollution. Other utilities are permitted to file Clean Energy Plans (CEPs) which reduce GHG emissions 80% by 2030, and utilities with approved CEPs that demonstrate that they will achieve these reductions are given a "safe harbor" from further regulation of their GHG emissions prior to 2030. The administration has encouraged utilities to voluntarily adopt plans that will achieve these goals, and to file CEPs, as a mechanism to achieve deep pollution reductions and a quick transition to renewables. While other utility CEP filings are voluntary, an approved CEP has enforceable obligations to attain the reductions. Through the mandatory and voluntary filing of CEPs, a clear and complete picture of the ongoing transition of the Colorado electric utility sector, and the emissions reductions associated with the transition, will be publicly available and tracked to ensure the sector achieves the projected reductions consistent with the modeling performed for this report.

While the current legal and regulatory frameworks in Colorado create a pathway for the state's electric utilities to reach an 80% reduction in carbon emission from 2005 from by 2030, and make it difficult to require utilities to achieve deeper reductions over this time frame, there may well be opportunities for deeper emissions

reductions while still maintaining reliability and affordability. We have already seen, for example, that Platte River Power Authority is considering resource plans that could achieve 90% or greater reductions by 2030. The PUC electric resource plan evaluations that Xcel Energy, Black Hills Energy and Tri-State Generation and Transmission will undergo in 2021 and 2022 will include financial analysis that includes the full social cost of carbon emissions and will give regulators an opportunity to evaluate the appropriate level of emissions reductions while considering these costs in addition to reliability and affordability.

There may be other opportunities to create additional regulatory mechanisms that could lead utilities to even deeper GHG emissions reductions. For investor owned utilities, performance based ratemaking may present one option. Under traditional forms of regulation, a utility earns a return on the capital that it invests. This can create an incentive for the utility to build new power plants. Under a performance based regulation framework, a utility earns based on its achievement of specified outcomes, including state environmental, just transition, and environmental justice goals. Because performance based regulation is outcome driven, it may better enable the creation of financial mechanisms that can drive utilities to seek deeper GHG pollution reductions across their entire system as well as opportunities to incentivize use of zero carbon resources to serve new electrification loads. There may also be other mechanisms that could be explored to incentivize deeper reductions, including from utilities whose rates are not regulated by the PUC.

REGIONAL HAZE RULE

Several of the announced early retirement dates for coal-fired electric generating units in Colorado will be codified through inclusion in Colorado's Regional Haze State Implementation Plan (SIP), providing legal certainty that these retirements will take place. The federal Regional Haze rules call for state and federal agencies to work together to improve visibility in 156 national parks and wilderness areas across the United States. In Colorado, there are 12 "Class I" areas that fall within the purview of the Regional Haze rule. EPA approved Colorado's first 10-Year Regional Haze SIP in 2012. Colorado's next Regional Haze SIP is due to EPA in July 2021. The

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Air Division is proposing a Regional Haze rulemaking that includes closure dates for eleven sources, mostly electric generating units at power generating stations around the state and a coal mine on the west slope. The projected emission reductions from these closures are up to 35,773 tons per year for visibility impairing pollutants (NOx, SO2, and PM). While the SIP is focused on these pollutants, it will have the co-benefit of locking in the associated GHG pollution reductions.

The table below (Table 7) reflects the projected CO2e emission reductions from the coal retirements in the Regional Haze rulemaking to be roughly 21.7 million metric tons per year, based on the facilities' most recent representative 3-years (2016-2018) of operation.

Table 7: CO2e Reductions from Regional Haze Generating Unit Retirements

Facility/Unit	CO2e Reduction (metric tons)	Closure Date
Rawhide Unit 1	1,963,468	12/31/2029
Drake Unit 5	4,275	1/1/2017
Drake Unit 6	446,247	12/31/2022
Drake Unit 7	755,376	12/31/2022
Nixon Unit 1	1,242,179	12/31/2029
Nucla	175,343	9/1/2019
Craig Unit 1	2,750,544	12/31/2025
Craig Unit 2	2,821,418	9/30/2028
Craig Unit 3	2,445,888	12/31/2029
Valmont	601,866	9/1/2017
Comanche Unit 1	2,090,251	12/31/2022
Comanche Unit 2	2,287,504	12/31/2025
Hayden Unit 1	1,296,204	12/31/2030
Cherokee Boiler 4	1,427,354	12/31/2028
TOTAL	21,660,969	Metric tons

COLORADO'S NATURAL GAS UTILITIES

Unlike electrical utilities, there are not currently direct legislative requirements for decarbonization of gas distribution utilities, analogous to the language in Senate Bill 19-236. Reducing emissions from the natural gas distribution utilities could be set as a statutory goal, analogous to the structure that SB19-236

created for electric utilities. The emissions trajectory is a more gradual reduction, since availability of low cost wind and solar enables a faster transition in the electric sector. The HB19-1261 Target scenario for 2030 found a need for GHG reductions of 37% below 2005 levels from natural gas end uses (exclusive of electricity generation). This will require significant decarbonization of end uses that currently rely on natural gas as well as other approaches that can reduce the emissions of the natural gas utilities. In order to achieve this, a number of policies should be considered, including: providing incentives for higher efficiency end uses, to reduce demand for gas; lowering the carbon intensity of gas that is used through some combination of use of "renewable natural gas" (RNG) and hydrogen rather than fossil methane; electrification of some end uses in buildings and industrial processes; increasing usage of electric and induction stoves; and reducing methane leaks from the natural gas distribution system. Much deeper reductions will be required to meet the 2050 goal and significant additional analysis and stakeholder engagement will be needed to develop these longer term strategies.

RNG PORTFOLIO STANDARD AND LEAK STANDARDS FOR GAS UTILITIES

As the state considers options for reducing the carbon intensity of the natural gas delivered to Colorado homes and businesses, it may look at a program that would require certain natural gas utilities to meet a carbon intensity standard across their portfolio. As part of a program like this, Renewable Natural Gas (RNG) and hydrogen could be used to replace a portion of the fossil-based natural gas currently sold to residential, commercial, or industrial customers. RNG refers to methane that is captured from sources such as sewage treatment plants, landfills and dairy farms and otherwise is emitted directly into the atmosphere. RNG could also be used to generate electric power or in the transportation sector to reduce emissions there. The state could also set enhanced leak detection and repair requirements that apply to the natural gas distribution system.

MODERNIZING GAS ENERGY EFFICIENCY PROGRAMS

Colorado adopted its initial natural gas demand-side management program in 2007. While the program has been extended, it is very modest compared to the level

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of efficiency improvements that are achieved by leading electric utility programs. Modernizing the state's statutory requirements for gas efficiency and demand-side management (DSM) programs may create additional pathways to reduce carbon emissions from the natural gas distribution systems including by setting savings-based targets, incorporating the social cost of greenhouse gas emissions in cost benefit analysis (as is done for electric sector DSM) and better aligning gas DSM with the state's goal of improving building shells and increasing electrification in buildings.

Transportation Sector

<u>ZERO-EMISSION VEHICLES</u>

The updated Colorado EV Plan was released in April of 2020 and establishes goals for zero-emission vehicle adoption statewide. Among these are the deployment of at least 940,000 EVs on the road by 2030 (including at least 1,000 transit vehicles), nearing the full electrification of the light-duty fleet by 2050, and a 100% zero-emission for new medium- and heavy-duty fleet by 2050. In addition, the plan identifies a number of strategies designed to increase consumer awareness, ensure user equity, and continue the build out of necessary charging and fueling infrastructure to support widespread adoption. Together, these will be critical to meeting the emissions reductions in the transportation sector.

- <u>Goal of Near-100% Zero-Emission LDVs by 2050</u>: The transportation sector is the single largest contributor of GHGs both nationwide and in Colorado, and nearly 60% of these emissions come from light-duty vehicles. Pursuing the near-complete electrification of these vehicles by 2050, with an interim target of nearly 1 million light-duty EVs in service by 2030, will significantly reduce the state's overall GHG emissions while saving consumers money and producing complementary benefits to the state's rapidly decarbonizing electrical grid. Importantly, light duty vehicles tend to remain in the fleet for 10 years or more, such that achieving near full electrification of all vehicles in service by 2050 will require a very high market share of EVs in new vehicle sales many years earlier. Complementary actions such as consumer incentives and building out a statewide network of charging infrastructure and accelerating turnover of

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fleet vehicles including in government fleets is essential in addition to potential regulatory action.

● Consider adoption of post-2025 Clean Car Standards: In November 2018, the Colorado Air Quality Control Commission (AQCC) adopted Regulation 20 on Low Emission Vehicle (LEV) standards for new light- and medium-duty vehicles sold in Colorado beginning in model year 2022. In doing so, it joined twelve other states and the District of Columbia in adopting California's vehicle standards under Section 177 of the Federal Clean Air Act. Currently, regulations requiring improvements in vehicle efficiency or ZEV adoption beyond 2025 are not in place at either the federal or California level. It is likely that both the federal government and California will soon pursue post-2025 standards. Colorado could choose to adopt future CARB standards through Section 177 as a means of continuing its progress after 2025, and can weigh in on development of both the California and federal standards. Because this is contingent on development of another state's standards that do not yet exist, and of post 2025 federal standards, it is likely a few years out before Colorado could consider this through a regulatory process, so it is not listed in the chart summary. However, we do recommend active engagement in rulemaking proceedings to help shape federal and California standards in the near term.

● EV Incentives for Consumers, including Low-Income Consumers: Current EV tax credits in Colorado are only available for the purchase or lease of new vehicles, but many consumers, particularly those in lower-income communities, are not able to access these incentives when purchasing used vehicles or other transportation modes such as transit passes, bicycles, Transportation Network Companies such as Lyft or Uber, and micromobility services. Establishing new incentives that cut across electrification of multiple modes will help spread the benefits of transportation electrification more equitably to all Coloradans. The Colorado Energy Office is currently developing a pilot electric micromobility project to provide electric bikes and scooters to low income essential workers

who have been negatively impacted by COVID-related public transit disruptions.

- Incentivizing EV Charging Infrastructure: Colorado has supported the build-out of publicly-accessible EV charging infrastructure at workplaces, public buildings, and along major travel corridors for years through the Charge Ahead Colorado and Alt Fuels Colorado programs and must continue to do so as the adoption of EVs grows statewide. Particular emphasis must be placed on filling gaps on the state highway network to allow for longer-distance travel, installing chargers at multi-family housing to allow renters and lower-income individuals to transition to EVs, and addressing the needs of medium and heavy duty vehicles.

- Local EV Planning: While state efforts to plan for and deploy zero emission vehicles and infrastructure are vital, local action by counties and municipalities will also be needed. Some Colorado communities have taken the lead in developing electrification plans and investing in their implementation, but many others lack the roadmap needed to begin making progress. State agencies can help local governments in taking this critical first step by providing grants, tools, and technical assistance for transportation electrification planning, multiplying impacts and spreading benefits more broadly across the state.

CLEAN TRUCKING STRATEGY, ADVANCED CLEAN TRUCK STANDARD AND FLEET RULES

In July 2020, the state joined a multistate memorandum of understanding on zero emissions trucks, and CDOT, CDPHE, and CEO announced plans to develop an all-of-the-above strategy to reduce pollution from medium and heavy duty transportation. With transportation now the largest source of air pollution in Colorado -- and with our economy increasingly reliant on freight, as exemplified during the COVID-19 crisis -- it is critical that we develop a thoughtful and balanced approach that provides a pathway for emissions reductions in this critical area. The draft strategy includes a suite of ideas that will be evaluated comprehensively (including

stakeholder input and in depth technical evaluation) to determine the most impactful and reasonable actions:

- Accelerating opportunities for fleet turnover within the conventional truck fleet, including diesel emissions reduction strategies: As motor carriers have noted, decades-old diesel trucks, manufactured prior to the enactment of more recent federal emissions standards for medium and heavy duty trucks, play an outsized role in current fleet emissions of particulates and nitrogen oxides. These federal standards were strengthened beginning in Model Year 2014, with a second set of stronger federal standards beginning in Model Years 2018 or 2021, depending on the class of vehicles. Continuing to pursue a variety of strategies to ensure that the diesel fleet is as clean as possible should be an important component of a clean truck strategy. Colorado is exploring a number of opportunities to design and support a public-private partnership program that focuses on displacing high emitting diesel trucks with cleaner models. This could be structured to increasingly reward models that meet the most rigorous emissions standards.

- Developing infrastructure to support zero emission vehicles in medium and heavy duty fleets: As zero emission vehicle truck technologies including electrification and hydrogen fuel cells proliferate, their success will depend on a robust network of charging and fueling infrastructure. The state is working with utilities and other industry partners to identify a strategy for supporting this sector with charging and fueling infrastructure.

- Incorporating clean technologies into key freight corridors and highway projects and developing a strategy for medium/heavy duty ZEV fueling infrastructure along these critical routes. As we consider the future of Colorado's infrastructure, it is critical that we support trucking along corridors that are important to our freight network. This includes features such as runaway truck ramps and signage to designate steep grades and other safety

concerns, and it should also incorporate improvements that facilitate cleaner trucking -- be it fueling infrastructure or elements that can help reduce pollution along those corridors, including a careful look at the siting for charging and hydrogen fueling infrastructure, working with utilities and other industry partners.

● Exploring opportunities for cleaner fleets: Across the country, major fleets such as UPS and Amazon are leading by example through planning large scale procurement of electric trucks. State agencies are engaging with major fleet owners to discuss how best to support large scale transition to ZEV fleets, including identifying what vehicle classes work best for early adoption, and what complementary policies can support fleet transition. The state is also working with shippers and carriers to explore acquisition of refrigerated trailers with electric standby units as well as having the necessary charging system to support those units at distribution or receiving sites.

● Exploring potential adoption of Advanced Clean Truck standards for medium and heavy trucks: As manufacturers introduce new ZEV technologies into the market, we must explore all options to ensure that Colorado truck consumers have access to innovations that are being made available elsewhere in the country. Thus, as other states explore Advanced Clean Truck regulations, Colorado is beginning an analysis of its own to evaluate the pros and cons of joining the program, as well as potential regulatory flexibilities that may be allowable under the Clean Air Act should Colorado pursue rulemaking. The California Advanced Clean Trucks Rule would require vehicle manufacturers to sell an increasing percentage of zero-emission trucks between 2024 and 2030 and for fleet owners of a certain size to track and report on their purchase and use of such vehicles. By 2030, 50% of Class 4-8 straight truck sales and 15% of all other truck sales would need to be zero-emissions to avoid penalties. The State of Colorado could choose to adopt this rule under Section 177 of the Federal Clean Air Act. CDOT, in collaboration with CDPHE and CEO, will engage

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in stakeholder discussions and technical analysis to inform the decision on whether to pursue a formal rulemaking process at the AQCC. This could also be paired with potential fleet rules requiring fleets above certain size thresholds to transition to ZEV, in order to address both the supply side and the demand side.

- Exploring Emission Reductions for Last Mile Freight Delivery and Pickup and Deployment of Sustainable Options: Both locally and on the internet, home and business deliveries have increased substantially. Downtown business areas have been affected. As we seek to reduce emissions in those areas, diminish congestion and make those areas more pedestrian-friendly, it is important that we work with logistics companies and businesses on a series of strategies to achieve those objectives. These include the greater adoption of cleaner and zero emission vehicles, use of routing optimization software, providing advanced parking solutions for deliveries, establishing freight consolidation centers, encouraging off-peak deliveries, and creating strategies to reduce dwell time and idling.

- Working with and Assisting Truck Dealerships and Private Maintenance Shops in Supporting Workforce Development and ZEV Vehicle Implementation: Moving toward ZEV vehicles will require investments on the part of truck dealers, private repair shops, and fleets with their own on-site maintenance. These groups will need to retrofit and upgrade their facilities to perform maintenance on these vehicles, as well as train mechanics and other personnel to service them. This could be part of a larger workforce development effort targeted at increasing the number of mechanics and technicians. It is critical that the state work with these different maintenance operations on how we can better support the movement toward more ZEV trucks.

- Encouraging Private Fleets to Become Partners in the Voluntary EPA SmartWay Program: The SmartWay Transport Partnership is a collaborative program

among logistics companies and the EPA. It helps companies to adopt and implement technologies and strategies that will reduce emissions and improve fuel efficiency.

- Leading by example through green procurement: The state is committed to "walking the walk" and will take a leading role toward reducing emissions from medium and heavy-duty trucks, both in its own fleet and with those private fleets with which it conducts business. The state is already working to turn over its light duty fleet to ZEV and more efficient fleet vehicles – including reducing the footprint of vehicles, where possible, to categories that are available in more efficient models. As more ZEV and hybrid options become available in the medium and heavy duty market, state procurement targets should look to these vehicle classes as well. Further, the state will explore whether there are options to improve air quality performance on its projects during construction.

PUBLIC INVESTMENT IN CLEAN VEHICLES AND INFRASTRUCTURE

Significant public investment will be needed to support electrification of medium and heavy duty vehicles. These include investment in infrastructure as well as vehicle purchase incentives. In addition, investment will be needed to both accelerate light duty vehicle electrification and to make it equitable, through mechanisms that could allow lower-income Coloradans with old and inefficient cars to upgrade to electric vehicles or other zero emission vehicles. The level of funding that will be required to achieve the transition to high levels of zero emissions vehicles is unlikely to be available through the state general fund, and instead would need bondable and sustained long term revenue mechanisms that could be considered either as a standalone clean transportation measure or as part of a broader transportation funding package.

VMT REDUCTION STRATEGIES

In addition to transforming the fleet towards zero emissions, reducing the growth in vehicle miles traveled (VMT) is a critical element of reducing pollution from

the transportation sector. In the HB19-1261 Target scenario, we must reduce 2030 VMT 10% below the levels in the reference scenario. Providing more options to travelers is important to reducing the emissions impacts of driving. This includes both increasingly clean vehicles and also providing more choices to manage demand, and associated pollution, on the roadways over time. The HB19-1261 Target scenario assumes a 10% VMT reduction relative to the 2030 pre-COVID forecast – a number that is based on current driving patterns. Notably, VMT during the "Stay at Home" period of the COVID-19 pandemic was much further reduced; reductions have hovered closer to 10% during the summer and during a period of months when economic activity has been much stronger. Thus, this number is included based on the assumption that shifts in behavior over a meaningful period of time may make this level sustainable, given a range of policies both to help manage demand and to help ensure that the Colorado economy remains in the top tier of the nation. This will likely require a suite of policy solutions, such as:

- Transportation demand management (TDM): Utilizing incentives, marketing, and other creative tools to encourage non-SOV travel, is a core strategy to reducing VMT. Traditionally, this has meant working with employers to provide transit passes, etc. to make multimodal options more appealing. In light of COVID-19, a specialized focus on making teleworking more permanent will be essential in promoting a longer-term shift towards alternatives to driving. This must be a concerted effort to support and encourage employees, employers, and local communities in reshaping the work commute. One strategy we recommend is a trip reduction requirement for large employers, which would require employers over a size threshold to develop TDM programs for their employees. This could be incorporated into a 2020 transportation GHG rulemaking by the AQCC. If the Denver/North Front Range Nonattainment Area is re-designated as Severe for ozone, TDM requirements will be required under the federal Clean Air Act.

- Land use planning and land use incentives: VMT is driven in part by the land-use planning decisions made at local and regional levels. Designing and building communities that allow for and encourage the use of biking, walking, transit, and other low-carbon modes of transportation will decrease emissions. Local governments often make decisions that have the effect of separating housing at long distances from employment, as well as often placing major trip destinations such as grocery stores, schools, colleges and hospitals far away from where people live, and often far from public transit access. In many cases, limited state transportation funds are then used to try to address the high levels of traffic that come from these land use decisions. These land use patterns negatively impact the state budget, often lead to racial and social inequities as low income workers are forced into very long commutes, and worsen air pollution and GHG pollution. State agencies must work with local governments and metropolitan planning organizations to develop strategies to promote more sustainable land use, and should develop criteria to use state investment to incentivize smart land use decisions. It should also be noted that land use planning strategies can have a beneficial multiplier effect on other transportation policies. For example, pairing land use planning policies or incentives with vehicle electrification will result in higher GHG reductions than doing either policy in isolation.

- Integrate GHG Pollution Standards and Analysis in Regional, and Statewide Plans: The transportation planning process in Colorado does not fully account for the impacts of GHG emissions when identifying and selecting projects for funding and construction. The Statewide Transportation Plan, Regional Transportation Plans, and Statewide Transportation Improvement Program (STIP) are key documents that establish funding priorities for future years and decades but do not meaningfully factor estimated increases or decreases in GHG emissions into cost-benefit analyses of specific projects or entire funding programs. Establishing GHG budgets for projects, programs, and future plans and requiring the inclusion of the social cost of carbon in benefit-cost analyses

will more accurately reflect the trade-offs between projects and allow for planners, decision-makers, and the public to evaluate them accordingly. For regional and state plans, a possible model is the existing air quality conformity process, in which CDOT would work with the AQCC to establish emissions budgets which would serve as constraints on regional and state plans, as is done today for ozone and other criteria pollutants. The state can also more fully incorporate GHG emissions in project level environmental review. The specifics of such policies must be developed through close collaboration between CDPHE, CDOT and major metropolitan planning areas – especially those that are currently situated in nonattainment areas, which is where policies should be most focused, in order to maximize the co-benefits of reduced ozone pollution.

● Enhanced multimodal options: Increased transit and active transportation options are critical to reducing VMT. This could include more investment in physical infrastructure such as mobility hubs or light or commuter rail (e.g., the proposed Front Range Passenger Rail project, along I-25). It could also include more regular and reliable service along existing routes, such as more frequent and expansive bus rapid transit (BRT) along congested corridors. Increased investment in transit and multimodal infrastructure can yield the behavior change required to get people out of their cars, as evidenced in Seattle, where a large ballot measure to fund light rail, enhanced bus services, and congestion mitigation, all contributed to a drop in VMT.[25] This will require incorporating such elements into future transportation funding packages, and prioritizing multimodal options in programming existing revenue streams.

