Colorado Energy Policy Simulator Insights: Current Emissions Trajectory, 1.5°C Scenario

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INTRODUCTION

In 2019, Colorado passed House Bill 19-1261 (HB1261), setting ambitious targets for economy-wide greenhouse gas (GHG) reductions in the state. The Climate Action Plan to Reduce Pollution ("2019 Climate Action Plan") requires the state to reduce GHG emissions 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050 from its 2005 levels. The legislative session also adopted a series of sector-specific policies including Senate Bill 19-236 (SB236), which requires the state to incorporate a social cost of carbon in power sector planning, and House Bill 19-1231 (HB1231), which increases energy efficiency standards for appliances. In the same year, Governor Jared Polis issued Executive Order B 2019 002 (EO-B-2019-002) supporting the state's transition to zero-emission vehicles (ZEV).

In late 2019, the Polis Administration directed a group of state agencies to develop a roadmap of near-term actions that allow the state to meet the targets set in HB1261. The result was the Greenhouse Gas Pollution Reduction roadmap ("GHG Roadmap"), which was released in January 2021.[1]

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The GHG Roadmap found that current policy in Colorado was insufficient to meet HB1261 targets.

At the time of this research note's publication, the Colorado legislature is considering Senate Bill 21-200 (SB200), which would require the state's Air Quality Control Commission to adopt final implementing rules no later than March 2022 to achieve HB1261 targets. The current SB200 draft sets 2025 and 2030 sectoral limits for emissions from electricity generation, transportation, buildings, oil and gas, and industrial sources. Because the SB200 bill language has not yet been finalized , we do not include an analysis of the targets identified in the bill.

However, the Colorado Energy Policy Simulator (EPS), developed by Energy Innovation (EI) and RMI, provides additional analysis of policies that can drive deep emissions reductions in Colorado. This research note outlines a policy package to decarbonize the state's economy, helping put it on the Intergovernmental Panel on Climate Change's recommended pathway to limit warming to 1.5 degrees Celsius.[iii]

Implementing stronger electricity, transportation, buildings, industrial, land, and agricultural sector policies can transition the state to a low-carbon economy, generate more than 20,000 new jobs and $3.5 billion in economic activity per year by 2030, and add nearly 36,000 new jobs and more than $7.5 billion to the economy per year by 2050. Policies in the 1.5°C Scenario would accelerate electricity sector emissions reductions, electrify all end uses where possible or switch to low-carbon fuels where not possible, expand emissions reductions from natural and working lands, and address non-carbon dioxide (CO_2) emissions. The associated reductions in air pollution from switching to cleaner sources of energy would also prevent 350 deaths and over 10,000 asthma attacks per year by 2030.

Policies necessary to achieve 1.5°C alignment include:

1. Switching to 100 percent clean electricity
2. Rapidly increasing sales of zero-emission cars and trucks while reducing passenger vehicle miles traveled
3. Shifting to efficient, all-electric buildings and appliances[iv]
4. Moving away from fossil fuel use in manufacturing
5. Reducing methane leakage from the oil and gas, water treatment, and waste management sectors
6. Improving land management to capture more carbon

THE COLORADO ENERGY POLICY SIMULATOR

The Colorado EPS is a free, open-source, peer-reviewed model that allows users to estimate climate and energy policy impacts on emissions, the economy, and public health using publicly available data. The model estimates these impacts through 2050 and considers how policies interact with

[iii] For more information see: https://www.unenvironment.org/resources/emissions-gap-report-2019.

[iv] While this is out of scope for the Energy Policy Simulator, reducing embodied carbon buildings is also an important part of decarbonizing buildings. Embodied carbon is defined as the total amount of GHG emitted during the manufacturing and supply of construction materials and equipment, as well as the construction process itself.

each other. EPS models have been developed for nearly a dozen countries and several subnational regions, including California, Minnesota, Nevada, and Virginia. The Colorado EPS is one of at least 20 planned state-level EPS models being developed by EI and RMI. A companion document explains key data sources, assumptions, and calculation methodologies used in the EPS.

