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Accelerating an Equitable Clean Energy Transition in New Mexico

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Accelerating an Equitable Clean Energy Transition in New Mexico

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The Roosevelt Project
A New Deal for Employment, Energy and Environment

About the Roosevelt Project

The Roosevelt Project takes an interdisciplinary approach to the transitional challenges associated with progress toward a deeply decarbonized economy. The project aims to chart a path forward through the transition that minimizes worker and community dislocations and enables at-risk communities to sustain employment levels by taking advantage of the economic opportunities present for regional economic development. The first phase of the project involved an analytical assessment of cross-cutting topics related to the transition. The second phase of the project assesses the transition through the lens of four regional Case Studies, working with local partners on the ground in the Industrial Heartland, Southwest Pennsylvania, the Gulf Coast, and New Mexico. The project was initiated by former Secretary of Energy, Ernest J. Moniz, and engages a breadth of MIT and Harvard faculty and researchers across academic domains including Economics, Engineering, Sociology, Urban Studies and Planning, and Political Science.

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MIT ROOSEVELT PROJECT: NEW MEXICO CASE STUDY

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Contents

Executive Summary

New Mexico's low-carbon energy transition is already well underway. Home to conventional and renewable energy production and resources, a robust innovation infrastructure, a large rural population, and a diverse ethnic heritage, New Mexico is tackling the transition from a position of strength. As an early mover in the national energy transition, New Mexico has some of the most aggressive climate policies of any U.S. state, a multifaceted homegrown entrepreneurial ecosystem, and a range of activities to deploy advanced energy infrastructures that support renewables, hydrogen, and carbon capture and storage.

This case study focuses on taking New Mexico's energy transition to the next level: building long-term momentum so that the state can thrive in a future with net zero greenhouse gas (GHG) emissions. The analysis evaluates opportunities for transition on multiple dimensions: cost effectiveness, workforce opportunities, ability to build on the state's capabilities and resources, and concerns of distributive justice. It incorporates the voices and experiences of local stakeholders. It asks how New Mexico's diverse communities see themselves in this clean energy future.

The clean energy transition, while critical for the future of New Mexico, the U.S., and the world, will encounter obstacles along the way. The state budget relies heavily on revenues from fossil fuel development. Without thoughtful, informed, and targeted investments in transition technologies and policies, the clean energy transition could have a detrimental impact on state revenues. Absent new sources of state revenues, this could make it easier to spark resistance to the clean energy transition. Also, in the long term, as the transition proceeds and the pressure to reach net zero emissions increases, reductions will require deploying technologies that are currently relatively expensive, replacing current jobs and requiring new supporting infrastructures; planning now will be critical to ease disruption later. Finally, without clear-eyed attention and efforts to address its distributional impacts, the clean energy transition could exacerbate ethnic and income inequities and increase the urban/rural divide in the state.

The analysis is structured to place these issues in context, analyze need and impacts, and make recommendations for the energy transition. Chapter 1 sets the stage by describing the context for the case study, the state's energy system today, and major sources of GHG emissions. Chapter 2 evaluates major opportunities for the state's energy sector and economy in a transition. Chapter 3 discusses the implications of transition pathways for jobs, salaries, communities, and workforce development. Chapter 4 considers what changes to the state's institutions and policies would support transition and what processes for achieving these changes would be viewed as legitimate by the state's diverse population, raising the prospects for a sustainable transition. Chapter 5 concludes with recommendations.

Recommendations from the case study focus on how technology opportunities, economic and workforce development initiatives, and public policies, working in tandem, could advance a clean energy future in New Mexico. The recommendations are designed to connect with and mutually reinforce each other.

Among the recommendations on energy technology opportunities, **this case study identifies options for the state to address distributional inequities and public revenue gaps** that could prevent the transition from gaining momentum.

The recommendations recognize that jettisoning existing traditional energy infrastructures would undermine an important source of jobs, public revenues, and affordable energy services for the state's citizens.

In electricity, the case study recommends that the state's leaders develop a vision and targets for power sector decarbonization that recognize the value of existing and future flexible generation options, as renewable energy expands to meet the state's goals of 50% renewable energy by 2030, 80% renewable energy by 2040, and 100% carbon-free energy by 2045. In the electricity sector, opportunities to develop natural gas and other energy sources with carbon capture and storage (CCS) should be evaluated for their potential to enable an increase in wind and solar generation given a fixed level of installed capacity and improve overall reliability of the electricity supply.

This evaluation should also consider the extent to which repurposing fossil fuel infrastructures would preserve jobs and public revenue and keep the costs of transition manageable. In transportation, the state should consider approaches to limit the burden on rural households, which tend to have lower incomes and higher driving requirements. Approaches will need to go beyond current strategies of electrification and vehicle mileage reduction to consider how to make clean options affordable to rural households. Subsidies for efficient vehicle purchases, early vehicle retirement, and refueling infrastructure for alternative fuel vehicles are options here. Distributional impacts should also be a central consideration in the design of a low-carbon fuel standard, which is under discussion. Finally, our case study identified long-term opportunities for the state. It recommends evaluating prospects for hydrogen-CCS hubs in its northwest and southeast corners, in partnership with oil and gas companies, their workforces, and infrastructure operators. It also recommends studying the feasibility of using deadwood in forests, which poses a fire hazard, as a feedstock for the net-negative emissions technology bioenergy with CCS (BECCS), which could offset residual GHG emissions and help support climate neutrality by mid-century.

Beyond energy, a second category of recommendations focuses on **harnessing opportunities created by a clean energy transition.** First, case research found that New Mexico, as the nation's second-largest copper-producing state and a potential source of other clean energy materials inputs, could potentially position itself as a competitive player in environmentally responsible mining. The case study recommends a feasibility study to assess the potential for such an activity to supply U.S.-based clean energy manufacturing and to generate high-quality jobs and public revenues. Second, the case study recommends pursuing with greater urgency and public resources a set of opportunities to increase and monetize recovered methane that would otherwise be emitted from agriculture and from oil and gas production and distribution, building on the state's new regulation requiring operators to capture 98% of methane by 2026. Third, the case study highlights the ways that the state's innovation assets—including community colleges, universities, national labs, and entrepreneurship hubs—could be engaged to support the realization of transition-related opportunities in energy and the knowledge economy. The state's national labs have an opportunity to play a major role in many proposed research pathways, from the design of CCS and hydrogen hubs, to energy materials research, to setting standards for processes such as responsible mining.