INDIRECT SOURCE RULEMAKING

Indirect sources are recognized by the federal Clean Air Act as sources which generate or attract motor vehicle activity, such as shopping malls, developments, office buildings, warehouses or industrial sites. In California, regulation has been used to mitigate the impacts of these sources' vehicular activity on air quality more directly than motor vehicle emissions standards. This can be done through the NEPA

process for some federally-funded or approved projects. For all or some categories of projects, indirect source rules could supplement local land use authority to ensure the impacts from large attractors of mobile sources are evaluated and mitigated. Implementation of this type of regulation could help encourage more sustainable, multimodal and transit-oriented development, and could generate mitigation measures that support electrification.

CLEAN FUELS STANDARD

A Clean Fuel Standard (CFS) is designed to decrease the carbon intensity of the state's transportation fuels and provide an increasing range of low-carbon and renewable fuel alternatives. A CFS functions by establishing carbon intensity (CI) ratings for different fuel types based on their lifecycle emissions impact and then establishing CI benchmarks that increase in stringency over time. Fuels that are below the CI benchmark generate credits while those above the benchmark generate deficits, and thereby a market is created that encourages greater investment in low carbon fuels and discourages continued production and use of high-carbon alternatives. A CFS could serve as a mechanism for continued progress towards reducing the emissions generated by the transportation system. CEO conducted a feasibility study in FY 19-20 that examined a range of clean fuel standard scenarios that would achieve reductions in carbon intensity of 10, 15 or 20% over 10 years. While the study concluded that a CFS was feasible, a number of questions remain unanswered. One is the level of overlap or double counting between emissions reductions from other light and heavy duty electrification efforts and from a CFS. A more significant issue is that the modeling indicated that, at least for the first decade, the bulk of emissions reductions would come through replacement of gasoline and diesel fuel with conventional biofuels. The state has not had a comprehensive analysis or public process examining the tradeoffs involved with large scale use of conventional biofuels, so it seems premature to move forward with a CFS. In addition, the compliance cost for a CFS would likely be passed along to consumers of high carbon fuels such as gasoline and diesel. It may be more appropriate in the near term to look at revenue mechanisms that directly support adoption of zero emissions

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vehicles. Thus, we are not recommending that a CFS be part of the near term action agenda for the state, but instead should be further evaluated.

Built Environment

COMMERCIAL BUILDING BENCHMARKING AND PERFORMANCE STANDARDS

Buildings are a major source of GHG emissions in Colorado. While state and local governments and utilities are seeking to decarbonize their building stock, it is challenging to set energy or emissions reduction targets without an understanding of how buildings are performing currently.

The Colorado Energy Office is in the process of launching a commercial building benchmarking program. The program, when fully developed, will enable building owners to report energy use data to a statewide database. The program will work to modernize utility data protocols to improve customer access to building level energy data. Making whole building energy use data more transparent will help identify cost-effective opportunities for energy efficiency and beneficial electrification upgrades.

Going forward, the administration is considering a benchmarking requirement and building performance standard for commercial buildings that would collect needed data about the built energy use. Under a performance standard, covered buildings would be required to meet energy or emissions intensity targets, which could drive investment in cost-effective building upgrades. Once the program requirements are in place, fee for service and fines for non-compliance could fund this program and provide additional dollars to dedicate to building decarbonization work.

BUILDING ELECTRIFICATION REQUIREMENTS FOR UTILITIES

A Colorado Energy Office funded study of beneficial electrification (BE) potential estimated the technical, economic, and achievable potentials for BE in buildings in Colorado over the next ten years. As shown in Figure 23, the report concluded electrification in Colorado provides substantial opportunities to reduce GHG emissions in the built environment. The report found a high potential adoption of residential space and water heating, concluding that with the right policy support

nearly 200,000 homes could have electric heat pumps by 2030. The report also found that switching from propane to electrified end-uses is most cost effective currently and recommended the state consider prioritizing efforts that can help transition customers from propane to electrification.

Figure 23: GHG Reduction Potential from CEO's Electrification Report

TABLE 1-2 CO2E REDUCTION POTENTIAL UNDER BENEFICIAL ELECTRIFICATION SCENARIOS

Potential Scenario	2030 Cumulative CO2e Reduction (short tons)
Technical Potential	31,147,459
Economic Potential	20,797,877
High Electrification	3,499,843
Moderate Electrification	2,085,315

The research also identified key technologies and sectors that can benefit from this transition. The report also analyzes market barriers that will impede electrification efforts and provides policy and program recommendations to accelerate the adoption of BE technologies noting that the BE market in Colorado is nascent—the next five years will be a critical market preparation period to develop policies, programs, outreach, awareness, contractor training and the supply chain to drive higher adoption rates over the long-term.

Based on the analysis in the report, the state is considering policies that would advance market transformation including adoption of a requirement for investor-owned to file plans to support beneficial building electrification by providing rebates and incentives for customers to switch to electric heat-pump water heaters and heat-pump space heating.

Oil and Gas

CONTINUED IMPLEMENTATION OF SB 19-181 DIRECTION TO AQCC TO MINIMIZE EMISSIONS FROM SECTOR

AQCC Rulemakings to implement Senate Bill 19-181 have already commenced and will be an iterative process over the next few years. A rulemaking that included combustion emissions from stationary engines used in this sector, mandatory monitoring for new wells, pre-production emissions controls and other measures was

completed in September 2020. Additional rulemakings are included in the AQCC long term planning calendar for 2021 and 2022 and are expected to focus on reducing methane pollution throughout the sector. In order to achieve the state's 2025 and 2030 emissions goals, methane emissions from the oil and gas sector as a whole will need to be reduced by at least 33% by 2025 and at least 50% by 2030. Note that this level of emissions reductions is deeper than shown in the HB19-1261 Target scenario, in order to reflect the challenges in achieving the required levels of reductions in that scenario by 2030 in a number of other sectors. The specific requirements of the rule are expected to be informed through a stakeholder process, including a review of technological and operational changes that can be implemented to reduce methane releases. By reducing methane releases, VOCs and other emissions are also reduced because they are part of the gas stream being controlled. In order to achieve the targets set by House Bill 19-1261, the rules adopted in these 2021/22 AQCC proceedings will need to drive deep reductions in methane pollution.

In addition to the ongoing activities to implement the Senate Bill 19-181 requirements, Senate Bill 20-204 allocated additional funding to APCD and created a new Air Quality Enterprise for Colorado. The additional resources allocated to APCD are expected to be used for permitting, inspection, and enforcement activities associated with the oil and gas sector resulting from the increase in the number of facilities subject to operating permit requirements under a serious nonattainment classification for ozone. The Air Quality Enterprise creates, for the first time, a mechanism for planning and funding collaborative research through educational institutions with public and private sector involvement. Some of this research is expected to focus on better understanding and reconciling the differences between top-down monitoring and bottom-up inventory methodologies for the Oil and Gas sector, which is crucial to ensuring the projected emissions reductions through the implementation of Senate Bill 19-181 are realized.

COGCC IMPLEMENTATION FOR FURTHER FLARING RESTRICTIONS AND COMPREHENSIVE PLANNING

In November 2020 the COGCC is expected to have completed a series of rule changes to implement the updated priorities of the commission under Senate Bill

19-181. This rulemaking includes revisions to regulations to strengthen flaring restrictions, comprehensive planning, as well as evaluating and addressing the cumulative impacts of oil and gas development. The commissioners are receiving input from diverse stakeholders throughout the rulemaking process. Further detail on the outcome of the COGCC rulemakings, and their expected implications for oil and gas GHG pollution, will be included in the final draft of the Roadmap once rulemakings are complete.

Natural and Working Lands

NATURAL AND WORKING LANDS GREENHOUSE GAS INVENTORY

A comprehensive natural and working lands emissions inventory is essential for monitoring and verifying changes in GHG pollution and carbon sequestration from land-based activities, and is a critical priority for the Natural and Working Lands Task Force over the next 1-3 years. While Colorado's existing GHG inventory includes metrics such as emissions from agricultural fertilizer applications, methane associated with livestock production, forest carbon, and certain emissions from wildfires, it does not quantify the effects of land use conversion on the total carbon balance of Colorado's natural and working lands. Accounting for the impact of changes in land use, including the reduction of carbon sequestration when natural lands are developed, will allow the state to track and measure the critical role land conservation and ecosystem restoration play in reducing GHG pollution, and support policies and programs to improve land use planning. Simultaneously, the state is moving forward with assessing opportunities to mitigate climate change through improved conservation, restoration, and management of our natural and working lands.

NATURAL AND WORKING LANDS STRATEGIC PLAN

The NWL Task Force, in partnership with The Nature Conservancy, is currently conducting a technical analysis funded by the U.S. Climate Alliance to quantify the potential of Colorado's natural and working lands to contribute to the state's ambitious greenhouse gas reduction goals by 2050. This effort will result in a *Natural and Working Lands Strategic Plan* in 2021 that identifies priority pathways for carbon-

smart land management and informs strategic NWL research, program, and policy development. This analysis will also inform the ongoing refinement of Colorado's natural and working lands greenhouse gas emissions inventory.

While this technical work is underway, State agencies are implementing policies and programs that protect and enhance carbon sequestration on natural and working lands, even if that benefit is currently unquantified. The Colorado State Forest Service, in partnership with the U.S. Forest Service, Natural Resources Conservation Service, and other federal, state and local partners, carry out forest restoration work that reduces the risk of high-severity wildfire and improves forest health. Dozens of existing forest collaboratives, as well as the new Rocky Mountain Restoration Initiative and state-level Shared Stewardship initiative, are working to increase the pace and scale of this work. Colorado Parks and Wildlife, the Colorado State Forest Service, the State Land Board and other agencies, conserve several million acres of natural lands in Colorado that are important carbon sinks. These conservation efforts include the acquisition of Fisher's Peak in 2020, Colorado's second largest State Park. As these efforts continue, state staff are exploring a variety of opportunities and policy actions to further support this work.

SOIL HEALTH PROGRAM

In 2020, the Colorado Department of Agriculture (CDA) will launch a new Soil Health Program to incentivize farmers and ranchers to adopt voluntary practices to sequester carbon, reduce greenhouse gas emissions, increase drought resilience, conserve water and energy resources, and promote sustainable agriculture in Colorado. Creating a Soil Health Program will map and quantify biological benefits for agricultural operations transitioning from conventional tillage programs to more biologically sustainable methods. Encouraging and potentially incentivizing voluntary participation in these practices will enhance resiliency for extreme weather/natural catastrophes, such as drought, flood and wildfire events. The program may also create a pathway for Colorado farmers and ranchers to participate in emerging

environmental services markets, including markets identified in this plan to reduce greenhouse gas emissions in Colorado.

AGRICULTURAL CLIMATE RESILIENCE OFFICE

CDA is exploring creation of an Agricultural Climate Resilience Office (Resilience Office) that would consolidate resources to combat climate change, help absorb risk and provide technical support for Colorado agriculture facing significant climate-related threats, and create the administrative framework to help address and measure the agricultural greenhouse gas reduction targets in the GHG Reduction State of Colorado Roadmap through voluntary, farmer- and rancher-led stewardship practices.

Industrial Sources

ENERGY AND EMISSIONS AUDIT REQUIREMENTS

As part of addressing GHG pollution from Colorado's energy-intensive trade exposed industries, House Bill 19-1261 directs the AQCC to require such industries to undertake energy and emissions audits. These audit requirements may also be extended to other industrial sectors as a mechanism to assess potential for GHG reduction strategies. A stakeholder process began in September 2020 to develop the requirements for conducting and reporting these audits. It is expected that the energy and emissions audit program will be part of a broader GHG rulemaking package scheduled on the AQCC long-term calendar for Summer 2021.

Other Sectors

COAL MINE METHANE REGULATIONS

Coal mine emissions in Colorado are declining with the transition away from coal-fired electricity generation. The trend of declining emissions is expected to continue as additional mines reduce production or close between 2020 and 2030. Monitoring of production levels and the number of active mines in operation will be performed as part of the tracking of critical metrics that are reported annually to the AQCC. Should these metrics indicate significant increases in production or if new mines are opened, permit requirements may be implemented or regulations

addressing methane venting may be proposed for future consideration at the AQCC. CDPHE and the Department of Natural Resources will also work with land managers and other parties to explore opportunities for using or flaring emissions from abandoned mines.

<u>METHANE FROM LANDFILLS AND WASTEWATER; INVESTMENT IN WASTE DIVERSION</u>

Waste management currently makes up a small but growing fraction of Colorado's GHG inventory. Methane capture from landfills and wastewater treatment facilities offers an opportunity to slow and ultimately reverse the emissions growth in this sector. Capital investments and new infrastructure are required to capture methane from these sources and these investments would benefit from legislative action on a renewable natural gas standard to create a market for the captured methane. In addition, future regulations may be considered for adoption by the AQCC to address methane emissions from these sources.

<u>HFC REGULATION</u>

In May 2020, Colorado became the first state to adopt the Climate Alliance States' Model Framework for the phasing out of hydro-fluorocarbons (HFCs). The Model Framework, adopted by the Air Quality Control Commission (AQCC) as part of Air Regulation Number 22, establishes phase-out dates for the use of these potent greenhouse gases in foams, aerosols, air conditioning and refrigeration. The phase out of HFCs in these products in Colorado is projected to reduce cumulative GHG pollution by 6.34 MMT CO_2e by 2030. Additional measures to reduce HFC emissions are also being explored at state and federal levels. Potential measures include bolstering maintenance and repair requirements for products in service that use HFCs such as air conditioners and expanding the scope of the phase out to additional end uses.

Carbon Pricing Mechanisms

The Roadmap focuses on a sector-based approach to meeting the state GHG pollution reduction goals with an emphasis on the near-term actions that can help the state meet the 2025 goals and get on a pathway to meeting the 2030 and 2050 goals.

We believe that sector based policies, based on standards and investment, are the fastest pathways towards near and mid-term emissions reductions. As part of the Roadmap process, the state has begun to evaluate the merits of shifting tax burden from income to GHG pollution. However, the work to develop the sophisticated tax and economic modeling that would be necessary to further explore this policy approach are outside the scope of this Roadmap, and we anticipate that this will require additional work, for future consideration.

While the state received feedback about consideration of an economy-wide cap and trade program, the Roadmap is not recommending pursuing that option. In Colorado, we are taking an approach that draws upon strong collaboration with the public and private sectors- as opposed to focusing on a singular rule by the state that would be expensive to administer, doesn't guarantee the critical emissions reductions needed, and risks shifting even more pollution to low wealth communities and communities of color that are already bearing the brunt of poor environmental quality. As outlined throughout the Roadmap, we have identified a variety of opportunities to achieve near-term, lasting emissions reductions through a number of sector based policies spanning standards, investment, innovation and partnership with key industries, local governments and other diverse stakeholders.

Reporting, Tracking and Adaptation

The Air Pollution Control Division of the Department of Public Health and Environment will report annually to the AQCC on current and projected GHG inventories, will provide a complete assessment every two years, and will provide assessments of the most dynamic sectors (e.g., oil and gas, transportation, etc.) and areas of major change every other year. The reports will compare current and projected emissions against subsector targets from the Roadmap and identify proposed measures to return to a trajectory to meet House Bill 19-1261 targets. As part of its reporting, APCD will also develop a dashboard of vital metrics that can be tracked monthly or quarterly, such as oil and gas production, rig counts, VMT, and gas

deliveries. The intent is to allow regular evaluation of whether the state is making progress toward the targets set by HB19-1261.

Leadership and innovation required to meet 2050 GHG Goal

All sectors have an important role to play in emissions reductions if the state is to reach 90% reductions by 2050. There are clear early priorities for the state to reach 2025 and 2030 targets, but achieving the state's science-based 2050 goals will require effort across all sectors of the economy. Figure 24 below shows the breakdown of emissions reduction by measure.

Figure 24: GHG Emissions Reductions by Measure in the HB19-1261 Target Scenario
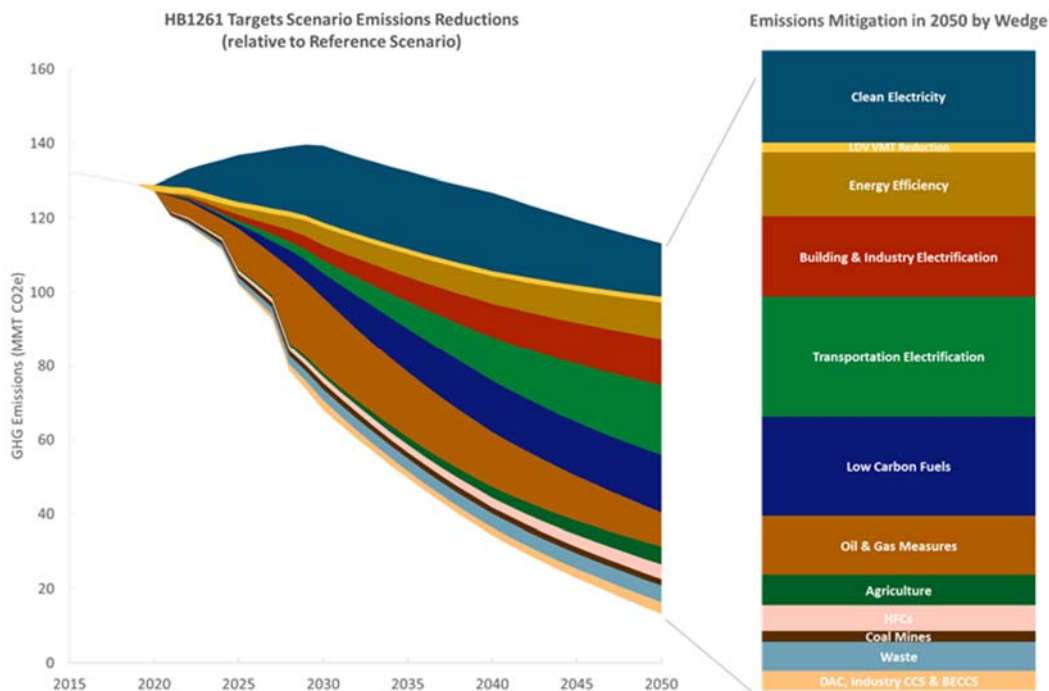
Electrification is the largest driver of demand-side emissions reductions by 2050. Widespread electrification in buildings and transportation, along with some in industry, leads to total electric load more than doubling by 2050 in the HB19-1261 Target scenario. Electrification, along with energy efficiency, is crucial to reducing emissions as Colorado's population is projected to grow at more than twice the

national rate over the next 30 years. Consumers, influenced by state and federal policy, will drive the pace of adoption for new passenger vehicles and appliances, which in turn determines a large share of the emissions from buildings and transportation.

Figure 25: Total Electricity Demand by Sector and Scenario
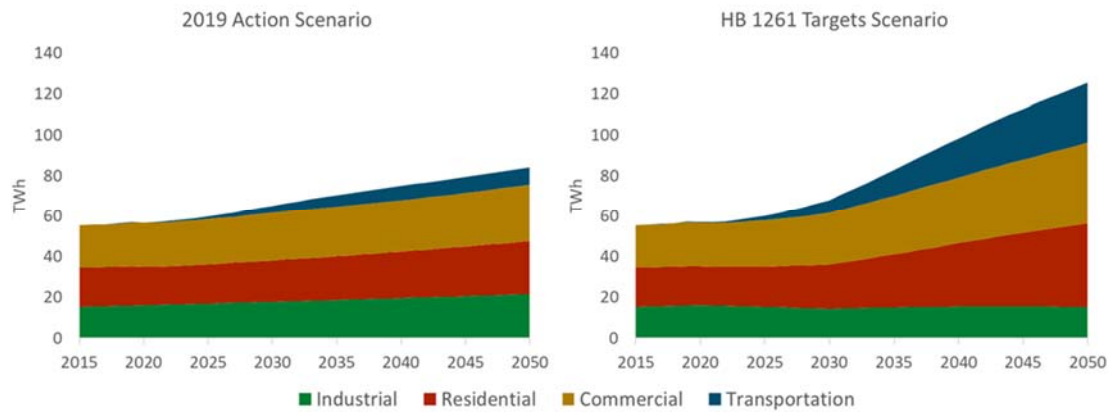
The vision for a decarbonized future in Colorado requires two key transformations in the electricity sector: (1) a need to serve increasing electricity demands due to population growth and electrification of fossil devices and (2) a need to significantly reduce emissions from coal and natural gas generation by developing new renewable resources. This two-fold challenge will require significant wind and solar resource development in the state. This level of development offers opportunities to reduce pollution and create local jobs, but will also require careful land-use planning across the state.
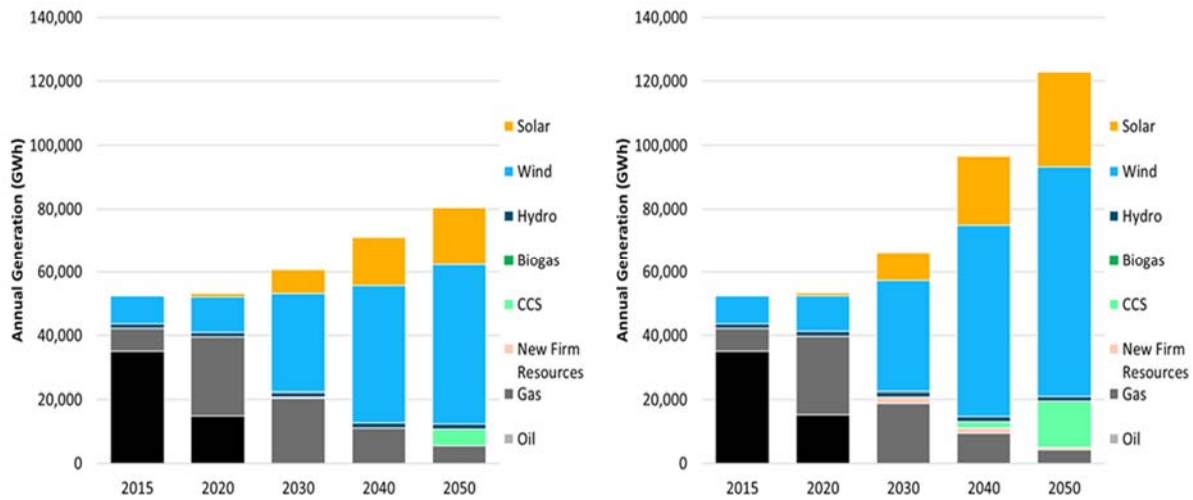
Firm dispatchable capacity is crucial to a reliable electricity system at high levels of renewables. At high levels of wind and solar deployment, it becomes increasingly important to have sufficient electric generating capacity that can be dispatched when winds are not blowing and the sun is not shining. Current battery storage can help by moving this power within the day, but as we approach 2050, the electricity system will also need to be able to function for multi-day periods without significant renewable output. While the vast majority of generation is projected to come from wind and solar, these infrequent periods will require firm dispatchable electric resources, which could include natural gas (with or without CCS), bioenergy, use of renewables to produce hydrogen combined with hydrogen combustion, nuclear power, or a future long-duration energy storage technology. It is unclear what the best technological solution will be for this challenge, so Colorado will work with electric utilities to ensure that a full suite of low or zero-carbon technologies can compete to fill that role.