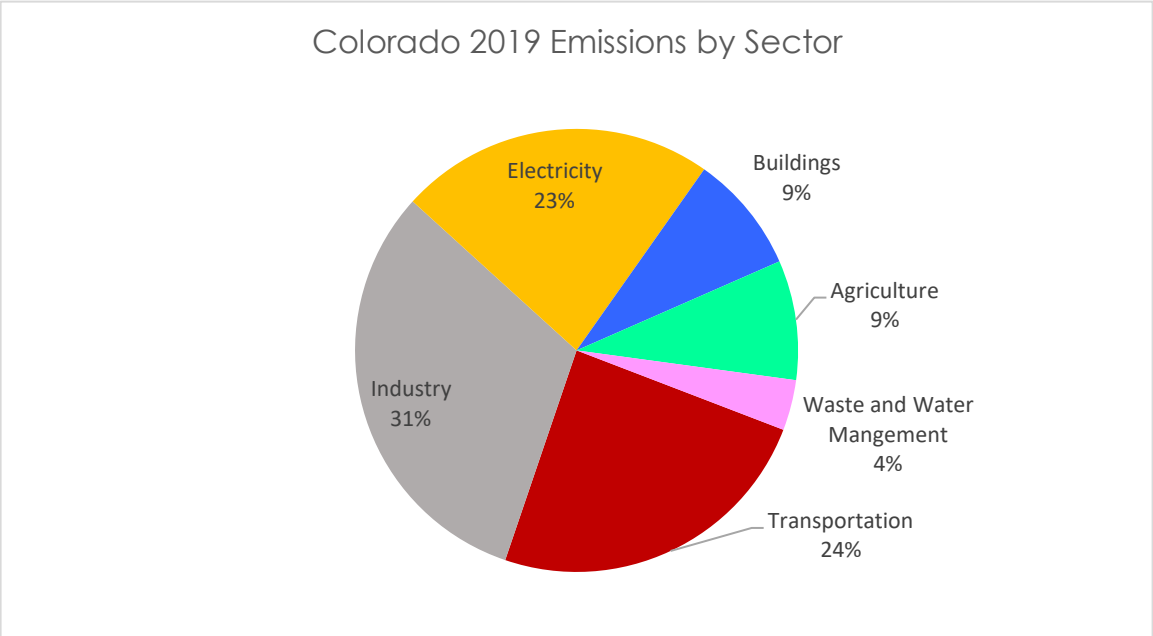
The Colorado EPS complements, but does not replace more granular analytical approaches such as energy demand infrastructure turnover and energy supply optimization,[2,3] electricity system reliability analysis,[v] mapping to ensure policies enhance equity, and others.[vi] A 2020 report released by environmental non-profits and energy modeling teams that proposes pathways for achieving the state's climate goals is particularly noteworthy on this topic.[4]

While these studies are critical to effective policy design and implementation, they are often expensive and slow to complete, representing a barrier to conducting robust analysis, particularly when funding is constrained. The Colorado EPS calculates impacts in seconds in an accessible web-based interface, which can help policymakers and advocates rapidly screen policies and understand remaining emissions gaps.

COLORADO'S EMISSIONS OUTLOOK

The Colorado EPS includes a pre-loaded Business-As-Usual Scenario (BAU Scenario) that incorporates existing policy, scheduled power plant retirements, some improvement in building and transportation efficiency, and economic adoption of electric vehicles (EVs).[vii] While electricity and transportation lead emissions in most states, Colorado's largest emitting sector is industry at 32 percent of 2019 GHG emissions, driven largely by oil and gas activity. Emissions from oil and gas infrastructure may be underestimated based on recent research that found additional emissions from the industrial sector that are not accounted for in recent GHG inventories.[5] Transportation and electricity follow closely behind, accounting for 24 percent and 23 percent, respectively, of Colorado's 2019 GHG emissions in 2019, as modeled by the EPS.[viii]

[v] See, e.g., https://www.2035report.com/wp-content/uploads/2020/06/2035-Report.pdf.
[vi] See, e.g., https://www.equitymap.org/equity-map
[vii] The BAU Scenario in the EPS is projected by the EPS model and is not identical to the Business-As-Usual Scenario presented in the Colorado GHG Roadmap.
[viii] Year 2019 emissions are modeled as part of the BAU Scenario emissions trajectory in the EPS. These emissions are benchmarked to Colorado's projected emissions from the GHG Roadmap, as modeled by E3.