A third category of recommendations focuses on public policy, including policy related to workforce retraining and development and public revenues. These recommendations are complementary and work synergistically with the recommendations above. First, policymakers should clarify that the Energy Transition Act (ETA) targets a goal of net zero grid emissions by 2050. This would allow near-zero carbon sources of electricity, in particular natural gas with carbon capture and storage, to contribute to reducing the carbon footprint of the electricity mix. Residual emissions could be offset through the use of carbon dioxide removal (CDR) technology or offsets.

Second, GHG emissions from sectors other than electricity will need to be addressed through policy. Here, the case study recommends developing new legislation and executive actions that address emissions from transportation, oil and gas, and agriculture. In transportation, particular attention should be given to impacts on low-income and rural households. If the low-carbon fuel standard is pursued by the state legislature as planned, provisions for encouraging broad availability and affordability of a diverse portfolio of low-carbon fuels suited for heavy-duty commercial and freight, such as hydrogen, as well as for passenger vehicles, could help to increase support among those concerned about distributional impacts.

Three recommendations focus on workforce development. The first involves supporting strategic partnerships for relevant government departments, employers in clean energy production and supply chains, higher education institutions, and certified apprenticeship programs to establish pathways for "newskilling, reskilling, and upskilling" workers, to ensure that they possess adaptable core skill sets that are sufficiently robust to meet projected needs in a range of transition trajectories. Examples include the construction trades and building energy efficiency. The types of training required will be highly diverse, ranging from certificate programs to expanded apprenticeship programs to four-year STEM degrees. Counseling to disseminate information about opportunities and facilitate job matches, especially for underrepresented groups, will be needed.

To support this effort, a second recommendation calls for a comprehensive ongoing study of prospective workforce impacts of energy transition through 2050 by industry and by sociodemographic group. This study should clearly differentiate near-term construction jobs from other job categories within clean energy sectors, as construction jobs are expected to be a large component of the jobs initially created and existing workforce skills and apprenticeship programs can be readily leveraged, while jobs associated with longer-term opportunities such as carbon capture and storage are more likely to require tailored technical training. A goal through 2030 should be to establish a standing capability to guide new or unemployed workers to opportunities in the state's clean energy economy. The strategic partnership mentioned above could leverage federal or state support to catalyze activities, adapt approaches from other contexts across the U.S. and worldwide, and engage with the state's executive branch and legislature on the design of transition assistance programs. A third recommendation focuses on ensuring a commitment to high-quality job creation, including by expanding and strengthening existing wages and benefit structures, apprenticeship opportunities, building standards, and worker safety requirements.

Focusing on the equity dimensions of the recommendations in this analysis on renewable energy expansion, this case study shows that financing provisions, workforce engagement, and educational outreach are needed to ensure full participation of indigenous communities in renewable and clean energy expansion on native lands. Another recommendation calls for expanding current efforts to reduce or replace fossil-dependent revenue sources in public budgets, in the state as well as tribal governments.

A final category includes **one recommendation intended to strengthen the participation of key stakeholders and the broader public in decisions** on technology pathways and policy related to the transition. The goal would be a model for hearing concerns and soliciting ideas on initiatives related to transition, with representation by tribal, ethnic, state, labor, industry, and other leaders. Examples of models are discussed, but ultimately the case study recommends that the Interagency Task Force on Climate Change determine a suitable model via a consultative process.

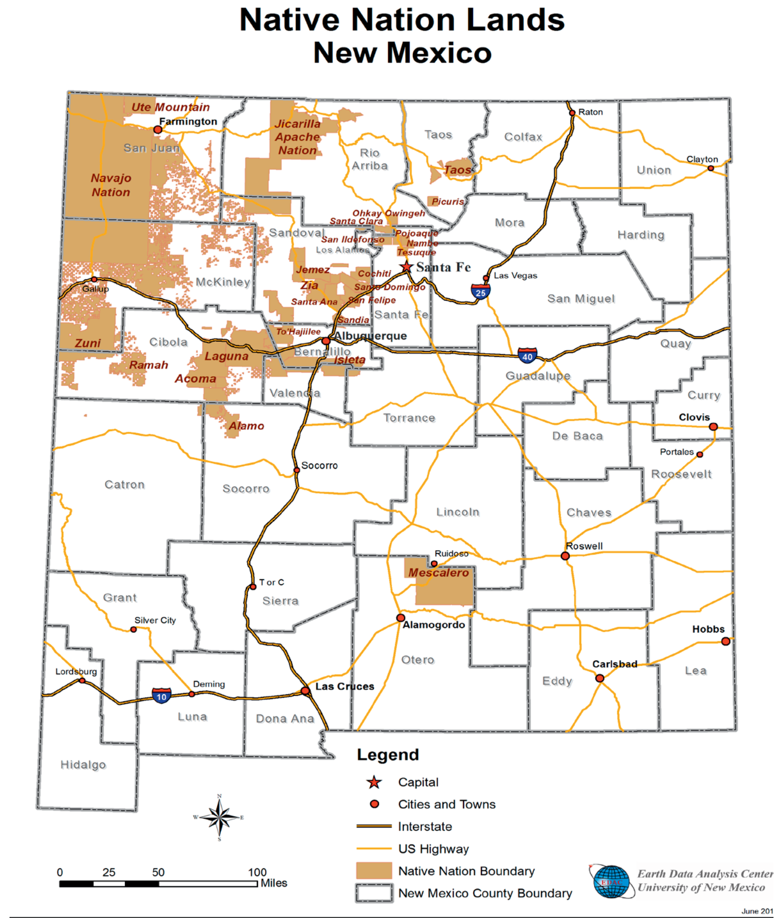
Chapter 1: Context for the Low-Carbon Transition

- Most of the recent economic and population growth in New Mexico is centered in urban areas, except for growth associated with oil and gas jobs, which are centered in rural areas in San Juan, Lea, and Eddy Counties.
- Large revenue streams and advantageous employment for indigenous and rural communities are at risk in an energy transition.
- As a state, New Mexico has disproportionately high CO_2 emissions per capita (14th) and high CO_2 intensity of energy supply (11th). Emissions are also distributed unevenly across the state—rural areas have much higher per capita emissions. The number one CO_2-emitting sector in the state is electricity generation, at 40% of the total.
- New Mexico has a higher share of methane emissions than most states. Capturing fugitive emissions from methane flaring/venting/leaks could lead to increased state taxes and royalties annually (~$43 million).
- The vehicle miles traveled (VMT) per capita in rural areas is twice that of urban areas, largely due to the lack of public transport, larger distances between locations, and preferences (found in a New Mexico Department of Transportation survey) for passenger vehicles.
- New Mexico is a major energy and electricity exporter, so its energy transition will be greatly influenced by changes outside its borders.
- An important open question is whether electricity generated from fossil fuels with CCS will be counted as low-carbon generation under state clean electricity goals.
- Recent legislative actions and movements mark shifts in the New Mexico energy policy landscape toward deeper decarbonization.