Supplying reliable energy to heat homes in winter is essential and requires careful planning, especially after 2030.

To reduce emissions in Colorado's buildings, we anticipate a significant effort to achieve greater efficiency in new appliances and building envelopes in addition to

strategic electrification of appliances like stoves (including induction), space heaters and water heaters. A subset of homes and businesses are cost effective to electrify today, but with consumer adoption and innovation, building electrification is expected to become increasingly cost competitive by 2030 and beyond.

One key consideration for building electrification is the need to reliably heat homes in the winter in Colorado, which requires careful electric sector planning if we shift to primarily electric space heating. E3's analysis indicates that Colorado could shift from a summer peaking to a winter peaking system with the levels of adoption in the HB19-1261 Target scenario. Continued research into cold climate air source electric heat pumps and barriers to electrification in Colorado's buildings will be essential to the transition. Winter peak heat impacts can be further mitigated through load flexibility in space heating and a balanced mix of technologies (such as ground source heat pumps and combustible fuel backup).

Low-carbon fuels will be necessary to decarbonize sectors that are difficult to electrify

E3's analysis finds the most optimal uses for low-carbon fuels in 2050 are in decarbonizing aviation fuel, remaining diesel consumption in transportation, and remaining natural gas use in industry. While some low-carbon fuels are used to decarbonize the remaining non-electric fuel demand in buildings and passenger vehicles, these constitute a small fraction of energy demand in those sectors. Low-carbon fuels can be sourced from sustainable biofuels (e.g. methane captured from landfills, agricultural wastes, forest thinnings) or can be produced by improving current processes (e.g. ethanol production with CCS). Low-carbon fuels can also be produced through electricity for fuels like hydrogen and synthetic fuels. A significant advanced biofuels or electrolytic fuels market will take time to develop in Colorado and neighboring regions, so it will be essential for Colorado to invest in research and development towards furthering these different low-carbon fuel options. New technologies including electric aircraft also have the potential to revolutionize this area.
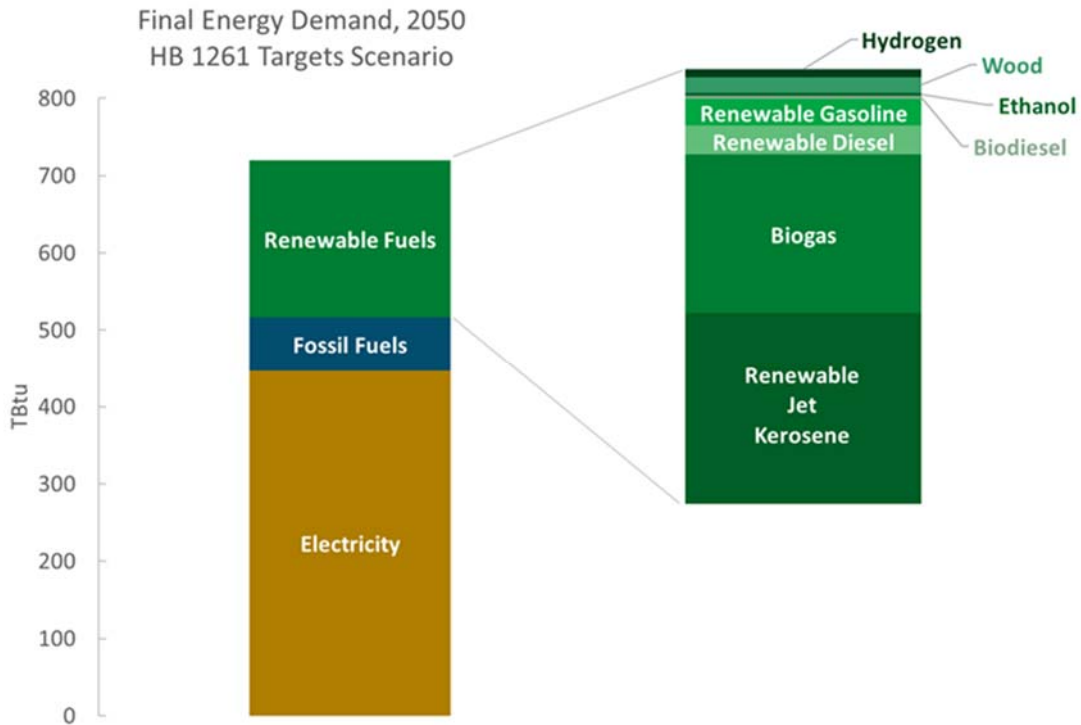
Reaching 90% GHG reductions will require significant transformation of the oil and gas sector, mainly by reducing upstream and downstream operation leak rates.

The oil and gas sector is a significant source of pollution in Colorado and production has been growing since 2005 (at least until the industry downturn starting in early 2020). A key strategy will be identifying and reducing leak rates in both upstream operations and downstream distribution of oil and gas. E3's HB19-1261 Target scenario assumed a reduction in upstream leak rate from 4% in 2005 to 0.25% in 2050 and a downstream leak rate reduction from 0.5% in 2005 to 0.15% in 2050. These reductions reflect realistic targets consistent with Senate Bill 19-181 and the goals of leading oil and gas companies.

Strategic deployment of carbon capture and sequestration can reduce pollution in key sectors.

Carbon capture technology is not new, but large scale deployment has been slow especially without an aggressive mandate to reduce emissions or economic incentive. Carbon capture is most cost-effective and appropriate in applications with a pure and concentrated stream of CO2 or significant non-combustion process emissions that would not be avoided from fuel switching. Prime candidates for CCS in Colorado include ethanol production facilities, central natural gas processing operations, and cement manufacturing. Continued engagement with these industries will be needed to determine the appropriate sites and timing of CCS deployment, in addition to the proximity to appropriate carbon sequestration and utilization opportunities.

Strategic efforts in the natural and working lands sector will be necessary to further reduce associated GHG pollution, and protect and enhance the ability for Colorado's lands to sequester carbon from the atmosphere.

Long-term priority actions include enhancing land conservation and reducing the conversion of native grassland, forests and pastureland to cropland, energy development, or urban and suburban development. Additional key strategies include reforestation and afforestation of wildfire burn scars, urban and suburban areas, and wind breaks in agricultural landscapes, while acknowledging that these practices must be adaptive to ongoing climate change and the availability of water resources. Additionally, increases in cover cropping and cropland nutrient management will achieve substantial emissions reductions from the agricultural sector, and active forest management must be increased to maintain forest health and reduce wildfire severity.

Appendices

Appendix A: Climate Action Plan to Reduce Pollution (House Bill 19-1261)

Placeholder

Appendix B: Just Transition From Coal-based Electrical Energy Economy
(House Bill 19-1314)

Placeholder.

Appendix C: Technical Appendix of Energy + Environmental Economics PATHWAYS and Resolve models

Technical Modeling Appendix

The Colorado PATHWAYS model is built using a "bottom-up" accounting of all energy-consuming devices and their emissions for key sectors of the economy along with a more general accounting of all energy demand and emissions for sectors where device-level data are not readily available. Scenarios are designed to test "what-if" questions and to provide a comparison of emissions reductions under a range of mitigation measures.

PATHWAYS captures interactions between demand- and supply-side variables (e.g. electrification of space heating leads to a reduction in natural gas demand and emissions in buildings and an increase in electricity supply and potentially emissions), with constraints and assumptions informed by existing analyses of resource availability, technology performance, and cost.

For key sectors like buildings and transportation, PATHWAYS uses a stock rollover approach primarily based on data from the EIA National Energy Modeling System (NEMS) that is validated through benchmarking to historical "top-down" energy consumption data for Colorado. For certain sectors like industry or off-road transportation where equipment stock data are not readily available, we benchmark directly to historical energy consumption data. Non-combustion emissions from sources like agricultural methane, industrial processes, and oil and gas extraction are benchmarked to a combination of federal and state data sources.

The study uses E3's PATHWAYS model to create strategically designed scenarios for how the state can reach its decarbonization goal. The PATHWAYS model is built using bottom-up data for all emissions produced and energy consumed within the state. It simulates the emissions from all sectors. To better understand the dynamic within the electricity sector, this study's modeling approach also incorporates

detailed electricity sector representation using E3's RESOLVE model. RESOLVE is used to develop least-cost electricity generation portfolios that achieve Colorado's policy goals while maintaining reliability.

To populate the Colorado PATHWAYS model, we focused on in-state data sources where possible, supplementing with national data sets to fill remaining data gaps. Specific inputs are detailed in the sections that follow.

S<small>CENARIOS</small>

For this analysis, E3 developed three distinct scenarios: a Reference Scenario that reflects a "business-as-usual" projection of energy consumption and emissions under existing policies prior to the 2019 legislative sessions, a 2019 Action scenario that includes the impacts of policies and measures adopted in 2019, and a HB-1261 Target scenario that is designed to meet the state's goals in 2025, 2030, and 2050.

- Reference Scenario: includes existing sector-specific policies adopted before the 2019, including the Renewable Energy Standard (RES) for electricity and federal CAFE standards for passenger vehicles.

- 2019 Action Scenario: includes the impact of key policies adopted during 2019, such as electric sector GHG emissions targets (HB-1261), the incorporation of the social cost of carbon in electric sector planning (SB-236), increased efficiency standards for certain appliances (HB-1231), and the creation of a Zero Emission Vehicle (ZEV) program (EO B 2019 002).

- HB-1261 Target Scenario: includes the impact of additional measures needed to reach the statewide goals to reduce 2025 greenhouse gas emissions by at least 26%, 2030 greenhouse gas emissions by at least 50%, and 2050 greenhouse gas emissions by at least 90% relative to 2005 levels.

Table 1. Full list of mitigation measures by scenario

Sector	Strategy	Expressed as	Reference	2019 Action	HB-1261 Target
Electricity	Clean Electricity	Required % reduction in emissions relative to 2005	None	80% by 2030, 95% by 2050	*Same as 2019 Action*
Buildings	Building Shell Efficiency	Efficient shell sales share	None	*Same as Ref.*	100% by 2030
	Building Electrification	Electric heat pump sales share	2%	*Same as Ref.*	60% by 2030, 95% by 2040
	Appliance Efficiency (non-HVAC)	Efficient appliance sales share	None	100% by 2021 for lighting, 100% by 2021 for com. cooking	100% by 2021 for lighting, 100% by 2030 for other appliances
Industry	Efficiency	Efficiency increase relative to baseline projection	None	*Same as Ref.*	20% by 2030, 40% by 2050
	Fuel Switching for Manufacturing	Share of natural gas demand electrified	None	*Same as Ref.*	17% by 2030, 32% by 2050
Transportation	CAFE Standards	LDV fuel economy	Extended 2021-2026	*Same as Ref.*	*Same as Ref.*
	VMT Reduction	LDV VMT reduction relative to Reference	None	*Same as Ref.*	10% reduction, beginning in 2020
	Vehicle Electrification	ZEV sales share	LDV: 9% by 2030 MDV/HDV: 0% Buses: 5% by 2030	LDV: 43% by 2030 MDV/HDV: 0% Buses: 5% by 2030	LDV: 70% by 2030, 100% by 2040 MDV/HDV: 40% by 2030, 100% by 2040 Buses: 100% by 2030
Oil & Gas	Leak Detection and Reduction	Catchall upstream leak rate	2.4%	1.5% by 2030, 1% by 2050	0.6% by 2030, 0.25% by 2050
	Fuel Switching	Share of diesel consumption electrified	None	*Same as Ref.*	100% by 2030
Other Non-Combustion	Soil Management	Amount of additional carbon sequestered	None	*Same as Ref.*	1 MMT by 2030, 3 MMT by 2050

	Enteric Methane Reduction	% reduction relative to Reference	None	*Same as Ref.*	25% by 2030
	HFC Phase Down	CO2e reduction in HFC emissions relative to Reference	None	*Same as Ref.*	1.7 MMT by 2030, 4 MMT by 2050
	Coal Mine Methane	% of abandoned mine methane emissions captured	None	*Same as Ref.*	38% by 2030
	Municipal Solid Waste	% of methane emissions captured	None	*Same as Ref.*	58% by 2030, 64% by 2050
	Wastewater Treatment	% of methane emissions captured	None	*Same as Ref.*	40% by 2030, 80% by 2050
Low Carbon Fuels	Conventional Biofuels	% of fuel demand met with conventional biofuels	7% ethanol blend for gasoline	*Same as Ref.*	15% ethanol blend by 2030, 20% biodiesel blend by 2030,
	Advanced Biofuels	% of fuel demand met with advanced biofuels	None	*Same as Ref.*	85% renewable gasoline blend by 2050, 80% renewable diesel blend by 2050, 1% renewable natural gas by 2030, 95% renewable natural gas by 2050, 97% renewable jet fuel by 2050
	Hydrogen	% of natural gas pipeline blend	None	*Same as Ref.*	5% blend by 2050
CCS	Industry CCS	Amount of CO2 captured and sequestered	None	*Same as Ref.*	2 MMT by 2030
	Direct Air Capture (DAC)	Amount of CO2 captured and sequestered	None	*Same as Ref.*	2.8 MMT by 2050

In 2015, Colorado had a population of 5.5 million people residing in 2.1 million households. In each sector of the economy, we create a representation of a base year (2015) of infrastructure and energy demand, and then identify key variables that drive activity change over the duration of each scenario (2015-2050). Table 2 shows the key drivers behind baseline projections of energy and emissions in each scenario.

Table 2. Key drivers of Reference Scenario energy consumption and emissions

Sector	Category	Annual Growth Rate	Source
Economy-Wide	Population Growth Rate	1.27%	State Demography Office
	GDP Growth Rate	1.9%	EIA Annual Energy Outlooks (AEO) 2019
Buildings	Households Growth Rate	1.33%	State Demography Office
	Commercial Sq. Footage	1.0%	EIA AEO 2019
Transportation	LDV VMT	1.49%	CDOT
	MDV VMT	1.3%	EIA AEO 2019
	HDV VMT	1.2%	EIA AEO 2019
Industry	Industry Fuel Use Growth Rate	Varies by Fuel	EIA AEO 2019
Electricity Generation	Electric Load Growth	Varies by Scenario	Bottom-up projection from electricity demands in buildings, transportation and industry in PATHWAYS
Oil & Gas	Oil Production	3% (2015-2030) -5% (2031-2050)	CDPHE Air Pollution Control Division
	Natural Gas Production	7% (2015-2030) -6% (2031-2050)	CDPHE Air Pollution Control Division
Waste and HFCs	Total Emissions	1.27%	Assumed to grow with population
Agriculture	Total Emissions	0%	Assumed to stay constant over the study period

Buildings Sector

Base Year

The Colorado LEAP model includes a stock-rollover representation of 17 residential and 10 commercial building subsectors, including space heating, water heating, and lighting. Sectoral energy demand is benchmarked to energy consumption by fuel from the EIA State Energy Data System (SEDS) for 2015 and is disaggregated by subsector based on the EIA National Energy Modeling System (NEMS) technology characterization. All residential and commercial subsectors are listed in Table 3.

Table 3. Representation of 2015 Building Energy Consumption by Subsector in Colorado

Sector	Subsector	Modeling Approach	Estimated Energy Use in 2015 [TBtu]	Estimated % of 2015 Energy Use [%]
Residential	Residential Central Air Conditioning	Stock Rollover	10	3%
	Residential Building Shell	Stock Rollover	-	0%
	Residential Clothes Drying	Stock Rollover	4	1%
	Residential Clothes Washing	Stock Rollover	0	0%
	Residential Cooking	Stock Rollover	3	1%
	Residential Dishwashing	Stock Rollover	2	0%
	Residential Freezing	Stock Rollover	1	0%
	Residential Reflector Lighting	Stock Rollover	1	0%
	Residential Room Air Conditioning	Stock Rollover	1	0%
	Residential General Service Lighting	Stock Rollover	5	1%
	Residential Exterior Lighting	Stock Rollover	1	0%

	Residential Linear Fluorescent Lighting	Stock Rollover	1	0%
	Residential SF SH	Stock Rollover	93	26%
	Residential MF SH	Stock Rollover	19	5%
	Residential Refrigeration	Stock Rollover	6	2%
	Residential Water Heating	Stock Rollover	31	9%
	Residential Other	Total Energy by Fuel	38	11%
Commercial	Commercial Air Conditioning	Stock Rollover	6	2%
	Commercial Cooking	Stock Rollover	5	1%
	Commercial High Intensity Discharge Lighting	Stock Rollover	0	0%
	Commercial Linear Fluorescent Lighting	Stock Rollover	6	2%
	Commercial General Service Lighting	Stock Rollover	2	1%
	Commercial Refrigeration	Stock Rollover	9	3%
	Commercial Space Heating	Stock Rollover	40	11%
	Commercial Ventilation	Stock Rollover	8	2%
	Commercial Water Heating	Stock Rollover	10	3%
	Commercial Other	Total Energy by Fuel	58	16%
All Building Sectors			**361**	**100%**

*Residential Other includes furnace fans, plug loads (e.g. computers, phones, speakers, printers), secondary heating, fireplaces, and outdoor grills. Commercial Other includes plug loads, office equipment, fireplaces, and outdoor grills.

Reference Scenario

The Reference scenario does not include any incremental energy efficiency or fuel-switching measures. The existing market shares for energy-consuming appliances are assumed to hold constant throughout the study period, with the increase in total energy consumption in buildings being driven by growth in the number of households

and commercial square footage in Colorado. Non-stock energy consumption in the Residential Other and Commercial Other subsectors is also assumed to grow at these rates.

S019 Action Scenario

The primary building sector measure in the 2019 Action scenario is the achievement of energy efficiency improvements. Energy efficiency in buildings is implemented in the PATHWAYS model in one of three ways:

1. As new appliance or lighting end use technology used in the residential and commercial sectors (e.g., a greater share of high efficiency appliances is assumed to be purchased). New equipment is typically assumed to replace existing equipment "on burn-out" at the end of the useful lifetime of existing equipment.

2. As a reduction in energy services demand, due to smart devices (e.g. programmable thermostats), conservation, or behavior change.

3. For the sectors that are not modeled using specific technology stocks (Residential Other and Commercial Other), energy efficiency is modeled as a reduction in total energy demand.

The full list of building sector measures and assumptions in the 2019 Action scenario is shown in Table 4.

Table 4. Building Sector Measures in the 2019 Action scenario

Category of Building Measures	2019 Action Scenario Assumption
Building retrofits for high efficiency building shells	None
New appliance sales	100% sales of efficient lighting and commercial cooking equipment by 2021 (represents HB 1231)
Building electrification	None
Behavioral conservation and smart devices	None
Other non-stock sectors	None

Since the model is based on a bottom-up forecast of technology stock changes in the residential and commercial sectors, the model does not use a single load forecast or energy efficiency savings forecast as a model input. It is important to note that the modeling assumptions used in this analysis may not reflect specific future energy efficiency programs or activities.

HB-1261 Target Scenario

The HB-1261 Target scenario includes electrification and more aggressive energy efficiency measures in buildings. Building electrification occurs primarily through the widespread adoption of electric heat pumps for space heating and water heating, while increased efficiency is achieved through sales of more efficient appliances, behavioral conservation, and building shell retrofits. The full list of building sector measures and assumptions in the HB-1261 Target scenario is shown in Table 5.

Table 5. Building Sector Measures in the HB-1261 Target scenario

Category of Building Measures	HB-1261Target Scenario Assumption
Building retrofits for high efficiency building shells	100% adoption of efficient building shells for new buildings and retrofits by 2030
New appliance sales	100% sales of efficient lighting and commercial cooking equipment by 2021 (represents HB 1231) 100% sales of all other appliances are efficient models by 2030
Building electrification	60% sales of electric heat pumps by 2030, 95% by 2050 for space heating and water heating
Behavioral conservation and smart devices	2% reduction in building energy demand by 2030, 4% by 2050
Other non-stock sectors	Full electrification of non-stock sector demand by 2050

A key assumption of the HB 1261 Target scenario is the adoption of high efficiency electric heat pumps for space heating and water heating. According to a 2012 assessment of residential energy demand commissioned by CEO, heat pumps only make up around two percent of space heaters in Colorado[1]. The market share for heat pump water heaters was not reported but is assumed to be negligible.