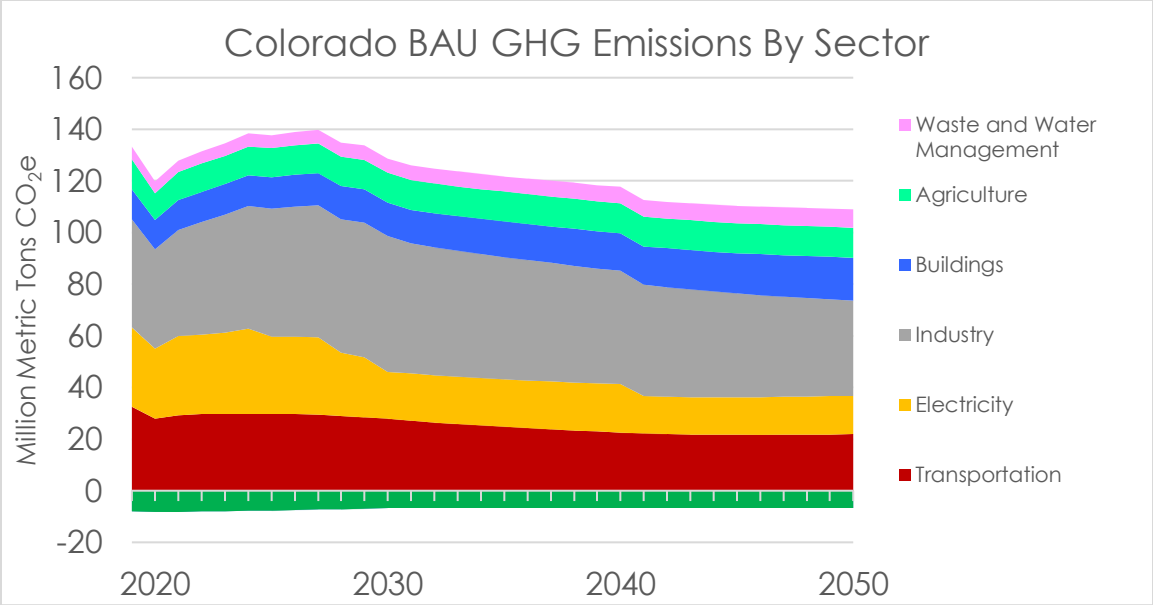


Colorado's estimated 2019 greenhouse emissions in the Colorado EPS

Electricity emissions have declined 26 percent since 2005, most recently with the retirement of the Nucla coal plant in 2019.[ix] In addition, Colorado's renewable portfolio standard (RPS) required 30 percent of utility-based electricity generation to be from qualifying renewable technologies by 2020. Approximately 33 percent of electricity generated in December 2020 was renewable.[x]

Looking ahead, the EPS projects that Colorado's economy-wide GHG emissions will decrease by just 3.4 percent by 2030 and 18 percent by 2050 under the BAU Scenario (excluding land sink). While we project that transportation and electricity emissions will decline 14 percent and 41 percent by 2030, these gains will be offset somewhat by increasing emissions in the industry; water and waste; and buildings sectors.

[ix] See Table 1-12 in 2021 Colorado Greenhouse Gas Inventory, https://drive.google.com/file/d/1YR-DAYkZcagZPiygafiIESwACzSSidAn/view.
[x] This does not include large-scale hydro. See, https://www.eia.gov/state/?sid=CO#tabs-4.