New Mexico's population of 2.1 million (2020) is diverse and dynamic. Nearly half (49.3%) of the population is of Latin or Hispanic origin, while indigenous groups comprise 9.6%, differentiating it from many other energy transition settings in the U.S. There are 23 federally recognized tribes in New Mexico—including 19 Pueblos, three Apache tribes and the Navajo Nation—each with its own government, traditions, and culture. Tribal lands are found in one-third of New Mexico's counties, while only three counties (McKinley, San Juan, and Bernalillo) are home to the majority of the state's indigenous population (see Figure 1.1).

New Mexico's population is growing, thanks to immigration and a rising birth rate. This growth is offset by a modest out-migration of New Mexicans born in the state. The population of the state expanded steadily from 1.02 million to 2.01 million between 1970 and 2010, but then growth slowed over the past decade in the aftermath of the Great Recession. In comparison to states such as Arizona, Idaho, and Nevada, which experienced annual average growth rates of 1.3–2.1% during that time, New Mexico grew at just 0.5% per year. In 2016, 20.9% of the state's population lived in poverty, well above the national average of 15.1%.

Figure 1.1: Location of counties (grey boundaries) and native lands (shaded areas) in New Mexico.



The state's population is unevenly distributed: 57% of the population lives in just four of 33 counties (Bernalillo, Doña Ana, Sandoval, and Santa Fe), which have sizable urban centers and a high average population density. A full 23% of the population lives in rural areas. The rural-urban divide has been increasing; much of the employment and population growth has been centered in urban areas, with the exception of Eddy and Lea Counties, which have seen substantial growth in jobs related to oil and natural gas exploration and production.

1.1 Role of Energy in New Mexico's Economy

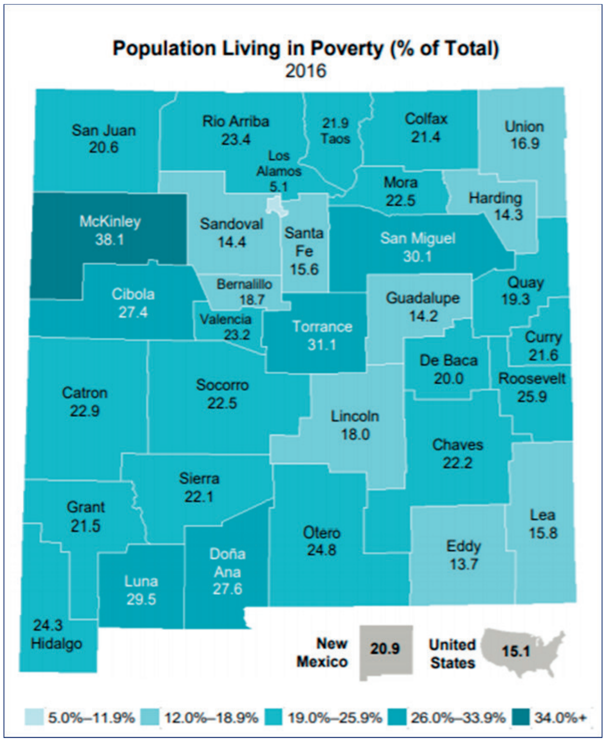
Energy plays an important role in New Mexico's economy. The traditional energy sector represents around 5% of employment; Hispanic, indigenous, and rural workers hold a greater share of these jobs relative to their share of the population. Clean energy jobs were estimated in 2018 to account for 1.4% of the total (University of New Mexico 2020).[1] Health care and social assistance account for the largest share of employment at 17.1% (University of New Mexico 2020).[2]

Reaching rural areas will be key to the success of the state's energy transition. Oil and gas jobs are disproportionately located in rural areas and particularly in the San Juan and Permian Basins—mainly San Juan, Lea, and Eddy Counties, among others (Broadhead 2021).[3] Unemployment levels are higher, and wages tend to be lower in predominantly rural counties, which tend to have higher shares of the population living in poverty (see Figure 1.2). In urban areas like Santa Fe and Albuquerque, manufacturing, finance, and information technology employ up to three times more workers than in non-metro areas. Higher-paying professional services and technical jobs are currently located in metropolitan areas.

The energy sector—defined as fuels, electric power generation (EPG), and transmission, distribution, and storage (TDS)—accounts for a total of 44,100 workers and 5.3% of New Mexico's state employment. This is higher than the national average of 2.3%. Fuels accounts for over half of the traditional energy workforce, with 25,123 workers; as of 2017, 87% of fuels employment was in mining and extraction. Fuels is followed by TDS and EPG, which have 13,668 and 5,321 employees, respectively (USEER 2020).[4] Among TDS employees, 47% are employed in construction (U.S. DOE 2017).[5] In EPG, more than 80% of workers are in either solar or wind electric generation; by industry, 20% are in construction and 40% are in manufacturing, while only 6% work for utilities (U.S. DOE 2017).[6] A substantial portion of jobs are in the construction industry, with 6,021 construction workers in TDS and 1,372 in EPG (USEER 2020).[7] These positions are reported to have a higher average annual wage than other occupations, paying workers a median wage of $24.69 per hour.[8]

A clean energy transition poses a particular challenge for New Mexico's native communities. While not all tribes rely on fossil fuels for revenue generation, those that do will be hit hard. For example, the combined tax, lease, and royalty revenues from the Navajo Generating Station (NGS), Four Corners Power Plant (FCPP), and associated mines make up more than 50% of the Navajo Nation's annual budget. These power plants, along with the San Juan Generation Station (SJGS) and mine, provide high-quality jobs with benefits to 1,515 Navajo people (Nez 2020)[9] and pay salaries with benefits equal to two times the average San Juan County household income (Highland Economics 2017).[10] The importance of these jobs should not be underestimated. According to a Department of Energy–supported study released in October 2020, "Over the last 20 years, unemployment in the Navajo Nation has been nearly 50%—compared to, as of January 2020, 4.7% in New Mexico and less than 4% in the U.S. Navajo Nation median household income is $20,000—compared to $47,000 for New Mexico and $60,000 for the U.S. 43% of those living in the Navajo Nation earn below the federal poverty level. 39% of Navajos 65 and older live in poverty—five times the share in New Mexico. 45% of children in the Navajo Nation live in poverty" (Enchant Energy 2020).[11] The Jicarilla Apache and other select Pueblos located on oil and natural gas basins are involved in developing fossil resources. The Jicarilla Apache Nation, for example, has its own oil and gas production company, and oil and natural gas revenues fund tribal government services (Kemp 2013).[12] They, too, could lose valuable revenue streams and job opportunities for their community members if these considerations are not recognized and addressed in transition planning.