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1 "Residential Energy-Use and Savings Potential Study for the Governor's Energy Office" E Source, 2012
https://www.colorado.gov/pacific/sites/default/files/atoms/files/Residential%20Energy-Use%20and%20Savings%20Potential%20Study.pdf

In the HB 1261 Target scenario we assume the shift to heat pumps displaces natural gas, LPG, and electric resistance space heating and water heating. Assumed equipment sales shares and the resulting stocks are shown in below.
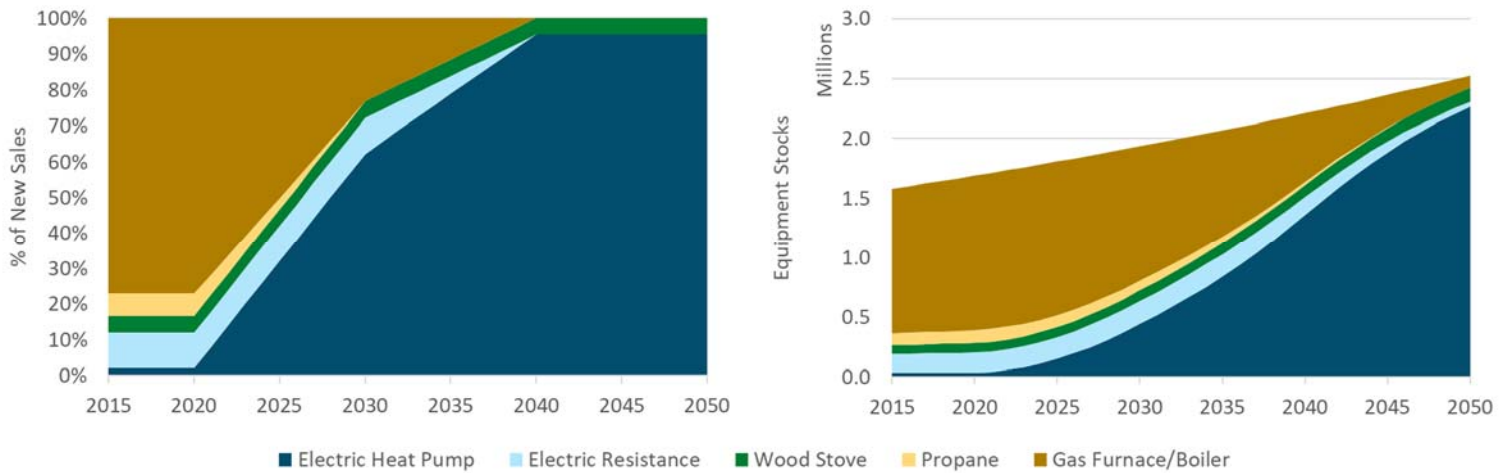

Figure 1. Annual equipment sales shares and stocks for residential space heating in the HB-1261 Target scenario

Transportation Sector

Base Year

The Colorado PATHWAYS model includes a stock-rollover representation of five transportation subsectors and an energy representation of two subsectors. Sectoral energy demand is benchmarked to energy consumption from the EIA SEDS for 2015 and is disaggregated by subsector based on vehicle population and vehicle miles travelled (VMT) data provided by CDOT. All subsectors represented in the transportation sector are listed in Table 6.

Table 6. Representation of 2015 Transportation Energy Consumption by Subsector in Colorado

Sector	Subsector	Modeling Approach	Estimated Energy Use in 2015 [TBtu]	Estimated % of 2015 Energy Use [%]
Transportation	Transportation Short LDV	Stock Rollover	122	30%
	Transportation Long LDV	Stock Rollover	151	37%
	Transportation MDV	Stock Rollover	4	1%
	Transportation HDV	Stock Rollover	35	9%
	Transportation Buses	Stock Rollover	0	0%
	Transportation Aviation	Total Energy by Fuel	53	13%
	Transportation Other	Total Energy by Fuel	41	10%
All Transportation Sectors			407	100%

Reference Scenario

The Reference scenario includes in an increase in ZEV sales for light-duty vehicles and buses based on the reference forecasts from the 2018 EIA Annual Energy Outlook report. This does not include the impact of any Colorado state transportation policies. The details of these assumptions are shown in Table 7 below.

Table 7. Transportation sector measures in the Reference scenario

Category of Transportation Measures	Reference Scenario Assumption
LDV VMT Reduction	None
LDV ZEV Sales Share	9% sales by 2030
MDV ZEV Sales Share	None
HDV ZEV Sales Share	None
Bus ZEV Sales Share	5% sales by 2030
Transportation Other	AEO 2018 non-highway total fuel growth rates

2019 Action Scenario

The primary transportation sector measure in the 2019 Action scenario is an increase in ZEV sales for light-duty vehicles, which represents the implementation of Executive Order B 2019 002, "Supporting a Transition to Zero Emission Vehicles". Previous analysis performed by Navigant for CEO found that ZEVs would reach around 43% of new light-duty vehicles sales by 2030 in a "ZEV+" scenario designed to represent the impacts of a ZEV standard, continued vehicle tax credit, and continued charging

infrastructure investment[2]. The light-duty vehicle sales shares in the 2019 Action scenario were aligned in PATHWAYS with the outputs from the Navigant ZEV+ scenario. The full list of assumptions for the transportation sector are shown in Table 8 below.

Table 8. Transportation sector measures in the 2019 Action scenario

Category of Transportation Measures	2019 Action Scenario Assumption
LDV VMT Reduction	None
LDV ZEV Sales Share	43% sales by 2030
MDV ZEV Sales Share	None
HDV ZEV Sales Share	None
Bus ZEV Sales Share	5% sales by 2030
Transportation Other	AEO 2018 non-highway total fuel growth rates

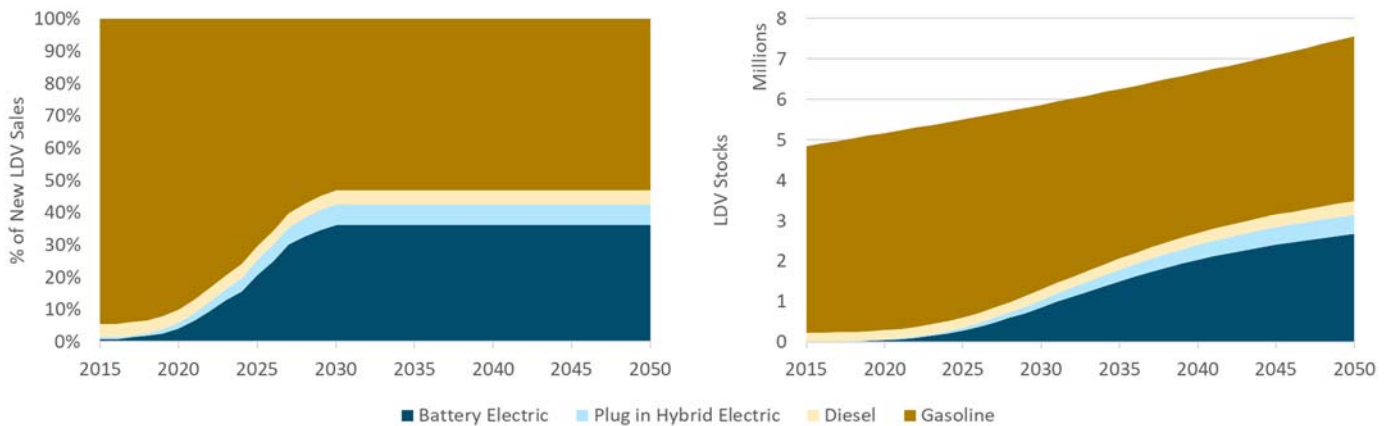Assumptions for new light-duty vehicle sales and resulting vehicle stocks are shown in Figure 2.

Figure 2. Annual light-duty vehicle sales shares and stocks in the 2019 Action scenario

HB 1261 Target Scenario

The HB 1261 Target scenario assumes aggressive levels of electrification for all vehicle classes along with VMT reductions for LDVs and increased use of low-carbon fuels for remaining non-electrified transportation. ZEV sales for LDVs go beyond what is included in the 2019 Action scenario, reaching 70% by 2030 and 100% by 2035, while ZEV sales for MDVs and HDVs reach 40% by 2030 and 100% by 2040. The full list of

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[2] "Electric Vehicle Growth Analysis Results" Navigant, 2019
https://drive.google.com/file/d/1ulRw0Yfjz53nbvBjWQO14z_4jLsqzK4z/view

assumptions in the transportation sector are shown in Table 9 below, and assumptions for light-duty vehicle sales and resulting vehicle stocks are shown in Figure 3.

Table 9. Transportation sector measures in the HB-1261 Target scenario

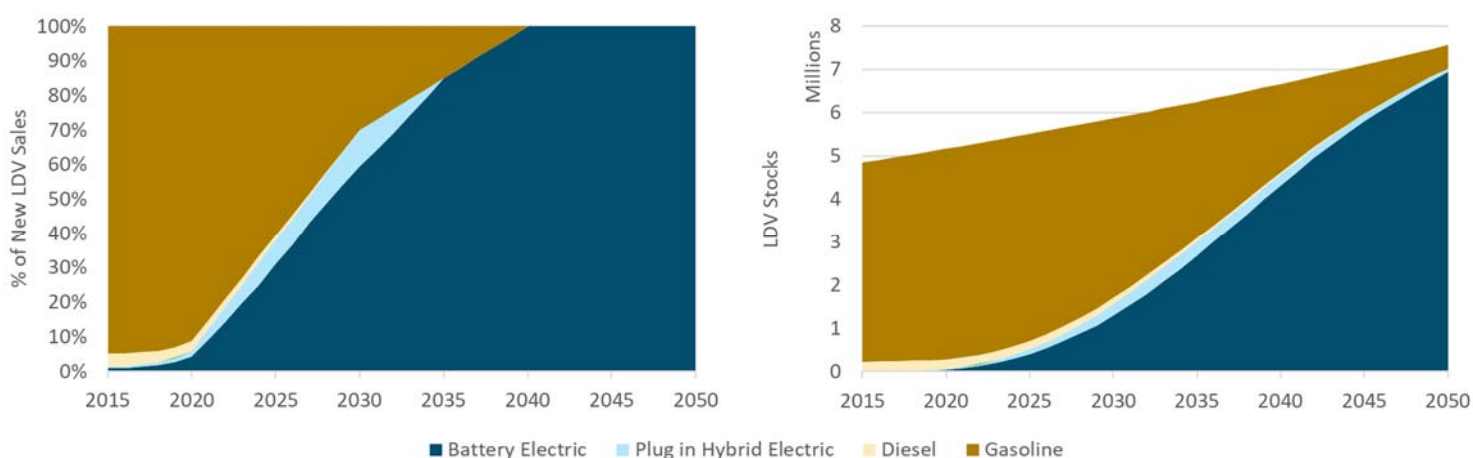| Category of Transportation Measures	2019 Action Scenario Assumption
LDV VMT Reduction	10% beginning in 2020 and held constant
LDV ZEV Sales Share	70% by 2030, 100% by 2040
MDV ZEV Sales Share	40% by 2030, 100% by 2040
HDV ZEV Sales Share	40% by 2030, 100% by 2040
Bus ZEV Sales Share	100% sales by 2030
Transportation Other	Low-carbon fuels meet 100% of demand by 2050

Figure 3. Annual light-duty vehicle sales shares and stocks in the HB-1261 Target scenario

Industrial Sector

Base Year

The Colorado PATHWAYS model includes a representation of three industrial subsectors: Industry Manufacturing, Industry Oil & Gas, and Industry Other (includes agriculture, construction, mining, etc.) Total sectoral energy demand by fuel was benchmarked to EIA SEDS for 2015. For Industry Manufacturing, energy demand by fuel was estimated by allocating the total energy demand for each manufacturing subsector calculated in a 2017 CEO study to various fuels based on the energy consumption patterns reported for those subsectors national in the EIA Manufacturing Energy Consumption Survey (MECS). For Industry Oil & Gas, natural gas demand was benchmarked to the total Lease Fuel and Plant Fuel[3] consumption reported by EIA. Remaining energy demand by fuel from EIA SEDS was allocated to Industry Other, with the exception of diesel, which was split evenly between Industry Other and Industry Oil &

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[3] The EIA defines Lease Fuel and Plant Fuel as "Natural gas used in well, field, and lease operations, such as gas used in drilling operations, heaters, dehydrators, and field compressors" and "Natural gas used as fuel in natural gas processing plants", respectively

Gas to account for diesel consumption used in oil & gas extraction. Final energy demand by subsector and fuel are shown in Table 10 below.

Table 10. Representation of 2015 Industry energy demand by subsector and fuel in Colorado

Fuel	Industry Manufacturing Demand [TBtu]	Industry Oil & Gas Demand [TBtu]	Industry Other Demand [TBtu]	Total Demand by Fuel [TBtu]
Electricity	30	0	22	52
Natural Gas	59	115	24	197
Coal	7	0	0	7
Diesel	1	12	12	24
Other Petroleum Products	10	0	6	16
Total Demand by Subsector	106	127	63	296

Reference Scenario

Industrial energy consumption in the Manufacturing and Other subsectors is assumed to grow at fuel-specific growth rates from the EIA Annual Energy Outlook. There are no energy efficiency, electrification, or low-carbon fuels measures assumed for industry in the Reference scenario. Energy consumption in the Oil & Gas subsector is assumed to grow and decline linearly with natural gas production. The natural gas production forecast used in this analysis is detailed further in the Oil & Gas Sector discussion.

2019 Action Scenario

There are no energy efficiency, electrification, or low-carbon fuels measures assumed for industry in the 2019 Action scenario. Energy consumption is assumed to grow at the same rates used in the Reference scenario.

HB-1261 Target Scenario

The HB-1261 Target scenario includes aggressive energy efficiency, electrification, and low-carbon fuels measures for industry. A 20% reduction in energy service demand is assumed by 2030 for Industry Manufacturing and Industry Other, with that amount increasing to 40% by 2050. The 17% of fossil fuel consumption electrified by 2030 in Industry Manufacturing represents full electrification of facility HVAC and electrification of some low-temperature process heat, while the 32% of

fossil fuel consumption electrified by 2050 represents additional electrification of process heating, along with a small amount of boiler electrification. CCS is assumed to be installed at all manufacturing facilities where coal is combusted by 2030, and a 90% capture rate is assumed. For Industry Oil & Gas, CCS equipment is assumed to be installed at all gas processing plants by 2050, also with a 90% capture rate. Remaining pipeline gas for Industry Manufacturing and Industry Other is assumed to have a 7% hydrogen blend by 2030, with the remaining 93% coming from biogas by 2050. The full list of industrial sector measures is shown in Table 11.

Table 11. Industrial sector measures in the HB-1261 Target scenario

Category of Industrial Measures	Subsector(s) Affected	HB-1261 Target Scenario Assumption
Energy Efficiency	Industry Manufacturing Industry Other	20% reduction in energy service demand by 2030, 40% by 2050
Electrification	Industry Manufacturing	17% of fossil fuel consumption is electrified by 2030, 32% by 2050
Electrification	Industry Oil & Gas	100% of diesel consumption is electrified by 2030
CCS	Industry Manufacturing	100% of coal consumption is assumed to have CCS installed by 2030 with a 90% capture rate
CCS	Industry Oil & Gas	16% and 32% of natural gas consumption is assumed to have CCS installed by 203 and 2050, respectively (90% capture rate)
Low-Carbon Fuels	Industry Manufacturing Industry Other	75% blend of renewable diesel by 2030, 100% by 2050 1% blend of renewable natural gas by 2030, 95% by 2050 5% blend of hydrogen for pipeline gas by 2030

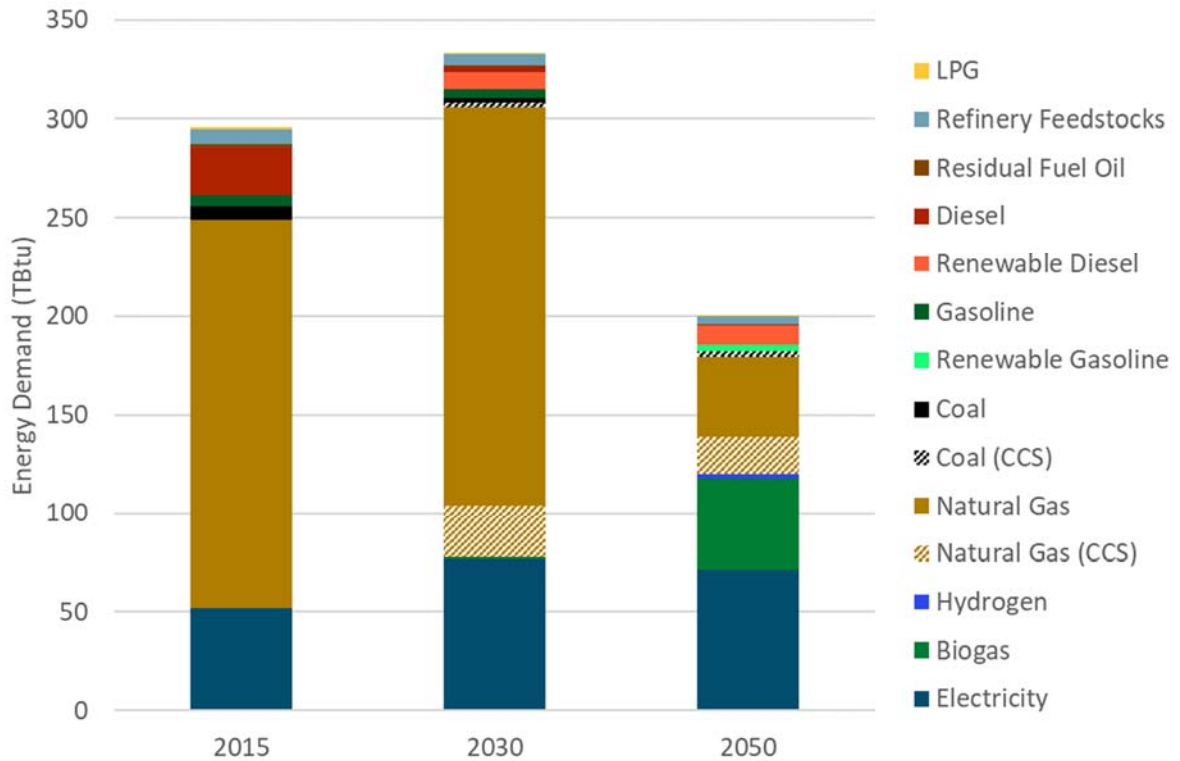Final energy demand by fuel is shown in Figure 4 below:

Figure 4. Final energy demand by fuel in the industrial sector for the HB-1261 Target scenario

Oil & Gas Sector

Base Year

The Colorado PATHWAYS model includes fugitive methane and carbon dioxide emissions from in-state oil and gas production (energy combustion emissions associated with oil and gas production are addressed in the previous section). Historical and forecasted oil and gas production and emission values were provided to E3 by the Air Pollution Control Division (APCD) at the Colorado Department of Public Health and Environment. Base year production, leak rates and emission values are shown in Table 12.

Table 12. Representation of key indicators for the oil and gas sector in Colorado for 2015

Category	Subcategory	Value
Oil & Gas Production	Natural Gas (billion cubic feet)	1,691
	Crude Oil (million barrels)	123
Leak Rate	Upstream Operations Leak Rate	2.5%
	Downstream Distribution System Leak Rate	0.5%
Fugitive Emissions	Methane (MMT CO_2e)	19.4
	Carbon Dioxide (MMT)	0.3

Production Forecast

Natural gas and crude oil production forecasts are assumed to be the same across all three core scenarios and are shown below in Figure 5.
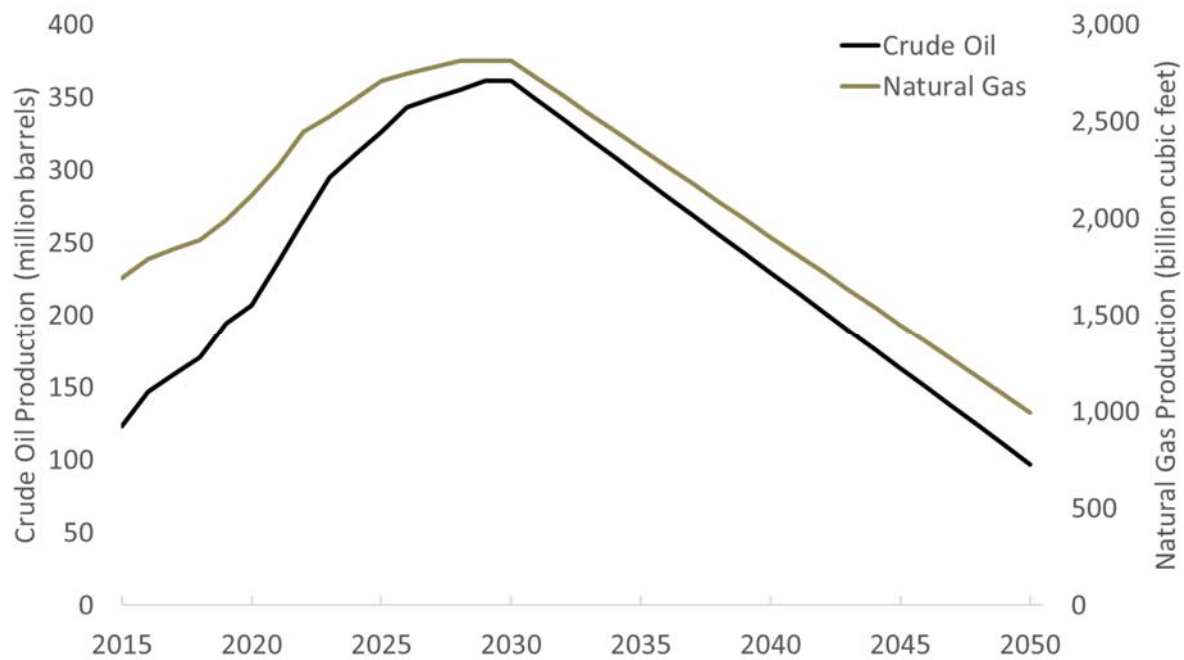
Leak Rate Forecast