Projected GHG emissions by sector in the Colorado EPS BAU Scenario

GHG ROADMAP 2019 ACTION SCENARIO

The Colorado EPS also includes a GHG Roadmap 2019 Action Scenario based on legislation, utility commitments, and executive action in 2019 and 2020. The scenario includes a carbon-free electricity standard, reaching 69 percent by 2030 and 97 percent in 2050, partly with the aid of carbon capture and storage to decarbonize remaining fossil generation. These percentages of a carbon-free electricity generation mix come from E3 modeling of the GHG Roadmap report's 2019 Action Scenario. In 2030, this includes a complete phaseout of coal generation, no new gas generation buildout, and more than 6,000 MW of new solar and wind capacity.xi While the emissions outcomes are very similar, some of the policy levers are different.

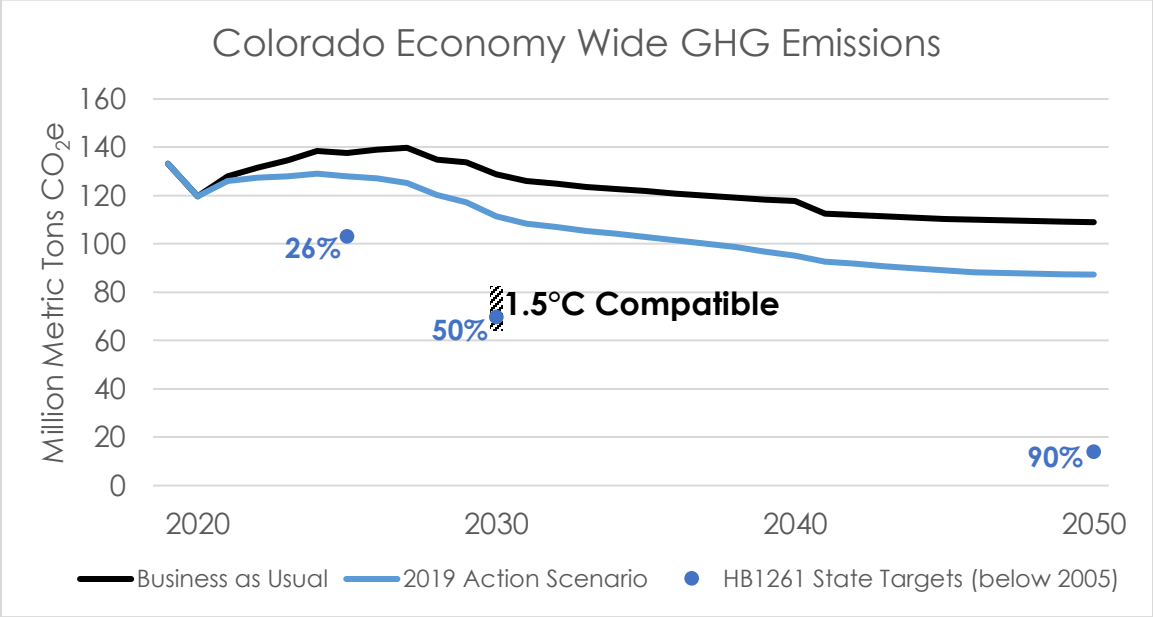
In the transportation sector, the GHG Roadmap 2019 Action Scenario models an electric vehicle sales standard that reaches 43 percent of light-duty vehicle sales and 5 percent of heavy-duty vehicle sales by 2030, based on Colorado modeling conducted by Navigant.[xii] While the policies highlighted in this scenario are policy options presented in the GHG Roadmap, they have not all been implemented to date.

[xi] See E3 Technical Appendix of the GHG Roadmap report for more information, https://drive.google.com/file/d/1215j7zfCsgE50msF_ZJt6ZUj0iG7Th3V/view?usp=sharing
[xii] See page 134 of the GHG Roadmap Report for more information.

THE GAP TO 1.5°C

The Colorado EPS includes a 2030 emissions target range consistent with limiting global warming to 1.5°C. This range is estimated by downscaling a national target, translating to a 36 to 50 percent GHG reduction below 2005 levels (excluding land sink) in Colorado.[xiii,xiv]

Comparing the BAU and GHG Roadmap 2019 Action Scenarios in the EPS to the EPS's 2030 1.5°C-compatible target range and the state's 2050 target (90 percent reduction) shows a large gap. Below, we discuss the policy options available to close this gap.