Figure 1.2: Share of population by county living below the state poverty threshold in New Mexico.



Source: U.S. Census, 2016.

However, this status quo comes with a range of issues. Although some tribes participate in, and benefit from, fossil-fired power generation, many still do not have access to reliable electricity. In the Navajo Nation, for example, 10% of its members do not have reliable electricity and 40% do not have running water (Nez 2020).[13] In these communities, air quality and water quality are compromised due to emissions from coal-fired power generation, reliance on traditional biomass cookstoves, and contamination from coal and uranium mining. Additionally, many tribes rely on utilities or rural electric cooperatives outside of their jurisdictions, which limits their ability to shape decisions about the deployment of new generation capacity.

Other rural communities in New Mexico face similar challenges. Some of these counties rely on fossil fuels for public revenue and job creation, and they have seen their populations fluctuate with the boom-and-bust cycles of the oil and natural gas industries. A clean energy transition could put added pressure on jobs in coal, oil, and gas, in addition to vehicle refueling and engine servicing and the trucking, pipeline, and rail transport industries. Outside of the energy transition, rural counties are already experiencing out-migration to urban areas and neighboring states as residents seek stable, higher-paying jobs. Consequently, a decrease in the working-age population reduces the funds counties have available for education and childcare (NM Legislative Finance Committee 2021).[14]

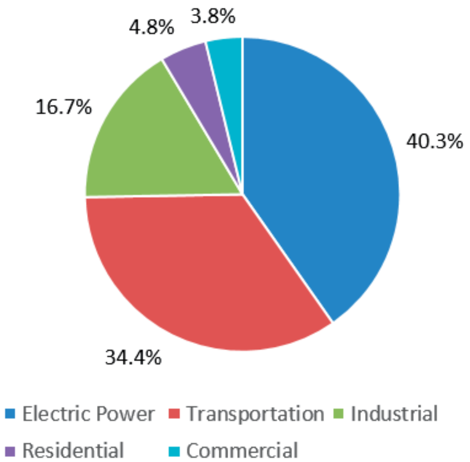
Out-migration and declining populations in general are increasing the relative costs of a range of services in the state's rural households. Households making less than 60% of the area median income, or 30% of households statewide, are considered "energy stressed" (paying 4–7% of income for electricity) or "energy burdened" (paying 7–10% of income for electricity) (Pacyniak et al. 2020).[15] Customers of rural cooperatives pay 70% more per month in electricity service fees than investor-owned utility customers (Pacyniak et al. 2020).[16] If the energy transition accelerates out-migration, resources to modernize and expand the existing grid will be even more limited.

1.2 New Mexico's Greenhouse Gas Emissions

New Mexico's GHG emissions reflect a transition already underway. At 77.7 million metric tons (mmt) CO_2-eq, New Mexico's GHG emissions account for 1.13% of the nation's total. The state's GHG emissions are mainly carbon dioxide (CO_2) (62%) and methane (35%) (NM Interagency Climate Change Task Force 2020).[17] The state's economy is relatively carbon-intensive: in 2016, New Mexico ranked 14th in per-capita energy-related CO_2 emissions at 23.2 metric tons of CO_2 per person and 11th in CO_2 intensity of its energy supply at 58.9 kg of CO_2 per million BTU (EIA 2021).[18] The national averages are much lower, at 16.0 metric tons of CO_2 per person and 53.1 kg of CO_2 per million BTU, respectively.

The sectoral breakdown of energy-related CO_2 emissions is shown in Figure 1.3. The electricity sector is responsible for the largest share of these emissions at 18.3 mmt (40%), followed by transportation (15.7 mmt, 34%), industrial (7.6 mmt, 17%), residential (2.2 mmt, 5%), and commercial (1.7 mmt, 4%) sources (EIA 2020).[19] The contribution of the electricity sector, which is expected to be less costly and complex to decarbonize, to the state's energy-related CO_2 emissions is proportionally larger than at the national level, which was 30% in 2019 (EPA 2020).[20]

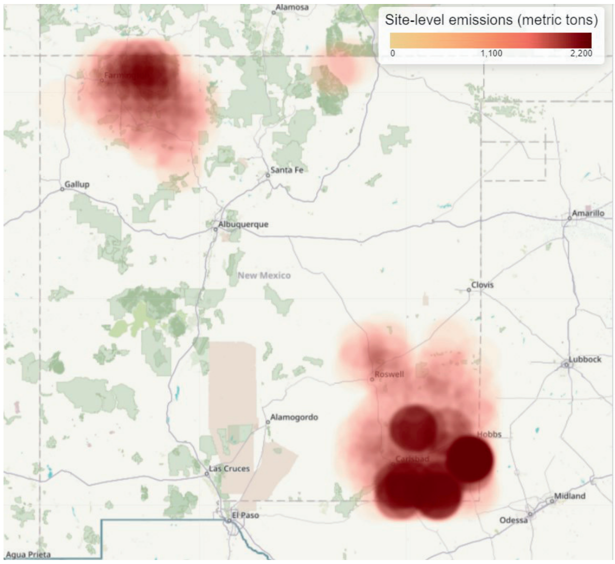
Figure 1.3: Energy-related CO_2 emissions in New Mexico by sector.



Source: EIA 2020[21]

The distribution of sources of GHG emissions in the state is geographically uneven. The fossil fuel–producing areas in Lea and Eddy Counties contribute disproportionately to the state's oil and gas emissions. Methane emissions are concentrated in the oil and gas–producing regions of the state, as shown in Figure 1.4.

Figure 1.4: Methane emissions density across New Mexico.