Upstream and downstream leak rates are expected to hold constant in the Reference scenario. In the 2019 Action scenario, the full impact of recent oil and gas regulations is assumed to lead to a decline in both Upstream and Downstream leak rates between 2020 and 2030, with a more gradual decline continuing through 2050. This pattern is true for the HB-1261 Target scenario as well, but incremental regulations are assumed to cause a larger drop in leak rates between 2020 and 2030. Leak rates by year for each scenario are shown in Figure 6 below.
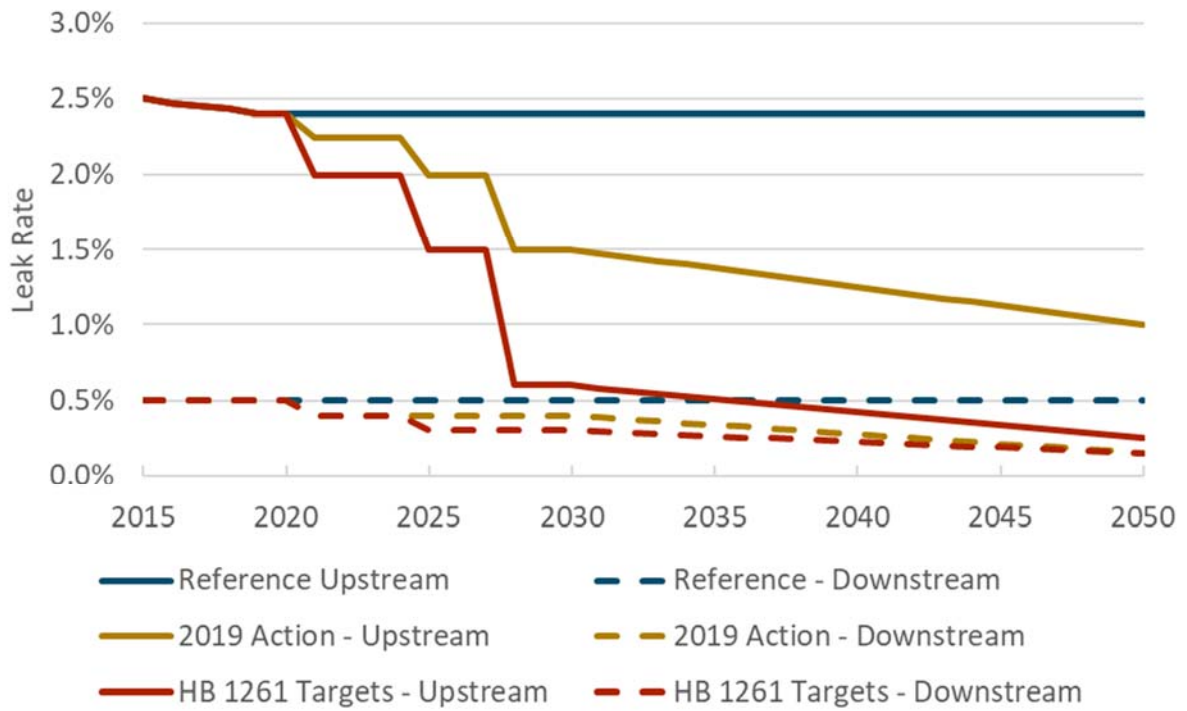
Figure 6. Forecasted leak rates by scenario for upstream and downstream oil and gas operations from APCD

Emissions Forecast

The upstream and downstream leak rate forecasts are applied to the crude oil and natural gas production forecasts as part of APCD's analysis to generate a forecast of fugitive emissions from the oil and gas sector. The results are shown in Figure 7 below.
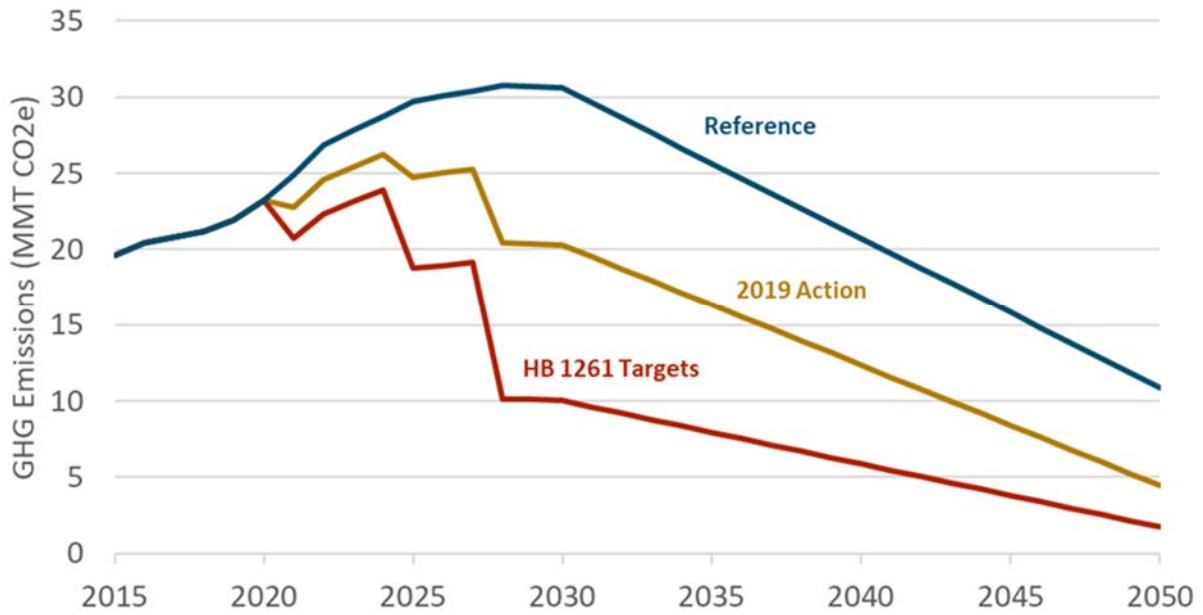
Figure 7. Forecasted oil and gas fugitive emissions by scenario from APCD

Other Non-Combustion Emissions

Base Year

In addition to fugitive emissions from the oil and gas sector, the Colorado PATHWAYS model includes non-combustion emissions from agriculture, coal mines, industrial processes, and waste management. Base year values were calculated using the EPA SIT with default inputs for Colorado. Base year emissions for each subsector are shown in Table 13.

Table 13. Representation of 2015 non-combustion emissions in Colorado (does not include oil and gas fugitive emissions)

Sector	Subsector	Estimated 2015 Emissions [MMT CO_2e]
Agriculture	Enteric Fermentation	6.9
	Manure Management	1.9
	Soil Management	2.3
Coal Mines	Abandoned Coal Mines	0.3
	Coal Mining	1.8
Industrial Processes*	Cement Manufacture	0.8
	Iron & Steel Production	0.3
	Lime Manufacture	0.4
	HFCs	2.9
	Semiconductor Manufacture	0.1
Waste Management	Municipal Solid Waste	3.9
	Wastewater Treatment	0.7
Total		22.3

Does not includes Industrial Processes with less than 0.1 MMT of annual CO_2e emissions

Reference Scenario

There are no non-combustion measures assumed in the Reference scenario.

2019 Action Scenario

There are no non-combustion measures assumed in the 2019 Action scenario.

HB-1261 Target Scenario

The HB-1261 Target scenario assumes aggressive non-combustion emissions reductions. In agriculture, changes in feeding practices are assumed to reduce enteric fermentation 25% by 2030, while incremental soil management practices are assumed to sequester an additional 1 MMT of CO_2 by 2030 and 3 MMT of CO_2 by 2050. For industrial process emissions, CCS equipment with a 90% capture rate is assumed to be installed at all cement and lime manufacturing facilities, and there is an HFC phase down in line with Kigali Amendment requirements. Emissions from active coal mining in Colorado are assumed to trend to zero by 2030, in line with electricity generation from coal in the HB-1261 Target scenario, after which those mines are assumed to be sealed at an average seal rate of 80%. In addition, it is assumed that 38% of abandoned mine methane emissions are captured based on the feasibility assessment from a 2016 CEO market report on coal mine methane. For waste methane, it is assumed that all landfills deemed as "Candidates" by the EPA's Landfill Methane

Outreach Program (LMOP) are equipped with methane capture by 2030, with those deemed as "Potential" added by 2050. An assumed 40% capture of wastewater methane by 2030 and 80% by 2050 is based on previous state-level E3 PATHWAYS analysis. The total impact of these measures is a 54% reduction in non-combustion emissions by 2050, relative to the 2015 base year. Non-combustion emissions for 2015, 2030, and 2050 are shown in Figure 8 below.
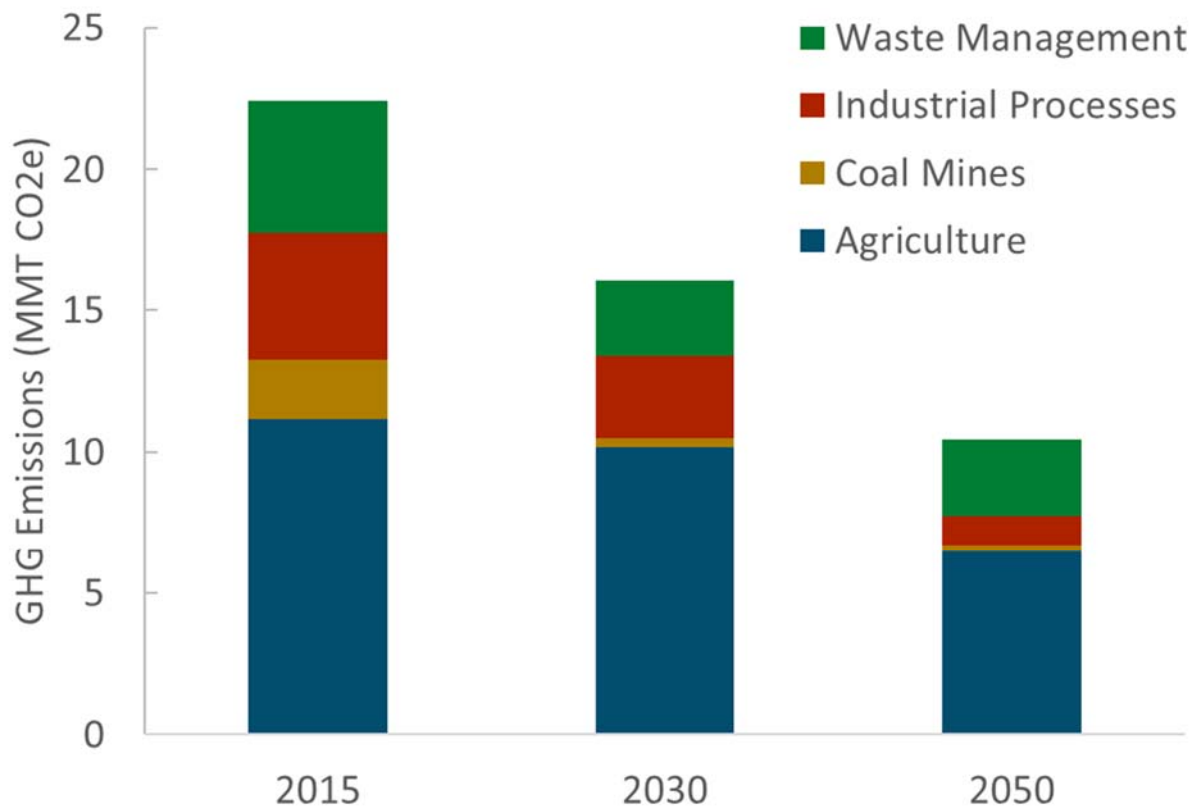

Figure 8. Non-combustion emissions by year for the HB-1261 Target scenario

ELECTRICITY GENERATION

RESOLVE Methodology

E3 modeled electricity generation using the RESOLVE model. RESOLVE is a capacity expansion model that uses linear programming to identify optimal long-term

generation and transmission investments in an electric system, subject to reliability, technical, and policy constraints. Designed specifically to address the capacity expansion questions for systems seeking to integrate large quantities of variable resources, RESOLVE layers capacity expansion logic on top of a reduced-form production cost model to determine the least-cost investment plan, accounting for both the up-front capital costs of new resources and the variable costs to operate the grid reliably over time. In an environment in which most new investments in the electric system have fixed costs significantly larger than their variable operating costs, this type of model provides a strong foundation to identify potential investment benefits associated with alternative scenarios. A graphic overview of the model is shown in Figure 9.
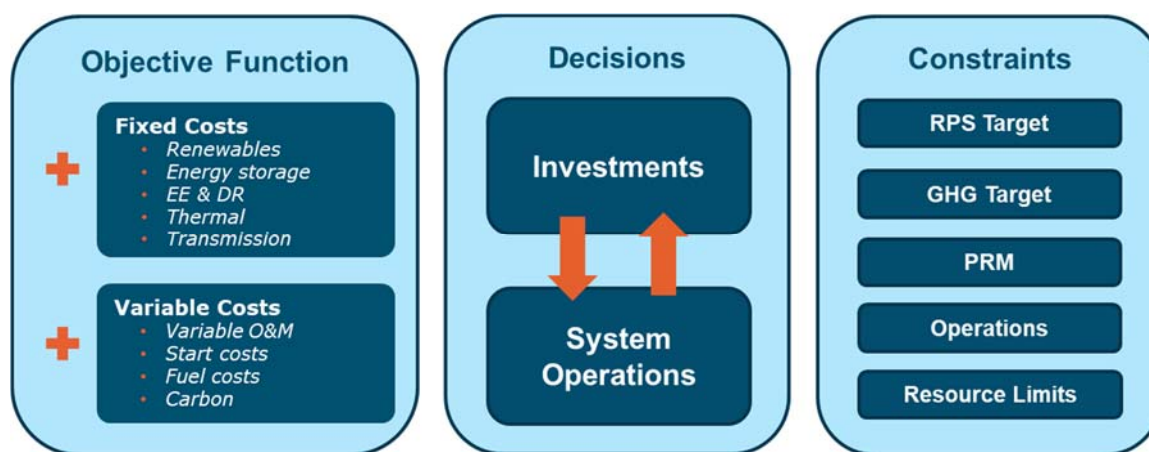

Figure 9: Overview of RESOLVE model architecture

RESOLVE's optimization capabilities allow it to select from among a wide range of potential new resources. The full range of resource options considered by RESOLVE in this study is shown in Table 14.

Table 14. Eligible resources for RESOLVE capacity expansion function

Resource Type	Available Options
Natural Gas Generation	• Simple cycle combustion turbines (CTs) • Combined cycle gas turbines (CCGTs) • CCGTs with carbon capture & sequestration
Renewable Generation	• Solar PV • Onshore Wind

To identify optimal investments in the electric sector, maintaining a robust representation of prospective resources' impact on system operations is fundamental to ensuring that the value each resource provides to the system is captured accurately. At the same time, the addition of investment decisions across multiple periods to a traditional unit commitment problem increases its computational complexity significantly. RESOLVE's simulation of operations has therefore been carefully designed to simplify a traditional unit commitment problem where possible while maintaining a level of detail sufficient to provide a reasonable valuation of potential new resources. The key attributes of RESOLVE's operational simulation are enumerated below:

- **Hourly chronological simulation of operations:** RESOLVE's representation of system operations uses an hourly resolution to capture the intraday variability of load and renewable generation.

- **Planning reserve margin requirement:** When making investment decisions, RESOLVE requires the portfolio to include enough firm capacity to meet coincident system peak plus additional 16.3% of planning reserve margin (PRM) requirement. This value is chosen based on PSCO's 2016 ERP[4]. The contribution of each resource type towards this requirement depends on its attributes and varies by type: for instance, variable renewables are discounted compared to thermal generators because of limitations on their availability to produce energy during peak hours.

- **Greenhouse gas cap:** RESOLVE also allows users to specify and enforce a greenhouse gas constraint on the resource portfolio for a region. As the name suggests, the emission cap requires that annual emission generated in the entire system to be less than or equal to the designed maximum emission cap. As it designs future portfolios, RESOLVE chooses both (1) how to dispatch new and existing resources to meet the goal (e.g. displacing output from existing coal plants with increased natural gas generation) and (2) what additional investments are needed to further reduce carbon in the system.

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[4]
https://www.xcelenergy.com/company/rates_and_regulations/resource_plans/2016_psco_electric_resource_plan

Colorado is represented as a single zone in RESOLVE. The study assumes no transmission or distribution constraint within the state. For further simplification, the study also assumes the Colorado system is islanded without electricity traded and transferred between Colorado and other states given the transmission capability between Colorado and other states is limited. However, wind from southern and eastern Wyoming are included as new resource options due to their proximity to Colorado's border and high wind quality.

GHG reduction target for the electricity sector is summarized in the table below. GHG targets for milestone years like 2030, 2040, and 2050 are calculated based on the announcement by the state or by utilities. Targets for the years between the goals are interpolated linearly. Even though the GHG targets are calculated based on each utility's announcement individually, the GHG constraints are enforced for the state aggregately without differentiating the utility service territories.

Table 15. Electric sector GHG targets

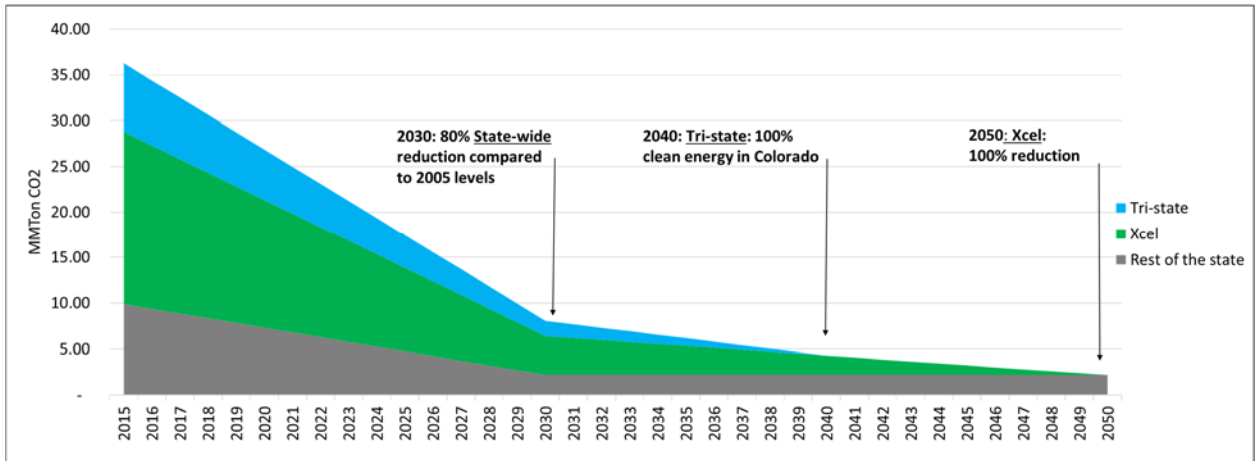| Reference	2019 Action	HB-1261 Target
Existing RPS policy, no additional GHG reduction target	- 80% statewide emissions reduction by 2030, - Tri-state's 100% clean energy in Colorado by 2040, and - Xcel's 100% reduction by 2050 (Represents Xcel & Tri-State commitments + HB 1261)	*Same as 2019 Action*

Figure 10. GHG reduction targets in 2019 Action and HB 1261 Target scenarios

The GHG emissions for the electricity sector are calculated based on generators that are physically located in Colorado. Therefore, RESOLVE is set up consistently to represent the GHG constraints. This means the total load modeled in RESOLVE is the load served by in-state generators, which is equal to

- + the Colorado loads

- - the Colorado loads that are served by out-of-state generators

- + the out-of-state loads that are served by Colorado generators

Inputs and Assumptions

This study relies on a wide range of inputs and assumptions to populate the RESOLVE model. Data is obtained from publicly available information. The key categories of inputs and assumptions are summarized in Table 16. Additional detail on each specific input is included in subsequent sections. We also have a separate input spreadsheet that contains inputs used in the model and data sources.

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Table 16. Key inputs and sources for RESOLVE model

Input Category	Source	Description
Demand forecast	PATHWAYS Study	Annual demand and peak forecast for the state of Colorado
Existing resources	WECC 2026 TEPPC Common Case + recent utility announcement	Capacity, commission dates, retirement dates and operating characteristics for all existing and planned resources within the state of Colorado
New resources	WECC 2019 Generator Capital Cost Tool	Costs and performance for candidate resources considered in the portfolio optimization
Hourly profiles	NREL Wind Toolkit & NREL's National Solar Radiation Database (NSRDB)	Hourly profiles for all the components of demand; hourly generation profiles for solar and wind resources
Fuel price forecast	Market Forward price & EIA AEO Forecast	Fuel price forecast data for all thermal resources

Existing Resources

Existing and planned resources represent what utilities have planned to build or retire in the future. Assuming utilities' plan will be executed, RESOLVE makes additional resource investment to meet the future load and policy targets while minimizing the overall investment and operating costs.

The primary source for operating characteristics and costs on existing and planned generation is the WECC 2026 TEPPC Common Case. After consolidating the existing fleet information from the WECC common case, this study adjusted the coal retirement schedule based on the recent utility announcements. The study also includes renewable additions announced by utilities as part of the planned resource additions. Coal retirement schedule for each scenario is summarized in the Table 17 below.