Projected GHG emissions, net of land carbon uptake, in Colorado EPS BAU and GHG Roadmap 2019 Action Scenarios. The blue dots show the state's 2025, 2030, and 2050 targets, and the gray hashed line shows an estimated 1.5°C-compatible target range.

[xiii] See the forthcoming Insight Brief from RMI on "Scaling United States Climate Ambitions to Meet the Science and Arithmetic of 1.5 C Warming."

[xiv] State level targets are approximate and should not be considered equivalent to an optimum state-by-state decarbonization assessment.

POLICY OPTIONS FOR DEEP DECARBONIZATION

While the BAU and GHG Roadmap 2019 Action Scenarios were designed to represent the current policy trajectories, the Colorado EPS also includes sample scenarios that demonstrate policy pathways to achieve policy targets.

The Colorado EPS includes a 1.5°C Scenario demonstrating a path to meet GHG emissions reduction goals aligned with global efforts to limit climate change. This illustrative policy scenario is adapted from a U.S.-wide scenario developed by EI[6] and shows one set of policies the state could use to achieve emissions reductions in line with limiting warming to 1.5°C, while meeting its interim and long-term climate goals.

The 1.5°C Scenario policies address emissions in all sectors with a focus on decarbonizing the electricity sector and electrifying the transportation and buildings sectors. A mix of electrification, energy efficiency, hydrogen fuel switching, and methane leak reduction drive industrial emissions reductions. Policy documentation for the Colorado EPS describes the 1.5°C Scenario policies in detail.

ELECTRICITY

Rapidly replacing fossil fuel generation with clean electricity is key to deep decarbonization and provides the foundation for reducing emissions in other sectors through electrification. The 1.5°C Scenario implements a clean electricity standard of 80 percent carbon-free electricity generation in 2030 and 100 percent in 2035 and beyond.[xv] Additional infrastructure investments as part of this scenario include a several-fold increase in battery storage over the state target, doubling transmission capacity, and 1.4 gigawatts (GW) of additional demand response capacity by 2050 to increase grid flexibility and reliability.[xvi]

TRANSPORTATION

Decarbonizing on-road transportation is critical to meeting climate goals. Colorado's existing policy targets a 40 percent reduction in transportation emissions by 2030; a Navigant study commissioned by the state estimates that achieving this goal would require 940,000 light-duty EVs on the road.[xvii]

The 1.5°C Scenario includes a strong EV sales standard requiring all new passenger cars and SUVs sold to be electric by 2035 and all new freight trucks to be electric by 2045. This new policy measure

[xv] The GHG Roadmap analysis by E3 implements 80% clean electricity by 2030 and 95% clean electricity by 2050 in both its 2019 Climate Action and HB1261 scenarios.

[xvi] Eliminating the last 10 percent of fossil generation and maintaining reliability in a zero-carbon grid is the subject of ongoing research. In the 1.5°C scenario, gas generators run at low and declining capacity factor to provide reliability, and in the 2040s these are modeled as being equipped with carbon capture and sequestration. Other decarbonized fuels could be possible, such as biogas or renewable hydrogen.

[xvii] See page 134 of the GHG Roadmap Report for more information.

would add nearly 1.5 million electric on-road passenger vehicles by 2030 and ensure nearly all on-road vehicles are electric by 2050 as older vehicles are gradually replaced.

The 1.5°C Scenario also invests in passenger car travel alternatives with supportive land use and transportation policies to enable people to use public transit and to walk and bike, reducing passenger car travel 20 percent by 2050. Such measures can be designed to provide broad economic and social benefits such as enhanced access to transportation and affordable housing[7] and would yield climate and health benefits beyond the direct emission reductions modeled in the Colorado EPS.

BUILDINGS

Transitioning buildings away from fossil fuels and improving energy efficiency are critical to meeting the state's climate goals. The 1.5°C Scenario includes measures for building electrification and energy efficiency. A sales standard would require newly sold building equipment be fully electric by 2030 in both new and existing buildings.[xviii] A sales standard would shift gas space and water heating systems to more efficient all-electric heat pumps, which are already commercially available and are common in many parts of the U.S.[8] Induction stoves provide a high-performing and clean alternative to gas stoves that also avoid indoor air pollution.[9]

The 1.5°C Scenario also includes deep energy efficiency retrofits of 15 percent of buildings by 2050.[xix] Enhanced efficiency standards for individual building appliances are also included, ranging from 11 to 40 percent energy savings by end use.