Source: EDF and Spherical Analysis, 2020[22]

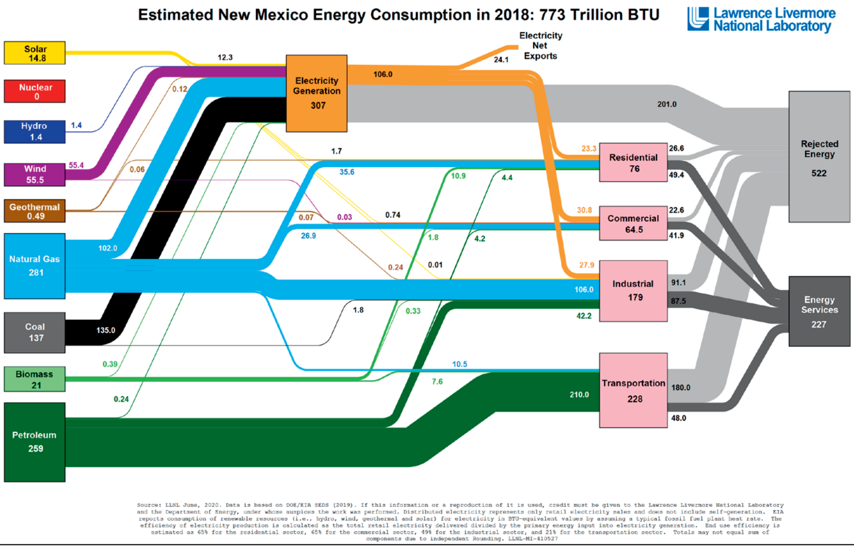
In New Mexico, methane emissions are primarily associated with oil and gas (62%) and agriculture (25%) (NM Interagency Climate Change Task Force 2019).[23] The methane emissions density is shown in Figure 1.4. Estimates of fugitive methane emissions from oil and natural gas vary widely (0.57–1.1 million metric tons) (McVay 2017; EDF 2021).[24, 25]

These emissions could be greatly reduced while adding value to the economy. According to the EDF analysis, flaring, venting, and leaks lead to the loss of at least $271 million worth of natural gas in New Mexico every year. As a result, New Mexico is forgoing roughly $43 million in state tax and royalty revenue annually, funds that would otherwise support schools, infrastructure, and other public services (EDF 2020).[26]

Energy production, conversion, and use are key contributors to emissions of both CO_2 and methane. A Sankey diagram of the composition of New Mexico's energy system is shown in Figure 1.5.

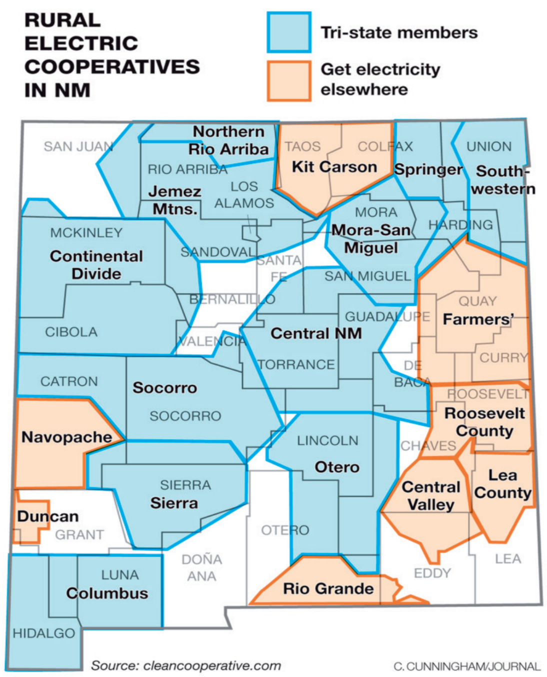
As noted, electric power today accounts for just over 40% of New Mexico's CO_2 emissions. Electricity in New Mexico is provided by three investor-owned utilities—the Public Service Company of New Mexico (PNM), El Paso Electric (EPE), and Southwest Public Service Company (SPS, a subsidiary of Xcel Energy)—and 16 electric distribution cooperatives, which are nonprofit organizations owned by their customers. Of the cooperatives, nine receive power from Tristate Generation and Transmission Association, based in Westminster, Colorado; four are members of Western Farmers Electric Cooperative, based in Anadarko, Oklahoma; and one obtains power from an independent wholesale power provider. The utilities have regulated monopoly status to provide generation, transmission, and distribution to specific geographic areas, and rates must be approved by the New Mexico Public Regulation Commission (PRC). The electricity cooperatives serve 80% of the state's land area and 22% of its population (see Figure 1.3). Electricity cooperatives are also regulated by the PRC, but in a more limited manner, given their nonprofit status.

Figure 1.5: Sankey diagram of New Mexico's energy system in 2017.



Source: Lawrence Livermore National Laboratory, 2018.[27]

Figure 1.6: Rural electric cooperatives in New Mexico.



Source: Albuquerque Journal, reprinted from CleanCooperative.com, 2019.[28]

In 2019, New Mexico had a total installed power generation capacity of 8,770 MW and net annual generation of 35 million MWh (EIA 2021).[29] According to the latest estimates from the U.S. Energy Information Administration (EIA), 40.6% of net electric power generation in New Mexico is sourced from coal, followed by natural gas (40.1%) and renewables (18.9%). The state's two coal power stations (San Juan Generating Station and Four Corners), 20 natural gas plants (EIA 2021), and a small amount of biomass generation account for all of the power sector's CO_2 emissions.[30]

Transportation emissions are from the combustion of petroleum-based fuels in vehicles. These emissions are relatively high per capita, due to the high average driving distances of passenger and freight vehicles; urban areas of New Mexico also generally lack public transit options. Personal or business vehicle travel is hard to avoid or substitute, especially in rural areas, and the use of low-carbon fuels remains limited. Rural households have higher annual vehicle miles traveled and spend a higher percentage of their income on transportation, compared to urban households in the state: VMT per capita in rural counties is twice that of urban counties (US Department of Transportation 2021; US Census Bureau 2019; USDA, n.d.).[31, 32, 33] How to make alternative fuel and high-efficiency vehicle technologies both accessible and affordable to less affluent rural households is a major challenge for the state.

Industrial emissions are generally from the state's major refineries, food production and processing plants, mines, and landfills and waste facilities. The vast majority of New Mexico's industrial emissions can be attributed to oil and gas processing. The state also has a small footprint in cement production and electronics manufacturing.