Table 17. Coal retirement schedule by scenario

Plant Name	Size (MW)	Reference	2019 Action	HB-1261 Target
Comanche 1	325	12/31/2022	12/31/2022	12/31/2022
Comanche 2	335	12/31/2025	12/31/2025	12/31/2025
Comanche 3	766	12/31/2069	12/31/2069	12/31/2069
Craig 1	428	12/31/2025	12/31/2025	12/31/2025
Craig 2	428	12/31/2034	9/30/2028	9/30/2028
Craig 3	448	12/31/2044	12/31/2029	12/31/2029
Hayden 1	212	12/31/2030	12/31/2030	12/31/2030
Hayden 2	286	12/31/2036	12/31/2036	12/31/2036
Martin Drake 6	83	12/31/2035	12/31/2022	12/31/2022
Martin Drake 7	141	12/31/2035	12/31/2022	12/31/2022
Pawnee 1	505	12/31/2041	12/31/2041	12/31/2041
Rawhide 1	280	12/31/2050	12/31/2029	12/31/2029
Ray D Nixon 1	208	12/31/2050	12/31/2029	12/31/2029

To accurately capture the coal retirement schedule, each coal plant unit is modeled separately. Existing gas and fuel oil plants are, on the other hand, modeled by plants. The composition of existing fleet for the reference case is shown in F. The final retirement schedule decided by RESOLVE might be different from the planned retirement schedule since RESOLVE can choose to retirement more coal plants earlier if it is economic to do so.
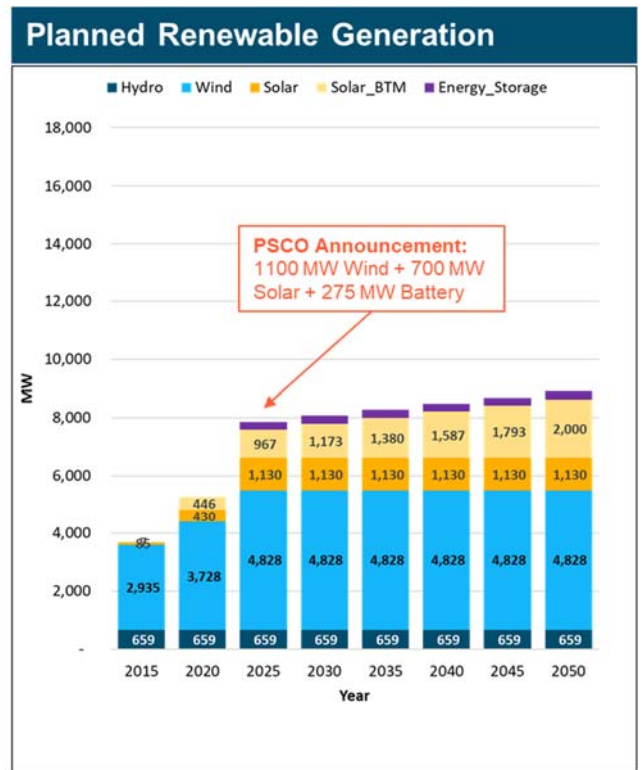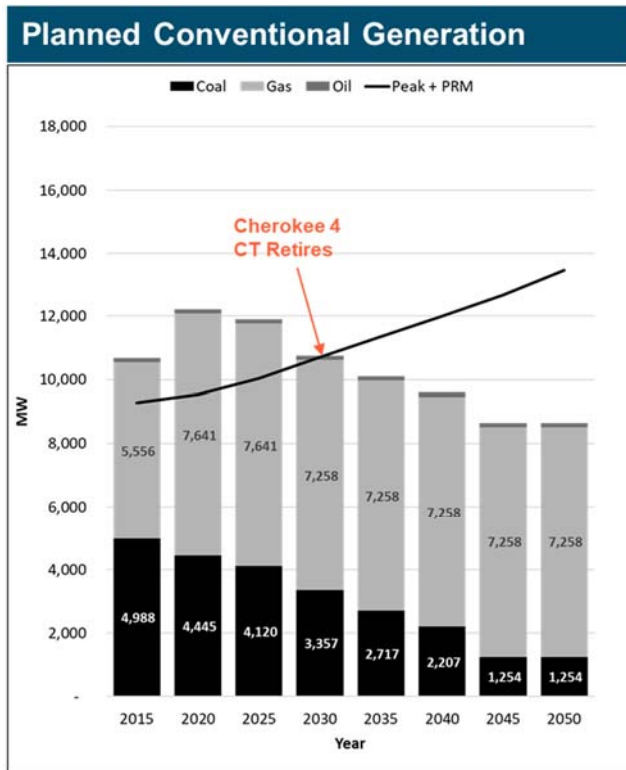
Figure 11. Planned conventional and renewable generation for the reference case

New Resource Options

A broad range of new resources options are considered as candidates in the portfolio optimization process. These options include new gas, renewable, storage, and new gas with carbon capture. The study includes biofuel as an alternative fuel to use. This section summarizes general assumptions on resource cost and performance used to characterize each of these options.

Natural gas

Two generic gas generation resources are included as options for additional capacity:

- Advanced CCGT: a generic new combined cycle plant that reflects both capital costs and the ongoing costs of operating the plant.

- Frame CT: frame CTs are available as resource options. As with the advanced CCGT, the capacity potential is uncapped.

The levelized fixed costs associated with each generic gas resource in this analysis was based on the WECC 2019 Generator Capital Cost Tool[5]. As shown in Figure 12, the fixed cost per kW of CCGT is higher than the cost of new combustion turbines. Gas-fired resources costs are expected to remain relatively constant in real terms through 2050.
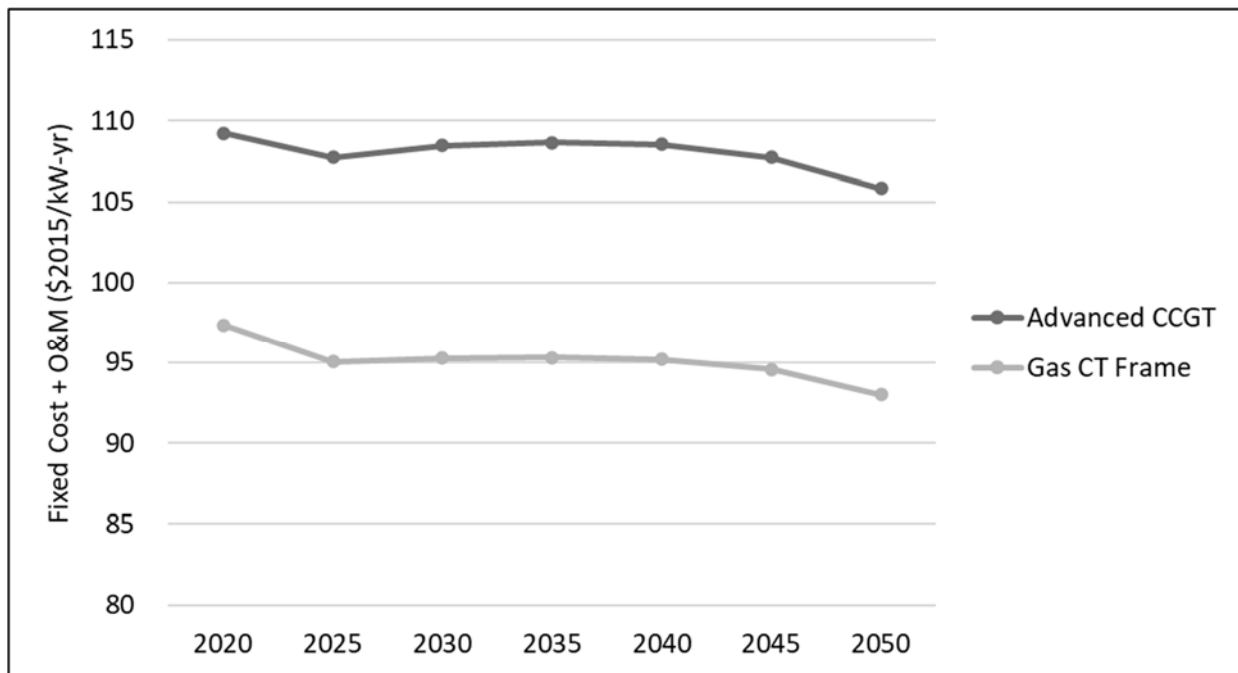

Figure 12. Levelized fixed costs for new gas generation resources

The study also included natural gas combined cycle power plants with carbon capture and storage (CCS) as a candidate resource. CCS is a new emerging technology, and thus there are many uncertainties around the future cost and performance. The operating characteristics and the cost estimates for candidate natural gas CCGTs are based on the Pathways to Deep Decarbonization in New York State report[6]. The CCS cost estimates for upstate New York are used as a proxy for Colorado.

Renewables

[5] https://www.wecc.org/Administrative/E3-WECC%20Resource%20Cost%20Update-201905%20RAC%20DS%20Presentation.pdf
[6] Available online: https://climate.ny.gov/-/media/CLCPA/Files/2020-06-24-NYS-Decarbonization-Pathways-App-A.pdf

Renewable resources candidates are shown in Figure 13 and are developed based on the Western Renewable Energy Zones[7].
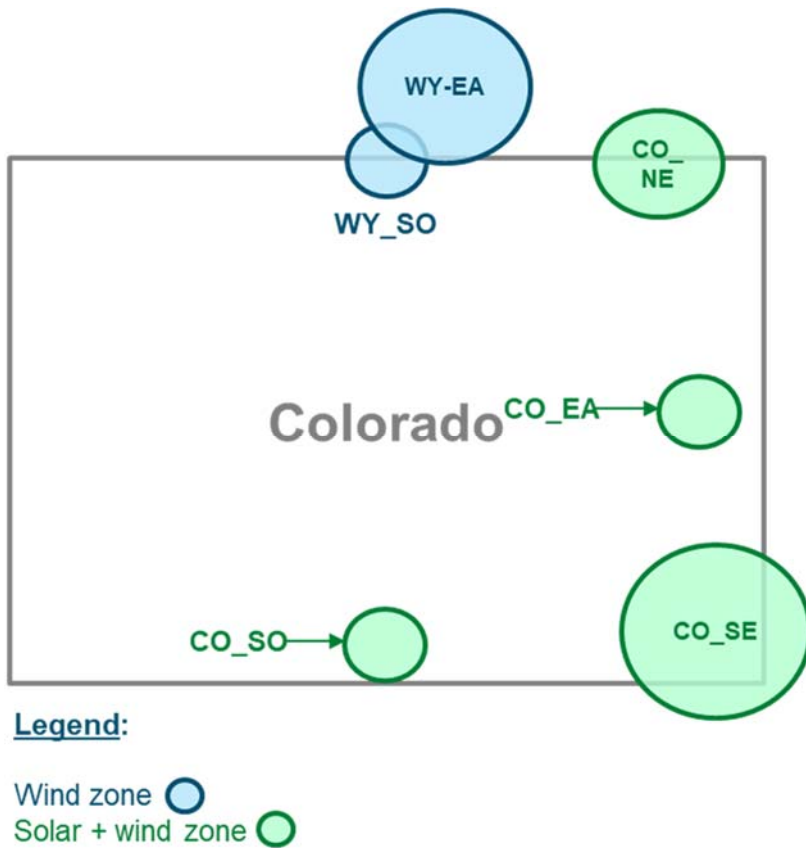

Figure 13. Renewable Resource Candidates

Colorado has significant quality renewable resources, and the wind and solar potentials in Colorado are both above 100 GW[8]. As a result, the study does not specify a limit for the wind and solar resources' technical potentials in RESOLVE. Even without the technical potential limits, RESOLVE won't build an unreasonable amount of renewables because the model also considers the economics. The study checks results for each scenario to make sure the renewable builds are within a reasonable range. On the other hand, RESOLVE does consider the differences in capacity factors

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[7] Available online:
https://www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/WREZ_Report.pdf
[8] Based on the Renewable Energy Deployment in Colorado and the West: A Modeling Sensitivity and GIS Analysis report by Clayton Barrows, Trieu Mai, Scott Haase, Jennifer Melius, and Meghan Mooney from National Renewable Energy Laboratory

for renewables in each region. Capacity factors for each candidate resource are summarized in the table below.

Table 18. Renewable Candidates and Capacity Factors

Renewable Candidates	Capacity Factor
Wind (WY_EA)	45%
Wind (WY_SO)	44%
Wind (CO_NE)	37%
Wind (CO_EA)	41%
Wind (CO_SE)	42%
Wind (CO_SO)	41%
Solar (CO_NE)	29%
Solar (CO_EA)	32%
Solar (CO_SE)	32%
Solar (CO_SO)	33%

Cost assumptions for new renewable resources in this study are also based on the WECC 2019 Generator Capital Cost Tool. This study translates the capital and fixed O&M cost assumptions for wind and solar PV (single-axis tracking) technologies into a levelized cost of energy (LCOE) metric for each type of resource that reflects an proxy for the price at which an independent developer might offer the resource to a credit-worthy utility through a long-term power purchase agreement (PPA). LCOEs for each resource vary through time due to assumed changes in technology cost, financing costs, and federal tax credits.

The LCOEs for new renewable resources also include a component to capture the transmission upgrades needed to ensure that resources can be delivered to loads. Transmission costs are additive to the capital cost of the resource itself and are estimated based on the distance between the location of the resources and the load center (Denver)

Figure 14 below shows the average LCOE for solar and wind candidates over time. Near-term wind costs are relatively low—in large part, due to the effect of the Federal Production Tax Credit (PTC); in the long run, the LCOE of wind is assumed to increase from today's level due to the expiration of the PTC, an effect that is partially offset by some improvements in capital costs. The near-term trajectory of

costs is heavily shaped by the expiration of the PTC, which results in a near-term cost increase; in the long run, the LCOE for new wind resources declines slightly in real terms as technology continues to improve at a modest pace. While the Federal Investment Tax Credit (ITC) available to solar resources today is scheduled to revert to a lower level of 10% in the next few years, continued anticipated cost reductions in capital costs over time helps to offset the effect of the sunsetting ITC on the resulting LCOEs for solar resources.
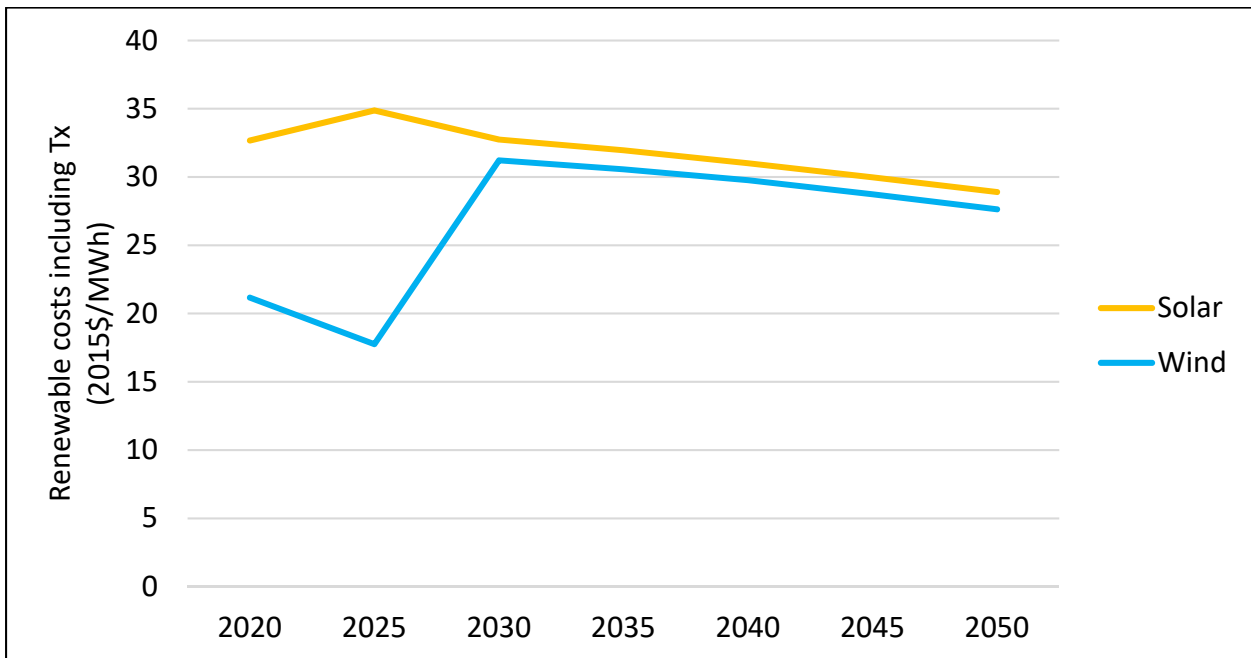

Figure 14. Average LCOE for Solar and Wind Candidates by Years

LCOE for each renewable candidate in 2030 is shown in the Figure 15 below. The LCOE is broken into the transmission cost and the capital and other costs. Wind in South Wyoming and South Colorado have the cheapest LCOE due to its high capacity factors and proximity to the load pocket.
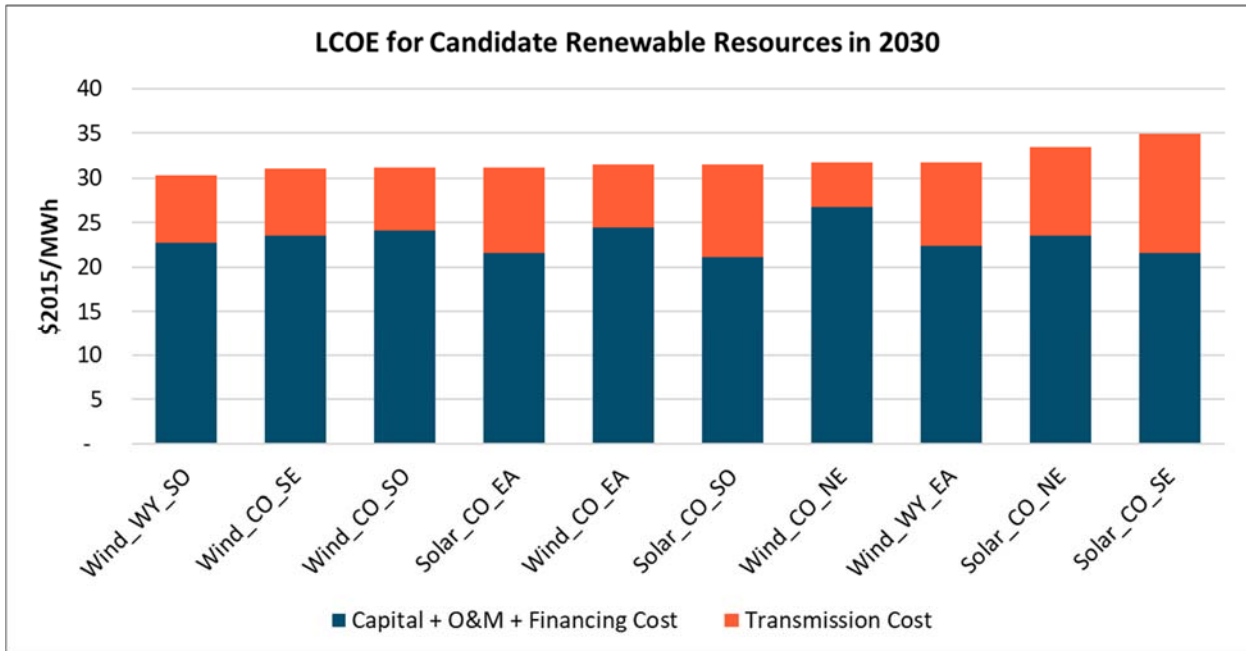
Figure 15. LCOE for Candidate Resources in 2030

Energy storage

4-hour Li-ion battery with 85% round-trip efficiency is included as one of the candidate resources in the study. Cost assumptions for new energy storage are also based on WECC 2019 Generator Capital Cost Tool. This study relies upon WECC's characterization of a utility-scale battery system with four hours of duration. Figure 16 shows the levelized fixed cost assumptions for battery storage across the analysis horizon.

Figure 16. Levelized cost projections for new storage resources

Hourly Profiles

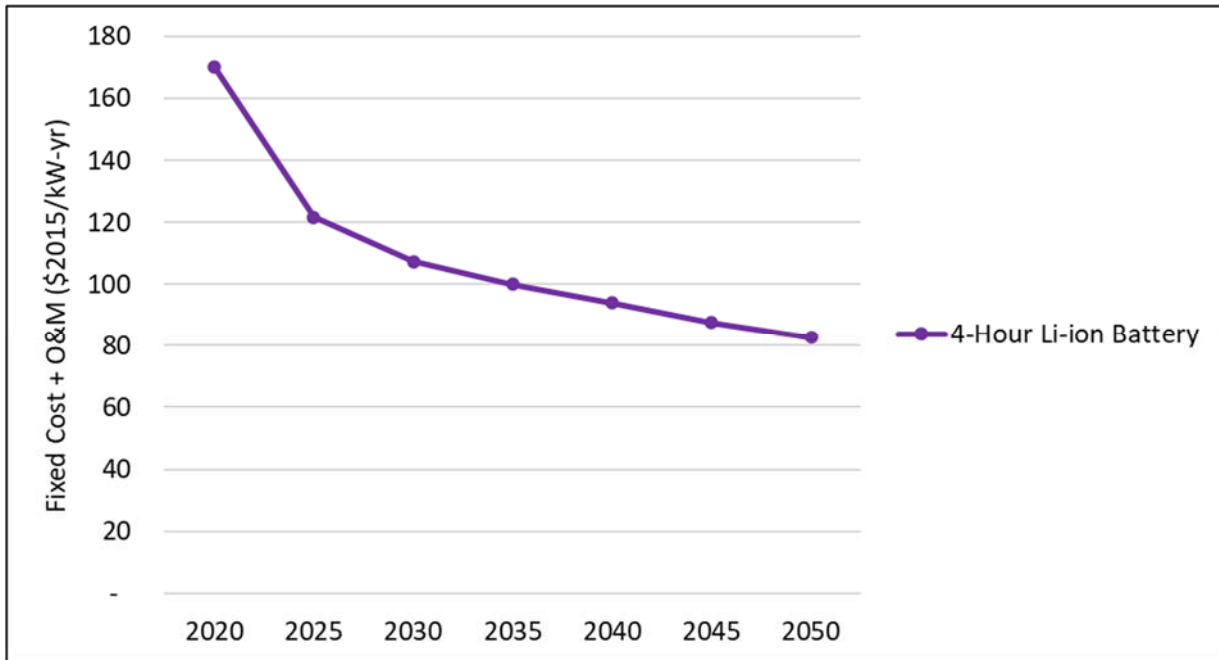Hourly profiles for load and wind and solar resources are key inputs to this study. Load, wind, and solar each vary on an hourly, daily, and seasonal basis, and their variations are often correlated due to underlying meteorological phenomena that affect all three. Capturing these patterns in a statistically rigorous manner is crucial to enable planning of a system that can operate efficiently on a day-to-day basis and is resilient in spite of an increasingly intermittent and variable energy supply.