INDUSTRY, AGRICULTURE, AND LAND

To reduce energy-related emissions in industry, the 1.5°C Scenario requires industrial facilities electrify all end-uses where possible and switch to a zero-carbon fuel (in this case, hydrogen) for all others by 2050.[xx] The scenario also requires hydrogen be produced through a zero-carbon process known as electrolysis. Policies promoting more efficient use of industrial materials and improved industrial energy efficiency achieve additional reductions in this sector.

The 1.5°C Scenario includes several policies to address non-energy combustion industrial emissions, including standards requiring methane leak mitigation in the oil and gas, water treatment, and waste management sectors. Methane leaks predominantly come from leakage during extraction and transmission from the oil and gas industry, and comprises close to half of

[xviii] The GHG Roadmap analysis by E3 implements 60% building electrification by 2030 and 95% electrification by 2050 in its HB1261 scenario, see https://drive.google.com/file/d/1215j7zfCsgE50msF_ZJt6ZUj0iG7Th3V/view.

[xix] While not modeled explicitly in the Colorado EPS, new buildings should also strive for low embodied carbon to reduce lifecycle emissions from construction.

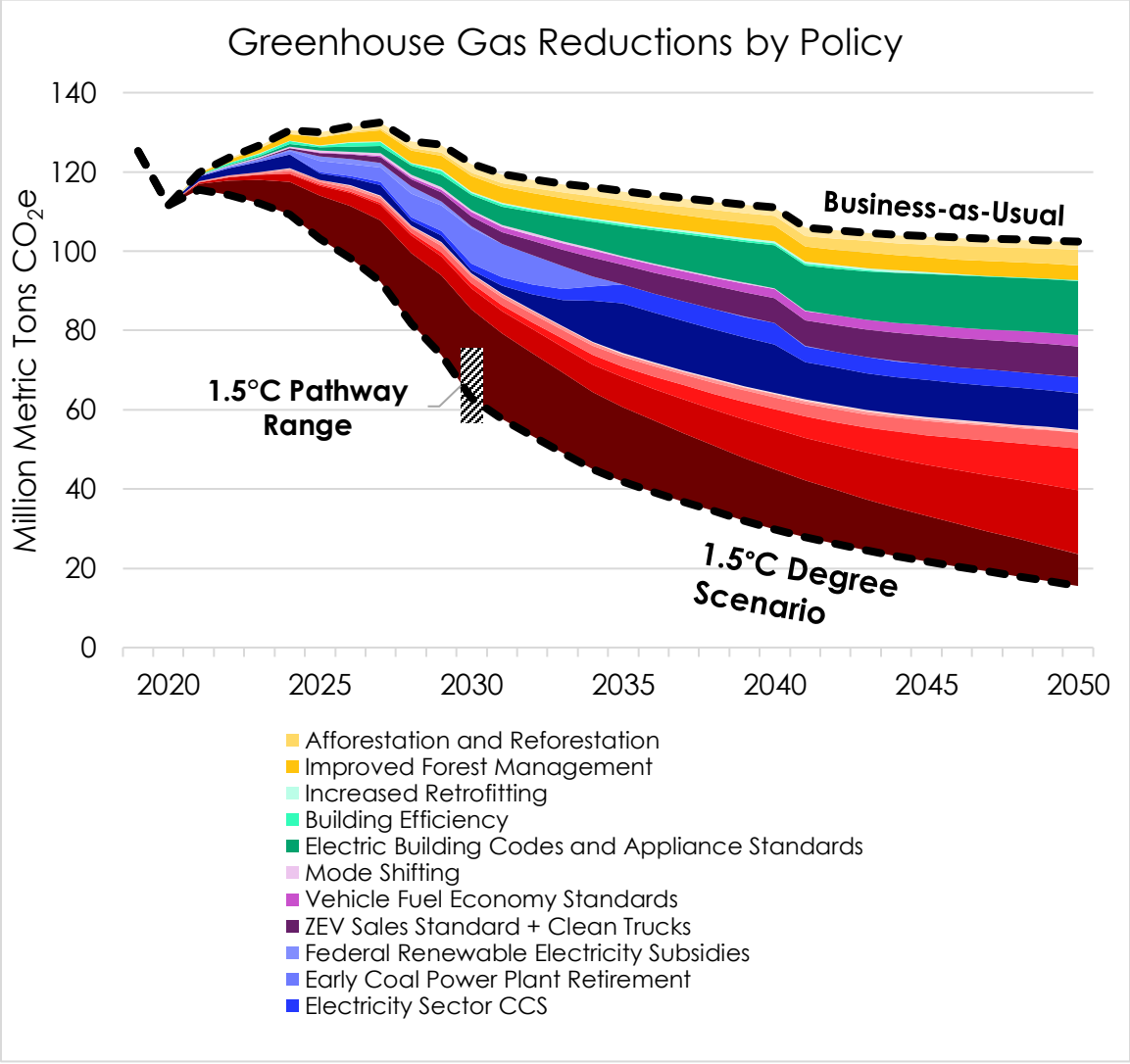
[xx] The Pathways Report also includes biofuels and synthetic carbon-neutral fuels in industry. Note that the optimal combination of industrial fuel decarbonization is the subject of ongoing research, which this simple treatment in the EPS does not replace.