Impacts of energy transition in the state will hinge in part on developments beyond the state's borders. New Mexico is a major conventional energy exporter, contributing to CO_2 emissions beyond its own borders. The state has 8% of the nation's proved crude oil reserves (EIA 2021).[34] Crude oil production increased fivefold between 2011 and 2020, most of it from the Permian Basin, to reach 8% of the national total yearly production. The state has 5% of U.S. natural gas reserves. Natural gas is produced in both the northwest (from shales, low permeability sands, and coalbeds) and in the southeast (oil and gas fields in the Permian), contributing 5% of total U.S. natural gas production in 2020. It is also a major gas exporter, predominantly to Arizona. New Mexico also exports electricity; California's decision not to rely on imported coal electricity in 2014 contributed to pressure on coal power stations in New Mexico.

1.3 Low-Carbon Transition Policy

New Mexico has some of the most aggressive climate policies of any U.S. state (Rott 2019).[35] In 2019, Governor Grisham formally ordered that New Mexico embrace the goals set by the 2015 Paris Agreement and join the U.S. Climate Alliance. The Biden administration has since issued more stringent targets than those set in Paris and, along with the European Union, is advancing a Global Methane Pledge, which would reduce the world's methane emissions 30% from 2020 levels by 2030. By executive order, the governor also ordered the creation of a New Mexico Climate Change Task Force, cochaired by the Energy, Minerals and Natural Resources Department (EMNRD) and Environment Department, calling on all state agencies to contribute to a statewide climate strategy and to incorporate climate mitigation and adaptation practices into their programs and operations.

1.3.1 The Energy Transition Act

Electricity generation has been the main target of state policy to reduce GHG emissions. In the 2019 legislative session, a landmark clean energy bill—the Energy Transition Act (ETA)—was passed into law. The ETA (Senate Bill 489), introduced by Representatives Jacob R. Candelaria, Nathan P. Small, Mimi Stewart, Patricia Roybal Caballero and Brian Egolf, sets a 50% renewable target for in-state power generation by 2030, 80% by 2040, and "100% zero carbon" by 2045 for investor-owned utilities and by 2050 for rural electric cooperatives. The ETA defines renewable energy as solar, wind, and geothermal; modern hydropower; some biomass resources certified by EMNRD; fuel cells that do not use fossil fuels to create electricity; and landfill gas and biogas. As such, the law is an important starting point for deep decarbonization. It does not appear that power generated from fossil fuels with carbon capture and storage (CCS) can be used to meet this goal. It should be noted that in the two years since the ETA was passed, authorities have appeared open to natural gas acting as a bridge to decarbonization, as long as GHG emissions are sequestered (Chamberlain 2020).[36]

The law further allows for the securitization of stranded infrastructure associated with the transition. This provision has been invoked to allow PNM to recover its stranded assets of $320–$353 million in the San Juan Generating Station, originally on its books to 2053 (Public Resources Commission 2020; New Energy Economy, n.d.).[37, 38] It provides tens of millions of dollars for economic and workforce support for communities impacted by coal plant closures and for the development of renewable electricity sources. Our interviews surfaced concerns that workforce support had encountered administrative delays and that Four Corners may remain open even after securitization and exit by PNM.

The ETA proposes assistance for workers and communities most impacted by the transition. It defines an affected community as "a New Mexico county located within 100 miles of a New Mexico facility producing electricity that closes, resulting in at least 40 displaced workers." The ETA creates three dedicated funds across three state departments: Workforce Solutions, Economic Development, and Indian Affairs. Each department will engage affected communities for input on how the funds should be spent, as well as assist with the creation of a Community Advisory Committee (CAC), which requires membership from each New Mexico tribe and Pueblo in affected communities, as well as four appointees representing diverse economic and cultural interests.

1.3.2 Other Policy Developments

Legislators advanced several efforts to further the state's clean energy transition in the 2021 legislative session. These include a Clean Fuel Standard that would seek to reduce the state's transportation emissions by 230,000 metric tons of CO_2 annually and the Local Choice Energy Act that would give communities more choice and the ability to set their own renewable goals. Senators also introduced legislation aimed at amending the ETA to reinstate regulatory oversight over rate increases related to plant abandonment costs, as well as legislation prohibiting new fossil-fuel generation facilities, including gas plants, from being built in the state. That legislative initiative led to much debate and ultimately did not pass ("NM SB155" 2021).[39] Nevertheless, these developments mark a shift in New Mexico's energy policy landscape towards enabling deeper decarbonization. Non-CO_2 GHGs are also a focus of state policy: in March 2021, New Mexico's Oil Conservation Commission under the Energy, Minerals and Natural Resources Department finalized language for a new rule that would require more than 98% of annual methane emissions (methane "waste") from oil and natural gas production and distribution to be captured by 2026. Addressing fugitive methane emissions measurement and abatement is particularly important in light of recent studies that estimated leakage rates of 9% of gross natural gas production (Chen et al. 2021),[40] far larger than most prior estimates.

1.4 Accelerating the Transition

This case study asks how New Mexico's clean energy transition, which is already underway, can deepen its impact and broaden its participation, so that every resident of New Mexico sees a climate-secure future for themselves and their communities.

Chapter 2 evaluates opportunities for the state to develop and deploy technologies that can support deeper GHG reductions, especially beyond the power sector, and to develop new industries that support a low-carbon economy.

Chapter 3 considers the workforce implications of transition, including changing worker and skills requirements, the geographic match between today's workforce and future clean energy jobs, training for workers at various career stages, and leveraging the state's innovation ecosystem.

Chapter 4 examines how public policy and institutional change can help to accelerate low-carbon transition while at the same time addressing inequities in histories, processes, and outcomes.

Chapter 5 concludes with recommendations that lay the groundwork for an economy-wide low-carbon transition in the state.