This study relies on a library of hourly load, wind, and solar profiles that reflect the meteorological conditions across the three-year time span from 2010 through 2012. Developing profiles that are weather-matched and time-synchronized in this manner ensures consistency across the data set, preserving the key underlying correlations among the variables. The hourly profiles for this study are based on the following sources:

- Load profiles are based on the historical hourly profiles from the WECC 2026 TEPPC Common Case

- Load shapes for end uses that may be electrified in the future (e.g. space heating, water heating, electric vehicle) are developed through E3's RESHAPE tool[9]; RESHAPE is designed to capture the diversity of space heating and transportation loads under higher levels of electrification. The tool does this by representing a diverse housing stock, including geographically explicit weather data, and using empirical estimates of hourly energy usage where possible. RESHAPE includes modules for both transportation and buildings.

- Wind profiles are developed for the same period using data from NREL's WIND Toolkit, which provides detailed geospatial simulations of wind speed and generation profiles for a large number of sites throughout the United States

- Solar PV profiles are simulated using NREL's System Advisor Model (SAM) and solar irradiance data from the National Solar Radiation Database (NSRDB) for a variety of plausible locations throughout the state

A representative subset of 40 days is sampled to reflect representative combinations of loads and associated renewable production profiles from the time series described. The reduced representative days enable portfolio optimization across multiple decades within a reasonable solving time.

Effective Load Carrying Capability

Capacity accreditation for variable and use-limited resources under a PRM framework requires an estimate of "effective load carrying capability," which captures limitations of each resource to meet reliability needs. The effective load carrying capability represents the amount of firm capacity that can be provided by the resource. The firm capacity is then counted toward the planning resource margin requirement in modeling. The assumed ELCC for each resource category are summarized in the table below. For thermal resources, the study uses the weighted average ELCC for each thermal resource category in PSCO's 2016 ERP as the ELCC for current and future thermal resources.

Table 19. Effective Load Carrying Capability Summary

Resource Category	ELCC (% of Nameplate)	Sources
Coal	93%	PSCO 2016 IRP
Natural Gas	92%	PSCO 2016 IRP
Oil	93%	PSCO 2016 IRP
Wind	Varies by installed capacity	E3's estimate
Solar	Varies by installed capacity	E3's estimate
4-hour Li-ion Battery	Varies by installed capacity	E3's estimate & NREL's report[10]

● In this model, ELCCs for renewables are estimated based on their respective impacts on the net peak demand across the top 100 hours of the year. As illustrated in the Figure 17 below, renewable ELCCs are estimated based on the achieved peak load reduction provided by the renewable resource when it is stacked against the system load shape.
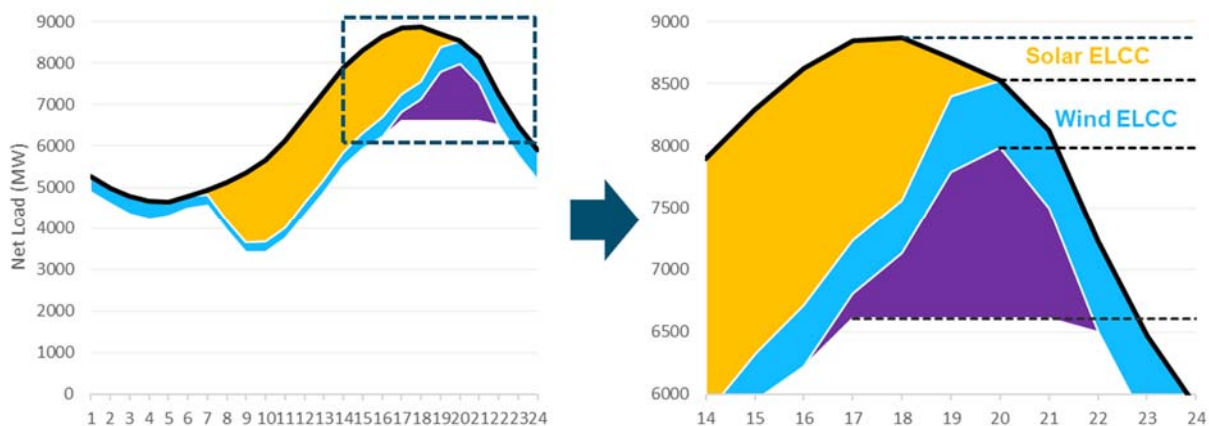

Figure 17. Illustration of the ELCC methodology

Based on the estimation method described above, the estimated average ELCCs for wind and solar combined is shown in the figure below. The average ELCC is shown based on the wind and solar penetrations in the system. Wind and solar penetrations are calculated as % of annual energy. The red dots represent how the average ELCC changes when solar penetration level is fixed at 10% and wind penetration level varies from 0% to 60%. More specifically, for the red dot on the right, of which the x axis is 60% and the y axis is 20%, it means that when solar penetration 10% and wind

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[10] NREL: The Potential for Battery Energy Storage to Provide Peaking Capacity in the United States: https://www.nrel.gov/docs/fy19osti/74184.pdf

penetration is 60%, solar and wind combined provide a firm capacity equal to 20% of the system peak.
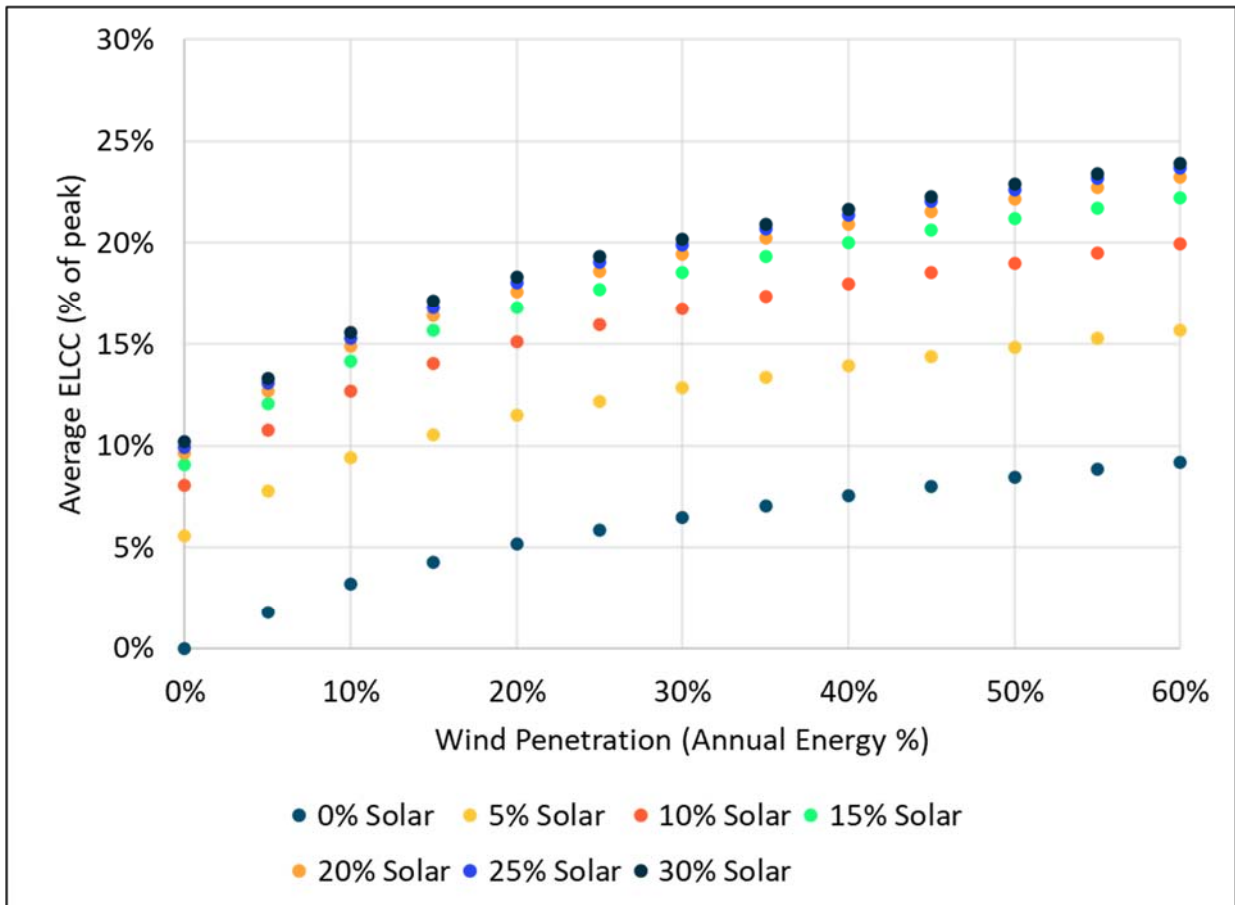

Figure 18. Estimated ELCC for wind and solar

The ELCC for 4-hour Li-ion storage is estimated based on the previous studies E3 conducted in Northwest Region[11], Xcel Minnesota[12], and a Small Northeast utility[13]. Based on these three studies, E3 summarizes the relationship between incremental ELCC and total installed battery capacity in the system and applies that relationship to Colorado. The nameplate capacity threshold for first trench with 100% incremental ELCC is based on the NREL study10. Li-ion batteries' incremental ELCC decrease as the total battery installed capacity increases. With more Li-ion batteries in the

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[11] Northwest Region: Resource Adequacy in the Pacific Northwest
[12] Xcel Minnesota: Upper Midwest 2019 IRP Support
[13] Small Northeast Utility: confidential internal analysis

system, system peak is flatter, and it becomes more difficult for the new 4-hour battery to provide capacity during the longer peak period.
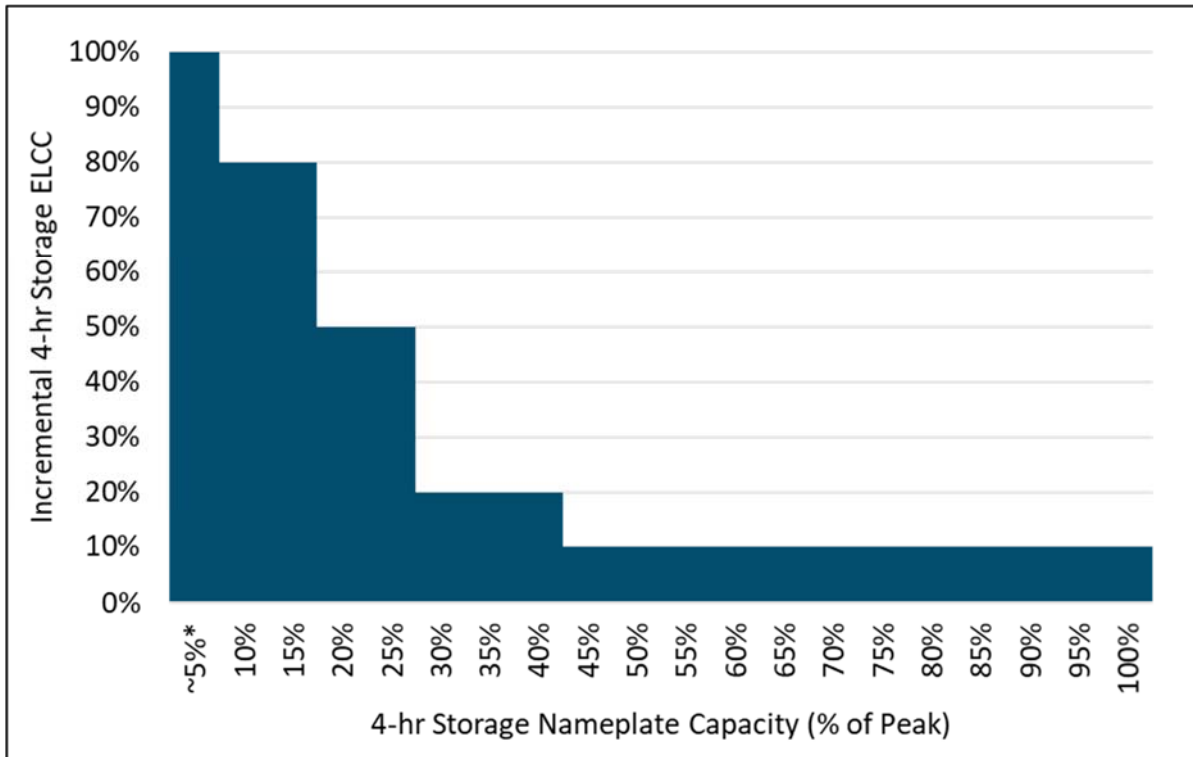
Figure 19. 4-hr Storage ELCC

Fuel Price Forecasts

Natural gas prices forecasts are based on the Market Forward prices for the near term (2020-2022) and EIA AEO Forecast[14] for the long term (2040-2050). Prices are interpolated linearly for the years in between (2022–2040).

Coal prices are assumed to stay the same in the real term for future years. Coal plants are grouped into two groups given there are significant differences in historical fuel prices among coal plants in the state as shown in Figure 20. The future coal prices for each group are assumed to be the same as the weighted average 2019 historical coal prices in real term. The two groups are:

- Uinta basin: Craig, Hayden, and Nucla

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[14] https://www.eia.gov/outlooks/aeo/

- Southern powder river basin: Cherokee, Martin Drake, Ray D Nixon, Rawhide, Pawnee, and Comanche

Figure 20. Historical Coal Prices by Plants

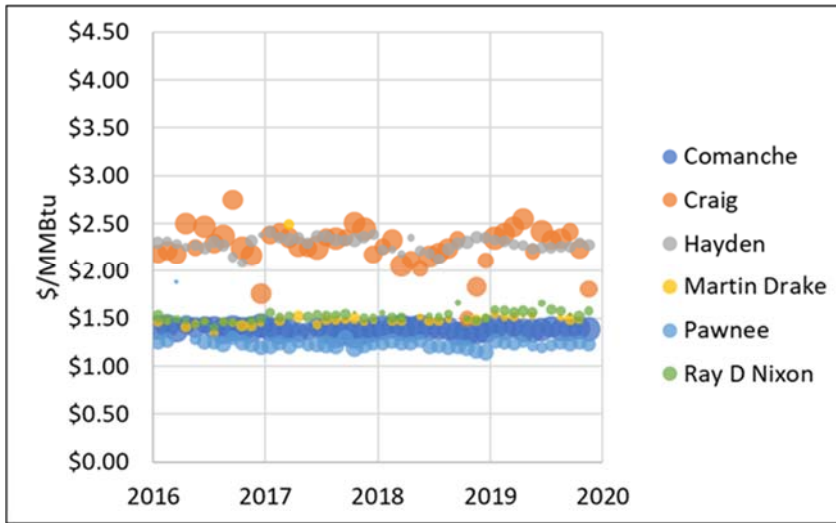Fuel price projections used in this study are summarized in Figures 21 and 22. Natural gas and fuel oil are expected increase in price.
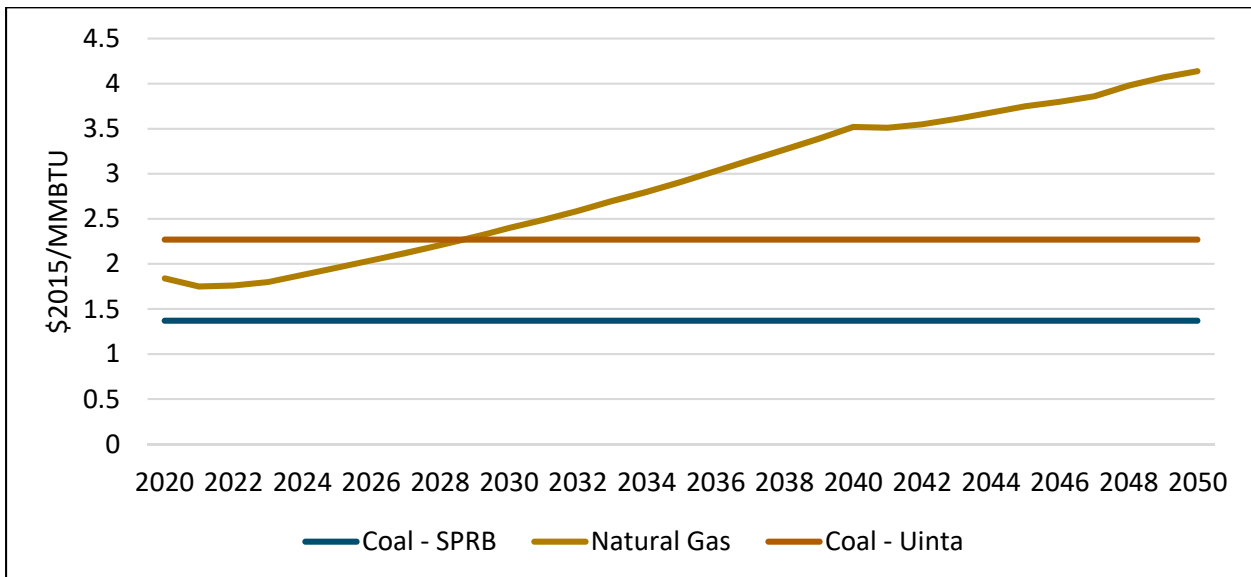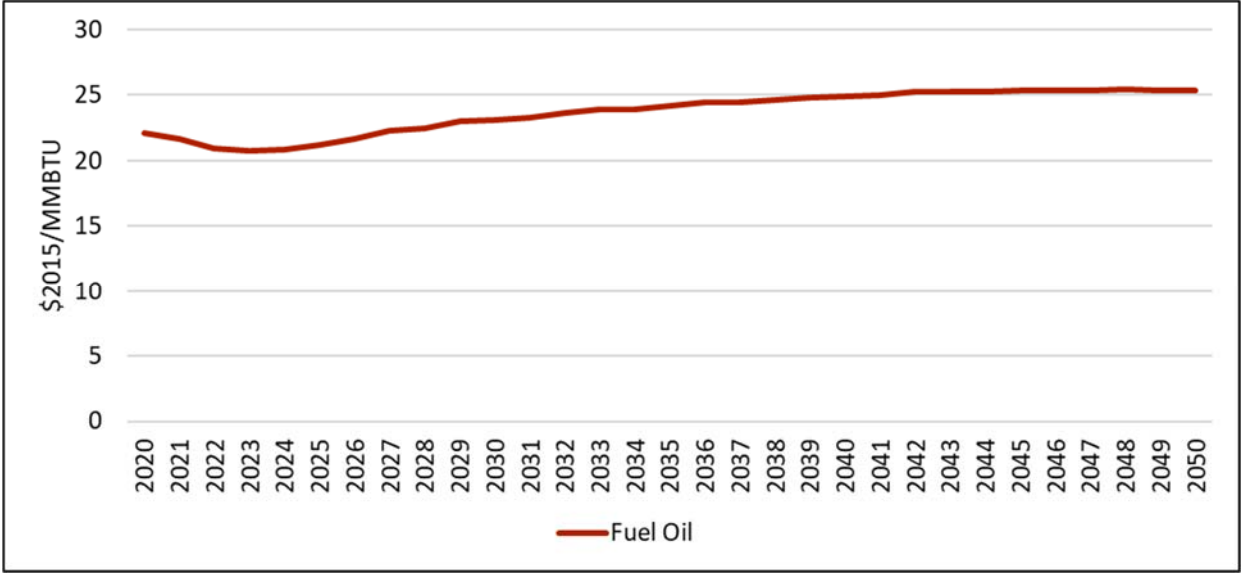

Figure 21. Coal and Natural Gas price forecast

Figure 22. Diesel Fuel Oil Price Forecast

Appendix D: State of Colorado GHG Pollution Strategy Projections and Assumptions

Appendix D outlines efforts conducted to align the sector emissions projections produced by E3 for the Roadmap project with emissions reductions from actionable strategies that are expected to be pursued by the state of Colorado.

The work performed by E3 for the Roadmap is an economy wide energy analysis, broken down into major sector components. The E3 analysis is designed to quantify total cumulative impacts of current policies and programs as well as provide guidance about actions that could be used to keep Colorado on a pathway to achieving the state's ambitious GHG targets. The modeling effort and analysis was not designed to compare or select individual strategies, but rather provide guidance about the scale of reductions from each economic sector based on overall energy consumption. This modeling represents one pathway for achieving Colorado's GHG goals.

During the course of the Roadmap project, CEO received input from various interested stakeholders, including the AQCC, that the analysis and final report should contain a discussion of progress achieved and actionable strategies that can be pursued, including estimated GHG reduction benefits from each strategy. In June, the AQCC formed a special subcommittee to discuss potential GHG strategies and emissions reductions. As part of this effort, CDPHE was tasked with developing and quantifying an initial list of actions already implemented and of actionable strategies for the AQCC subcommittee discussions. The CDPHE work also included using the E3 modeling data, referenced to 2015 through benchmarking, to make estimations of emissions reductions from 2005 baseline levels as required by House Bill 19-1261. The table below includes in progress and actionable strategies discussed during the AQCC subcommittee meetings held between July to September.