Colorado's industrial emissions. Appliance manufacturers are required to switch to low global warming potential refrigerants consistent with the Kigali Amendment to the Montreal Protocol.

The 1.5°C Scenario also requires carbon capture and sequestration to capture half of residual industrial sector CO_2 process emissions. Finally, implementing land use and agricultural policies, such as requiring the use of anaerobic digesters to capture manure emissions and afforestation of land, reduces emissions from land use and agriculture.

AGGREGATE EMISSIONS IMPACTS

The Colorado EPS estimates economy-wide emissions reductions considering interactions between policies in each scenario. It also automatically and quickly estimates the contributions to emissions reductions from each individual measure.

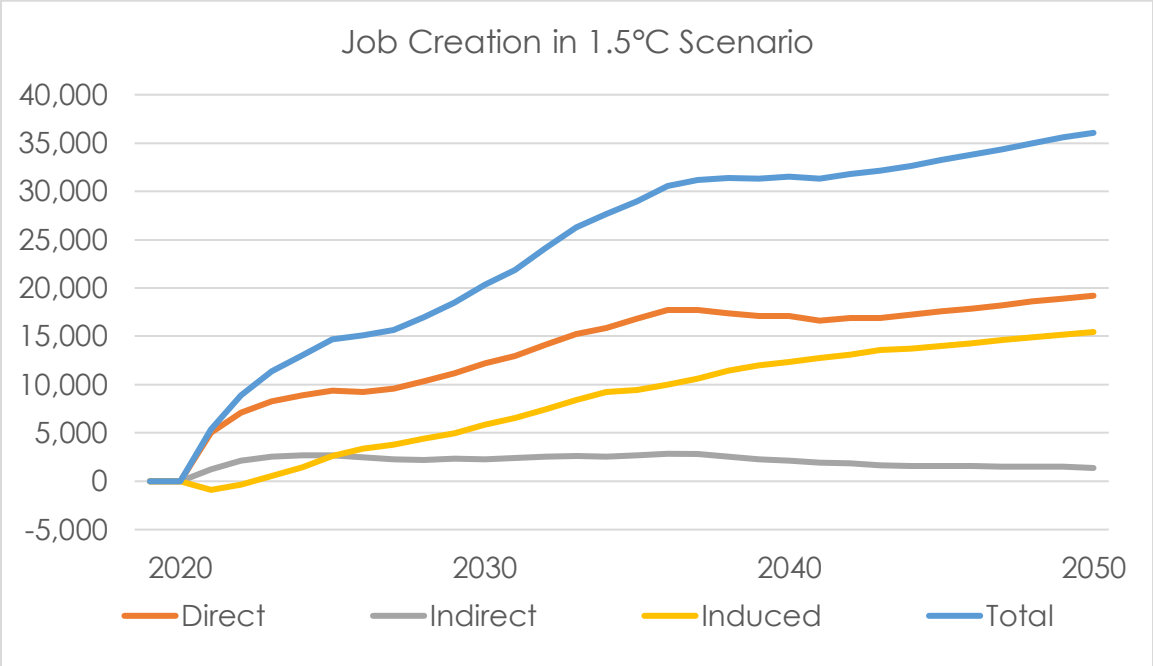


This wedge chart aggregates some policy levers to improve figure readability; a full interactive wedge graph is available on the Colorado EPS

The 1.5°C Scenario reduces Colorado's projected net emissions (i.e., including land use) 48 percent below the 2030 BAU projection and 85 percent below BAU by 2050. This would avoid 50 percent of the cumulative emissions currently projected by 2050 under the BAU Scenario. The most impactful measures are methane capture and destruction, industrial electrification and hydrogen fuel switching, building component electrification, and the carbon-free electricity standard.

JOBS AND HEALTH BENEFITS

Policies in the 1.5°C Scenario require installing new solar projects, retrofitting buildings, installing vehicle charging infrastructure, and more. The state-level input-output analysis embedded in the Colorado EPS[xxi] estimates that this scenario could add roughly 20,000 jobs through 2030 (see figure below) and 36,000 new jobs through 2050. Additionally, new investments and recycled expenditures from fossil fuel savings could help increase the gross state product by about $3.5 billion per year in 2030 and $7.7 billion per year in 2050.



Projected changes in jobs relative to BAU in the 1.5°C Scenario

Additional policies not modeled by the EPS will be necessary to ensure these newly created jobs benefit communities historically reliant upon or harmed by the fossil fuel economy with high-quality jobs paying fair wages. Policy can support a sustainable, equitable, and just transition by considering impacted communities when choosing the location of new clean energy infrastructure