Chapter 2: Opportunities in a Low-Carbon Transition

- New Mexico has abundant renewable energy resources. To accommodate further integration of renewable energy, New Mexico will need to modernize its transmission and distribution systems and grid, accommodate the need for firm power, and explore the potential to enlarge balancing areas.
- Coal and natural gas power generation account for more than two-thirds of total generation in New Mexico. Installing or retrofitting existing plants with carbon capture and storage could further reduce CO_2 emissions from fossil generation by 90% or more. The sedimentary formations in southeastern and northwestern New Mexico could serve as CO_2 storage sites, and the use of existing pipelines and rights-of-way could expedite the buildout of CO_2 transport as part of a larger CCS ecosystem.
- Drought and bark beetle infestations have left much deadwood in New Mexico's forests, exacerbating the danger of forest fires. This abundant, dry deadwood could be used as a feedstock by converting wood into chips and pellets, which would create jobs and reduce forest fire danger.
- Hydrogen is a flexible energy carrier/fuel that can be produced from a range of primary sources. New Mexico's northwest and southeast corners have existing and potential infrastructures that could be used for hydrogen production, initially from natural gas with carbon capture and storage (blue hydrogen) and from renewable (green hydrogen) sources longer term.
- Transportation is the second-largest source of GHG emissions in the state. Among the state's two main decarbonization strategies for the sector, scaling electric vehicle (EV) adoption and reducing total vehicle miles traveled (VMT), it will be important to consider the distribution of impacts on rural and low-income households.
- Agriculture is responsible for roughly 8% of the state's annual GHG emissions. To reduce these emissions, New Mexico can improve carbon-storage potential of soils, reduce N_2O emissions, manage enteric fermentation, and improve manure management.
- New Mexico ranks among the top fifth of mineral-producing states in the country and registers high production volumes of copper, zeolite, perlite, potash, coal, and uranium. The state may be able to adopt approaches tried in Australia and Canada to develop sustainable mining practices.

As noted, New Mexico's clean energy transition is already well underway. Today's challenge involves deciding what opportunities to focus on in the near and longer term. To select opportunities and to inform our analysis of them, we consulted representatives of diverse stakeholder communities: education, finance, state and tribal governments, industry, labor, and NGOs/nonprofits.

This chapter evaluates these opportunities based on multiple goals:

- **Economic cost:** Is the opportunity affordable for the state, and does it deliver GHG reductions cost effectively?
- **Total high-quality jobs preserved or created:** How many net new local jobs are created in the state, and how do wages compare to existing options?
- **Equity:** Do the economic, jobs, and revenue impacts advantage or disadvantage underserved, vulnerable, or marginalized populations?
- **Technical and system integration complexity:** To what extent is the pathway's success dependent on broader system changes, and how difficult are these?

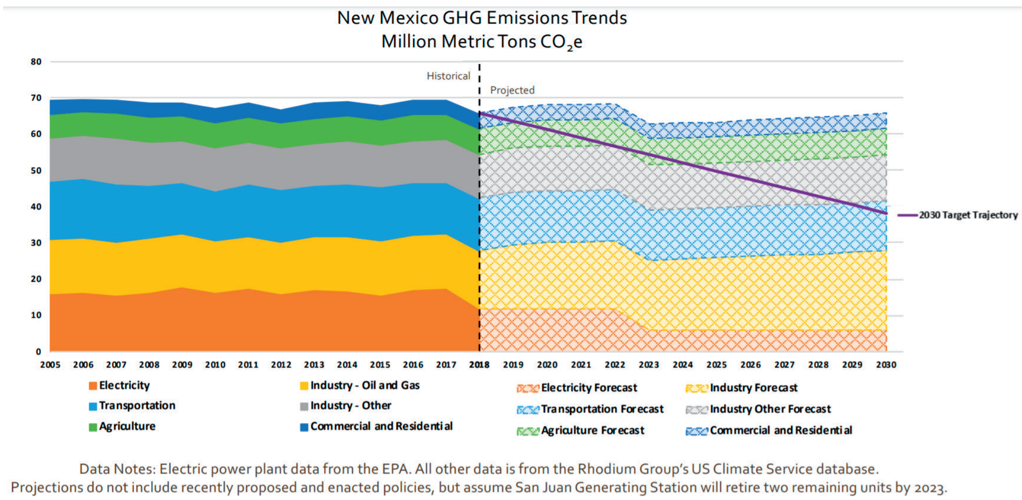
- **Builds on existing resources and capabilities:** Does the pathway allow the continued use or repurposing of existing assets in economically, or at least socially attractive, ways?
- **Public revenue generation:** Does the pathway preserve and ideally expand public revenues available to tribal, state, and local governments?

The sections that follow describe these opportunities. When information is not sufficient to evaluate a particular dimension, the need for further study is highlighted. The case study explicitly avoids developing quantitative comparisons among opportunities, since doing so would be subjective and potentially misleading. Policymakers will ultimately choose how much to emphasize any single dimension in reaching decisions about the mix and sequencing of opportunities.

2.1 Opportunities to Advance a Low-Carbon Future

Major global and national modeling studies describe technologies and behaviors that could support a low-carbon future (Cozzi et al. 2020; Nalley et al. 2021).[41, 42] This case study localizes these opportunities in and for New Mexico. It focuses primarily on opportunities to reduce GHG emissions and support clean energy supply chains. The analysis draws on state plans and studies, as well as interviews with practitioners who in some cases have already begun developing these opportunities.

Figure 2.1: Projection of GHG emissions from sectoral activities in New Mexico.



Source: Tabor et al. 2020[43]

While New Mexico's low-carbon transition is already underway, the path to net zero remains unclear. Figure 2.1 shows how, under current plans, the state's projected GHG emissions would not deviate much from historical levels, except in electric power, which reflects the closure of the San Juan Generating Station by the end of 2023 (Tabor et al. 2020).[44] Meeting the state's present 2030 target trajectory (purple line) advanced by the state's Climate Change Task Force will require deep GHG emissions cuts and cuts outside the power sector.