		2025 Reductions Low End	2025 Reductions High End	2025 Target Reduction	2030 Reductions Low End	2030 Reductions High End	2030 Target Reduction
Economic Effects of COVID		0.00	5.00	0.00	0.00	2.00	0.00
Recent, Ongoing and Near Term Actions							
Electric Generation Sector Transition	Ongoing / Near Term	17.96	19.85	18.90	30.59	33.81	32.20
Ongoing SB19-181 Rulemakings	Priority / Near Term	4.00	8.00	7.00	10.00	15.00	12.00
Coal Mine Methane	Ongoing	4.50	5.50	5.00	5.40	6.60	6.00
Transportation: Business As Usual including CAFE and LEV	Ongoing	4.50	5.50	5.00	5.40	6.60	6.00
Comprehensive Transportation Efforts: GHG Planning and Pollution Standard; Vehicle Miles Travelled Reduction; Medium-and Heavy-Duty Strategy; Additional Light Duty Vehicle Standards and Incentives; Indirect Source Rules	Priority / Near Term	1.80	2.20	2.00	4.14	5.06	4.60
Local Action Programs (Denver, Boulder, Ft. Collins, and others)	Ongoing	0.90	1.10	1.00	2.25	2.75	2.50
Reg 22 Hydrofluorocarbon Phase-Out (May 2020)	Ongoing	0.50	0.62	0.56	1.04	1.27	1.15
Waste Diversion Programs -- Front Range Waste Diversion Enterprise	Ongoing	0.45	0.55	0.50	0.45	0.55	0.50
ZEV Regulations and Utility Transportation Electrification Plans	Ongoing / Near Term	0.36	0.44	0.40	1.35	1.65	1.50
Focus Areas under Comprehensive Economy Wide Program							
Renewable Natural Gas Standard for gas utilities	Priority	0.56	0.68	0.62	1.00	4.50	1.55
Landfill and Wastewater Methane Rulemaking and Investment		0.43	0.52	0.47	0.85	1.04	0.95
Refrigerant Management Program	Medium Term	TBD	TBD	TBD	0.45	0.55	0.50
Residential Hydrofluorocarbon High Global Warming Potential Phase-out							
Beneficial electrification requirements	Priority	TBD	TBD	TBD	0.90	1.10	1.00

Expanded natural gas demand side management requirements							
Building Benchmarking and Peformance Standards					2.11	2.57	2.34
Industrial Energy and Emissions Audits and Efficiency Rulemakings							
TOTAL Reductions		35.95	49.95	41.45	65.92	85.05	72.79
Estimated GHG Growth (R-C-I Fuel, Ag, Waste, Industrial Use)		3.26	3.26	3.26	5.09	5.09	5.09
Overall Change		32.69	46.69	38.19	60.83	79.96	67.70
CO2e MMT Reduction Needed for 1261 Targets				35.09			67.48

Included below is a list of inputs and information used to develop the list of strategies in the table above.

ELECTRIC GENERATION SECTOR TRANSITION:

- Includes announced coal plant retirements
- Includes reduced coal unit capacity for units remaining online
- Includes increased natural gas usage in 2025 to offset decreased coal capacity and retirements as additional renewables, storage, and transmission are constructed and brought online
- EGU sector achieves 80% GHG reduction by 2030 through Clean Energy Plans and Regional Haze SIP requirements

TRANSPORTATION SECTOR TREND:

- Compares 2005 GHG Inventory value to REFERENCE scenario modeled by E3 for Roadmap
- 2005 Value ~31 MMT, 2025 Value ~26 MMT, 2030 Value ~25 MMT
- CAFE standards and extension as well as historical vehicle turnover used for projected values in the model

COAL MINE METHANE:

- 2019 Inventory calculated decrease from ~6.8 MMT to ~1.8 MMT between 2005 and 2015
- 5 MMT reduction held constant through 2025

- Additional 1 MMT reduction expected by 2030 through additional closures and flaring permit(s)

ONGOING OIL AND GAS RULEMAKINGS:
- Based on revised O&G Inventory and Projections included in June 18 AQCC Roadmap update, with projections updated in July based on COGCC mill levy information
- Includes production growth post-COVID
- Assumes declining state-wide leak rate due to ongoing Rulemakings for SB-181 and HB-1261

REGULATION 22 HFC PHASE-OUT:
- Emissions reductions estimates from Economic Impact Analysis (EIA)

  ZEV Regulation and Utility Transportation Electrification Plans (TEP):

- Assumes smaller impact in 2025 and expanding impact in 2030 and beyond due to vehicle life span and fleet turnover
- Includes emissions reduction estimates from rulemaking EIA and recently filed TEPs

WASTE DIVERSION – FRONT RANGE WASTE DIVERSION ENTERPRISE:
- Uses EPA's WARM tool to estimate benefits of increasing waste diversion rates for paper, cardboard, food and yard waste from 18% to 28% by 2025 and maintains that level through 2030
- Assumes total waste generation remains flat

LOCAL ACTION PROGRAMS:
- October 2018 report for Boulder county that estimated ~1.8 MMT reduction potential by 2030
- Expect that Denver, Fort Collins, and other municipalities will also be achieving GHG reductions through planning and programs implemented
- May be some double counting but cities and counties are pushing forward with these programs and will achieve benefits looking forward

<u>LANDFILL AND WASTEWATER METHANE RULEMAKING AND INVESTMENT</u>:
- Uses a target of 20% reduction by 2025 and 40% reduction by 2030 from 2005 levels

  Renewable Natural Gas Standard:

- Uses Energy Office review of RNG potential in Colorado to estimate benefits

<u>REFRIGERANT MANAGEMENT PROGRAM</u>:
- Emissions reductions highly dependent on scope and timing of program
- Assumes no reductions by 2025 due to rulemaking and program implementation timing
- Provides a way to limit GHG emissions growth with possible reductions from 2005 levels

<u>RESIDENTIAL HFC HIGH GWP PHASE-OUT</u>:
- Emissions reductions highly dependent on scope and timing of program
- Assumes no reductions by 2025 due to rulemaking and program implementation timing
- Combined with refrigerant management program rules could target an overall reduction from 2005 levels of 0.5 MMT with additional reductions beyond 2030

<u>BENEFICIAL ELECTRIFICATION REQUIREMENTS</u>:
- Based on Energy Office study of potential benefits
- Limited ability to achieve 2025 benefits once legislation and rulemakings are completed
- Expedited implementation could be possible through strong support by the AQCC for utility beneficial electrification programs

<u>OTHER BUILDING AND EFFICIENCY REQUIREMENTS</u>:
- Includes natural gas DSM, Benchmarking and Performance Standards, and Industrial Energy and Emissions Audits and Efficiency requirements
- Limited ability to achieve 2025 benefits once legislation and rulemakings are completed

- Could target about ~5 MMT total reductions from buildings and energy efficiency by 2030 with expansion beyond that time period
- Modest change in overall BE well below technical potential

COMPREHENSIVE TRANSPORTATION PLANNING:
- Includes maintaining 10% VMT reductions post COVID
- Includes expanded ZEV adoption for LDV
- Includes HD/MD ZEV adoption
- Includes mass transit ZEV adoption

Throughout the Roadmap development process, other organizations conducted their own modeling of Colorado's GHG reduction trajectory. Below is a comparison table prepared by CDPHE for the September AQCC subcommittee meeting describing other publicly available modeling efforts at the time of this report publication.

Placeholder for table being developed.

APPENDIX E: Public Outreach Process and List of Groups that Participated in Outreach Meetings

During the development of the draft Roadmap, the state implemented a Stakeholder Outreach Plan to engage citizens and stakeholders, to inform them about developments in the Roadmap process and to hear their feedback about the Roadmap and how Colorado is addressing climate change.

As part of the Stakeholder Outreach Plan, the State agencies formed a Technical Advisory Group comprised of technical experts who provided input on the study's assumptions and results.

The state also developed a webpage and web-based form to allow anyone to submit comments either through the form or by uploading comments. In addition to the public comment form on CEO's website, the Roadmap team provided regular, monthly updates to the Air Quality Control Commission, where time was provided for the public to comment on the Roadmap.

STATE OUTREACH PLAN

This is the initial plan developed by the state and its contractors. The next section of this appendix describes how this plan has been carried out. With assistance from the project contractors (E3 and CNEE), the Colorado Energy Office (CEO) and Colorado Department of Public Health and Environment (CDPHE), in collaboration with the Governor's Office and other State agencies (Colorado Department of Transportation, Department of Natural Resource, and Department of Agriculture), will carry out an outreach and communications effort designed to engage citizens, stakeholders, and technical experts to help inform development of the administration's Greenhouse Gas Emissions Roadmap. This effort will begin in January 2020 and continue through completion of the project in September 2020. It will also lay the foundation for further outreach and communications related to GHG policy development and implementation in Colorado over the coming months and years. The outreach and communications activities described below will ensure:

○ Technical input on study design and review of draft work products by leading experts in each of the major sectors covered by the Roadmap to provide a solid technical foundation.

○ Opportunities for input from the public and stakeholders to ensure transparency, gauge reactions to policy options, develop support for the Roadmap, and to implement stakeholder engagement requirements established by House Bill 19-1261 and Senate Bill 19-096.

○ Identification of, and input from, disproportionately impacted communities and communities that are currently economically dependent on industries with high levels of greenhouse gas emissions (see: HB19-1261)

○ Coordination with the Air Quality Control Commission (AQCC) in accordance with its statutory mandates to adopt rules for GHG reporting and abatement in Senate Bill 19-096 and House Bill 19-1261.

○ Collaboration with other state commissions involved in the development and implementation of policies to address GHG emissions in Colorado, including the Transportation Commission, Public Utilities Commission (COPUC), Agriculture Commission, and Oil and Gas Conservation Commission (OGCC).

○ Participation of technical and policy experts from all State agencies with a role in the development and implementation of the Roadmap to gather data and ensure consistency with agency-specific analysis

○ Relationship building with experts at Colorado colleges and universities, national laboratories, and other Colorado institutions that have experience and expertise to contribute to the effort.

There will be three categories of outreach as a part of this project:

○ Technical Advisory Group (TAG)
○ Public Outreach
○ Targeted Outreach

More detail on the strategy for these types of outreach is included in the sections that follow.

Technical Advisory Group

A first step in the implementation of this outreach plan will be to form a Technical Advisory Group (TAG) tasked with providing input on the study design, including assistance with data collection and evaluating modeling assumptions. This group will also be asked to provide feedback to the state and E3 on emissions inventory data that will be used in the modeling and the assumptions included in the modeling of a reference case and a current policies case. As the project moves into later phases, the TAG, along with other stakeholders and the public, will be asked to provide input on the additional policies and strategies that could be considered to ensure timely progress toward the state's 2025, 2030, and 2050 GHG goals.

The TAG will be comprised of individuals with expertise covering business and industry, clean energy, academic and research institutions, and local government. The TAG will assist the state and the contractor in data collection, vetting of technical modeling assumptions, assessments of the modeling results, and evaluation of various emission reduction pathways. Lead modeling staff from State agencies will also participate in the TAG. Input from the Public and Stakeholders

Public Outreach

A website will be established on the Colorado Energy Office domain so that all members of the public have access to information about the project, and to reports and presentations as they become available. The website will include a comment function so that members of the public and stakeholders can provide written comments to the state team working on the Roadmap. E3 and CNEE will help provide content for the website.

The state will host a public workshop in early April 2020 to update the public and stakeholders on progress and initial results (2005 base year and current policies case), and to provide an opportunity for input on mitigation measures that should be

considered for modeling. This will also provide the state with an opportunity to outline changes since the 2019 Inventory. A second public workshop will be held when the Roadmap is complete so that state leadership can describe the results of the project and discuss next steps. These public workshops will be organized so that interested parties can attend in-person or remotely via live-streaming.

The first public meeting was not held as planned due to COVID-19. During that time, public updates have been given at AQCC meetings which have been well attended. The state held a public listening session in August 2020, with roughly 300 people participating via Zoom.

A second public listening session will be held in October, after this public draft of the Roadmap is released, to provide additional opportunity for interested persons to provide comment on it.

<u>Targeted Outreach</u>

During the course of the project, the state's leadership team will also hold informational meetings with diverse stakeholders and stakeholder groups to keep them informed on the project's objectives and progress, and to solicit their input on the technical and policy issues addressed by the Roadmap. Stakeholders and stakeholder groups with whom the state leadership plans to meet during the course of the project include, but are not limited to:

- Agriculture
- Labor
- Environmental advocacy and clean energy organizations
- Environmental justice groups and impacted communities / workers
- Electric utilities
- Extractive industries
- Local governments and local elected official
- Automakers, auto dealers, and fuel suppliers
- Homebuilders, developers, and construction companies

- Industrial sources
- Trucking and delivery companies
- Business Community

These meetings may be held with individual companies or organizations, or may be scheduled to include multiple companies or organizations from a given sector.

Air Quality Control Commission

The AQCC plays a key role in the implementation of Colorado's legislation aimed at reducing GHG emissions. This includes adopting rules for GHG reporting pursuant to Senate Bill 19-096 and rules to ensure timely progress toward the state's GHG goals pursuant to House Bill 19-1261.

Accordingly, the state's Roadmap leadership team will ensure ongoing communication and information sharing with the AQCC throughout the course of the project. The first such presentation was given to the AQCC at their November 2019 meeting, and that presentation is available on the AQCC's website.

The first major milestone for coordination between the AQCC and the Roadmap project relates to the GHG reporting rule that the AQCC will adopt in mid-2020. E3's work to update the state's GHG emissions inventory for use in its modeling may yield helpful information that the AQCC and Air Pollution Control Division can use as they develop the state's new reporting rule. Therefore, E3 and the state's Roadmap leadership team plans to brief the AQCC on the inventory at its February 2020 monthly meeting. Additional briefings for the AQCC are anticipated approximately every other month during the course of the project. Collaboration with Other state commissions, including the Transportation Commission, Public Utilities Commission, Agriculture Commission, and Oil and Gas Conservation Commission play important roles in the state's overall strategy to address GHG emissions. The state's Roadmap leadership team will work with each commission's staff to identify specific areas for collaboration and coordination.

Dr. Morgan Bazilian	Payne Institute, School of Mines
Jill Cooper	Geosyntech Consultants
Dr. Bryan Hannegan	Holy Cross Energy
Jeffrey Lyng	Xcel Energy
Dr. Keith Paustian	Colorado State University
Dr. Gabrielle Petron	NOAA ESRL Global Monitoring Division
Tracy Winfree	CDR Associates
Lee White Stifel	Public Finance

LIST OF STATE UPDATES TO THE AQCC AND OTHER PUBLIC MEETINGS

August 2020

The state hosted a public listening session on August 12. The state provided an overview of the Roadmap and state climate equity work with time dedicated for public comment and answering questions.

July 2020

CEO presented to the Board of Directors of the Denver Regional Council of Governments on July 1 and to the Colorado Chamber of Commerce Energy & Environmental Council on July 17. We also held a Roadmap Business Briefing for Ceres network members on July 21.

June 2020

CEO, CDA and CDPHE presented the GHG Reduction Roadmap process to Colorado's agricultural commodity and advocacy groups on June 4, 2020. Discussion centered around opportunities for farmers and ranchers to volunteer to employ conservation inputs that improve production, energy efficiency, water quality, and reduce greenhouse gases. We also hosted Roadmap presentations for the Metro Mayors Caucus, Colorado Municipal League, Colorado Counties, Inc., and Counties and Commissioners Acting Together on June 17 and 18.

May 2020

On May 11, CEO in partnership with the Climate Unit at the Colorado Department of Public Health and Environment, presented an update of the Roadmap and the rulemaking process for Regulation 22 at the Public Utilities Commission.

April 2020

E3, joined by CEO and CDPHE, gave a presentation on the Roadmap at a public meeting of the The Air Quality Control Commission. The presentation provided an update on the inventory analysis and discussed scenarios for the greenhouse gas emissions reduction needed to meet the state's goals. There was an opportunity to provide comments on potential mitigation strategies. CDPHE Staff presented plans to identify and engage communities disproportionately impacted by climate change.

March 2020

The state's Roadmap team and E3 convened the first meeting of the Technical Advisory Group (TAG), a cohort of individuals from industry and the academic and scientific communities who possess specialized technical expertise in key areas that will be evaluated as part of the Roadmap study. The TAG will review and provide valuable input to the Roadmap team on the study's modeling assumptions, mitigation scenarios, and results on an ongoing basis.

February 2020

The Air Quality Control Commission hosted a public meeting that included an update on the Roadmap process. While this presentation primarily focused on the inventory analysis that has taken place, there will be future public meetings and engagement opportunities to more directly weigh in on potential mitigation pathways. The Commission will be taking steps to hear more from communities impacted by climate change.

January 2020

As part of implementing Colorado's laws to track and report GHG pollution (Senate Bill 19-96 and House Bill 19-1261), the Air Pollution Control Division at the Colorado Department of Public Health and Environment (CDPHE) held public meetings on January 16, 2020 and January 17, 2020 to gather stakeholder input to inform draft rules. CDPHE also gathered input from representatives of impacted communities, industry groups, environmental groups, local governments, utilities and other states through January 27, 2020.

TARGETED OUTREACH

Throughout the development of Colorado's GHG Pollution Reduction Roadmap, the State Roadmap Team held dozens of meetings with local governments, community leaders, public interest groups, businesses, and others to provide information on the Roadmap and to solicit input on the plan. Listed below are groups that participated in

these outreach meetings. In addition, regular updates were given at open, public meetings of the Colorado Air Quality Control Commission starting in February 2020.

List of Groups that Participate in Outreach Meetings

Several of the groups on this list participated in more than one meeting.

- ○ Air and Waste Management Association - Rocky Mountain Region
- ○ Black Hills Energy
- ○ Boulder + CC4CA
- ○ Ceres
- ○ Colorado Dept. of Transportation: GHG Workshop
- ○ Colorado Ag Council
- ○ Colorado Agriculture Commission
- ○ Colorado Association of Municipal Utilities
- ○ Colorado Chamber of Commerce
- ○ Colo. Coalition to Enhance Working Lands, Quivera Coalition, and Collab. for Healthy Soils
- ○ Colorado Communities for Climate Action (CC4CA) and Local Government Representatives
- ○ Colorado Counties, Inc. and Counties and Commissioners Acting Together (CCAT)
- ○ Colorado Electric Vehicle Coalition
- ○ Colorado Energy Office – Weatherization Group
- ○ Colorado Environmental Coalition
- ○ Colorado Forum
- ○ Colorado Mining Association
- ○ Colorado Municipal League
- ○ Colorado Oil and Gas Association
- ○ Colorado Public Utilities Commission
- ○ Colorado Renewable Natural Gas Coalition
- ○ Colorado Rural Electric Association

- Community Leaders from Disproportionately Impacted Communities
- Conservation Colorado
- Denver Regional Council of Governments
- Environmental Defense Fund
- Healthy Colorado / The Nature Conservancy
- ICLEI – Local Governments for Sustainability
- Metro Mayors Caucus
- Natural Resources Defense Council
- Regional Air Quality Council
- Signal Tech Coalition
- Southern Ute Tribe - Tribal Leadership
- The Nature Conservancy / Outdoor & Recreation Industries Group
- Tri-State Generation & Transmission
- Ute Mountain Ute Tribe - Environmental Programs staff

List of Groups or Organizations that Provided Written Feedback on the Roadmap

Note that all written comments that have been received are available on the Roadmap website (https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap) in the public engagement section.

- 62 Organizations group letter
- Boulder County
- Colorado Counties for Climate Action (CC4CA)
- Colorado Climate Business Roundtable
- Conservation Coalition
- Colorado Forum
- Colorado Oil and Gas Association and American Petroleum Inst.
- Colorado Ski Country USA
- Environmental Defense Fund
- Healthy Air and Water Colorado

- Natural Resource Defense Council
- Protect Our Winters
- Renewable Natural Gas Coalition
- Southwest Energy Efficiency Project
- The Nature Conservancy
- University of Denver Law Clinic
- Western Resource Advocates

Upcoming process

This public review draft of the Roadmap will be released on September 30, 2020. Comments will be accepted through 5 PM on November 1, 2020, and can be submitted though the web portal at https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap or emailed to climatechange@state.co.us. The state will host a public listening session to take additional input on the evening of October 20.

End Notes

[1] The Climate Action Plan to Reduce Pollution, House Bill 1261 (2019). Accessed from the Colorado General Assembly, https://leg.colorado.gov/bills/hb19-1261.

[2] Other major greenhouse gases include: Methane (CH_4), Nitrous Oxide (N_2O), and fluorinated gasses such as hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride.

[3] National Oceanic and Atmospheric Administration State Climate Series. Accessed at https://statesummaries.ncics.org/chapter/co/

[4] National Oceanic and Atmospheric Administration State Climate Series. Accessed at https://statesummaries.ncics.org/chapter/co/

[5] National Oceanic and Atmospheric Administration State Climate Series. Accessed at https://statesummaries.ncics.org/chapter/co/

[6] Colorado Climate Plan: State Level Policies and Strategies to Mitigate and Adapt. State of Colorado, 2015. Page 49.

[7] https://statesummaries.ncics.org/chapter/co/

[8] Colorado Climate Plan: State Level Policies and Strategies to Mitigate and Adopt. State of Colorado, 2015. Page 49.

[9] Colorado Climate Plan: State Level Policies and Strategies to Mitigate and Adopt. State of Colorado, 2015. Page 49

[10] The 2017 Economic Contributions of Outdoor Recreation in Colorado. Southwick and Associates. July 23, 2018.

[11] U.S. EPA, 2019, Section 12.5.4.

[12] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

[13] House Bill 2019-1261. https://leg.colorado.gov/bills/hb19-1261

[14] Senate Bill 19-96, https://leg.colorado.gov/bills/sb19-096

[15] Heald, Sarah. Colorado 2015 Greenhouse Gas Inventory Update Including Projections to 2020 & 2030. State of Colorado, December 2019.

[16] A complete list of the groups that met with the Roadmap team is included in Appendix E.

[17] The modeling inputs and assumptions developed by E3 are available to download from the Colorado Energy Office's Roadmap webpage. The state modeling assumptions and data is available from the Colorado Department of Public Health and Environment website.

[18] *Colorado Climate Action Plan: A Strategy to Address Global Warming*, Governor Bill Ritter, Jr., November 2007.

[19] Section 40-2-124(1)(c)(I)(E), C.R.S.

[20] Decision No. C10-1328, Proceeding No. 10M-245E

[21] https://www.chieftain.com/news/20200807/evraz-on-solid-ground-in-pueblo-with-new-rail-mill-project.

[22] Source Tri-State filings PUC proceeding 20M-0218E.

[23] http://www.usclimatealliance.org/nwlchallenge

[24] GHG emissions in 2015 were estimated in the EPA's State Inventory Tool that uses national, regional, and state energy and activity data to calculate a greenhouse gas emissions inventory in a given year. This was supplemented with a detailed analysis of oil and gas fugitive emissions from the Colorado Air Pollution Control Division of the Department of Public Health and Environment.

[25] https://usa.streetsblog.org/2019/02/08/minneapolis-and-seattle-have-achieved-the-holy-grail-for-sustainable-transportation/