[xxi] Read more at https://energyinnovation.org/2020/10/19/united-states-eps-3-0-update-adds-gdp-and-jobs- impacts-improved-public-health-metrics-and-more/.

projects. Policymakers can also create training programs to equip transitioning workers with the required skills, among other efforts. Other social policies can provide for basic needs such as healthcare or other financial assistance to ease the transition.[xxii]

The 1.5°C Scenario also unlocks significant health benefits. Fossil fuel power plant retirements, emissions-free building appliances, zero emission on-road vehicles, and industrial fuel switching all reduce harmful particulate emissions and secondary atmospheric pollution created by burning fossil fuels. The Colorado EPS, which includes a simple assessment of these benefits based on regional emissions factors by fuel and end use,[10] estimates that the 1.5°C Scenario policies would prevent more than 350 deaths and more than 10,000 asthma attacks per year by 2030 and more than 1,400 deaths and nearly 44,000 asthma attacks per year by 2050. Including a conservative estimate of the benefits of reduced climate pollution,[xxiii] the monetized health and other social benefits reach $21 billion annually by 2050.

CONCLUSION

Colorado has outlined ambitious decarbonization goals, but careful planning and execution is critical for a rapid transition to help limit the worst effects of climate change. As state policymakers begins considering how to meet the goals laid out in HB1261, the Colorado EPS can quantify how proposed policies could reduce emissions and improve the state's economy and public health. The 1.5°C Scenario provides a strong example of a strategic set of decarbonization policies that can rapidly reduce harmful emissions, while creating thousands of new jobs and adding millions to Colorado's economy every year.

[xxii] See National Academy of Sciences. 2021. Accelerating Decarbonization in the United States: A Comprehensive Policy Approach to a Just Transition.

[xxiii] The Interagency Working Group estimate from 2016, from https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf. The central estimate of $42/ton in 2020 is used. Note that recent studies have suggested much higher possible ranges for social cost of carbon, such as $187-805/ton in https://www.nature.com/articles/s41558-018-0282-y.

[1] Colorado Energy Office, *GHG Pollution Reduction Roadmap,* 2021, https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap.
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