2.2 Electric Power

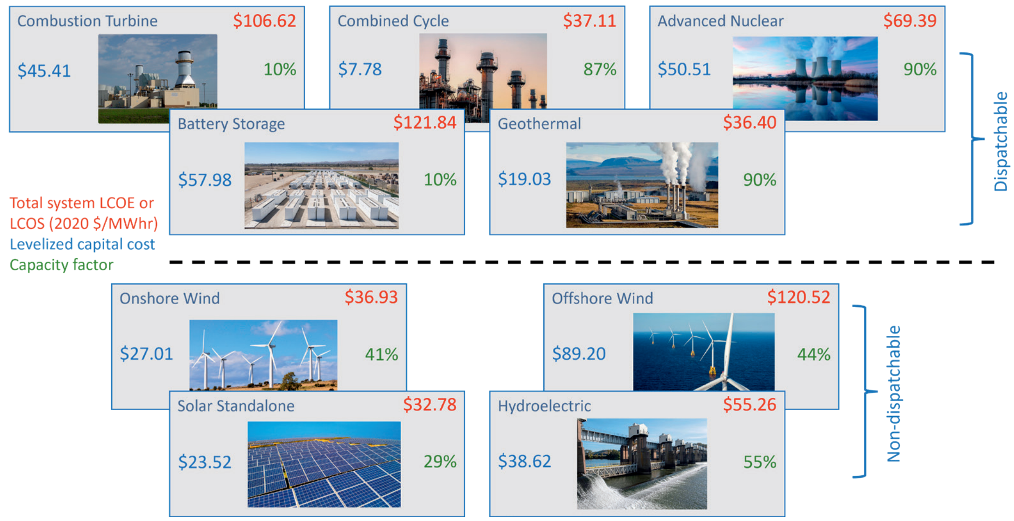
Reducing CO_2 emissions from electric power is a common starting point for the transition globally, and New Mexico is no different. As noted, the Energy Transition Act (ETA) sets a zero-carbon resource standard for electricity production by 2050 (2045 for investor-owned utilities, 2050 for rural electricity cooperatives). Renewable energy (wind, solar, and biomass) is expected to play an important role here: interim targets include 50% renewable energy standard by 2030 and 80% by 2040. According to the Energy, Minerals and Natural Resources Department (EMNRD), the majority of renewable energy is projected to come from both utility-scale projects and, to a lesser extent, distributed generation. Studies further suggest that upgrading the grid to coordinate wired and non-wired (e.g., demand response) solutions will be an important enabler of transition in the power sector (Pacyniak et al. 2020).[45]

Tracking the ETA goal of net zero carbon emissions from electricity generation by 2050, this analysis examines several candidate low-carbon electricity generation opportunities:

- Wind
- Solar
- Geothermal
- Coal with carbon capture and storage
- Natural gas cycle generation with carbon capture and storage
- Bioenergy with carbon capture and storage (BECCS)

It should be noted that this analysis does not focus on nuclear and hydropower as zero-emissions electricity options for the state. Nuclear is a very small part of the state's current electricity mix; all of the state's nuclear energy is imported from the Palo Verde Nuclear Generating Station in Arizona. Hydropower has limited additional potential, given that the state's water resources are already under pressure, and the situation is expected to worsen with climate change. Also, costs of generation are a consideration as the state contemplates the buildout of renewable wind and solar and the retirement of fossil generation. Figure 2.2 describes the projected levelized cost of electricity, including capital costs for plants entering service in 2026, as well as expected capacity factors.

Figure 2.2: Unsubsidized levelized cost of energy (LCOE) and storage (LCOS) for plants entering service in 2026 (2020 $/MWh).



Source: EIA 2021[46]

2.2.1 Renewable Energy: Wind, Solar, and Geothermal for Power Generation

New Mexico has abundant renewable energy resources. The vast majority of New Mexico has high-quality wind resources (NREL 2020),[47] and ranks fifth in the nation for wind and solar generation as a percentage of overall consumption (Dutzik et al. 2020).[48] Electricity generation from wind is increasingly economic as larger turbines mounted on taller towers with longer blades increase capacity factors and improve overall financial performance (Wiser 2020).[49] Electricity generated from wind has grown steadily since 2015 and already accounts for 21% of New Mexico's utility-scale net generation (DOE 2021).[50]

New Mexico has large estimated technical potential for both concentrated solar power (CSP) and solar photovoltaic (PV) (Lopez 2012).[51] New Mexico has 73 solar PV companies and 1,200 major projects. New Mexico ranks 16th among U.S. states in installed solar PV (New Mexico Solar 2020).[52] Community solar projects, which spread the costs of installation among a group of local subscribers, have also recently expanded (Sylvia 2021).[53]

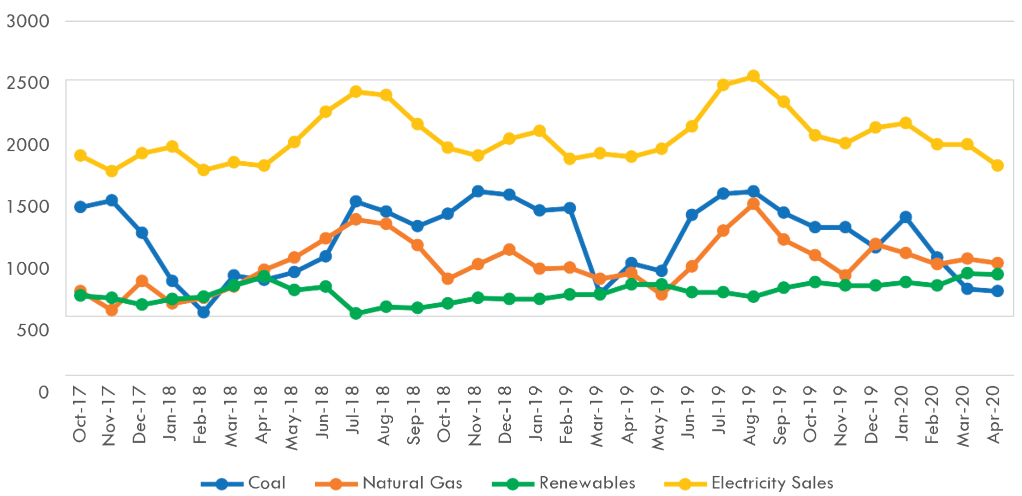
Wind and solar development generate near-term temporary construction jobs, for both capacity installation and transmission lines, as well as longer-term maintenance jobs. Wind energy jobs can be done with a secondary non-degree certificate or a multi-year apprenticeship program. Jobs requiring a secondary education pay higher wages. Wind energy jobs draw on a range of skill sets, expanding opportunity in the state, while still providing relatively competitive pay (BLS 2021).[54]

An important consideration, however, is the intermittency of wind and solar generation. Today, renewable energy provides over a quarter of total power generation in most months (see Figure 2.3). Expansion will sharply increase the need to manage the intermittency of these resources. Current storage technologies can help to bridge short periods when wind and sun are not available, but they are currently not effective for periods longer than a few hours (Aneke 2016).[55] Analysis of wind generation in California showed there were 90 days in 2017 with little to no wind and as many as 11 days in a row with little to no wind. Battery storage technologies generally have a duration of around four hours.[56]

PNM is evaluating options for balancing these intermittent resources, including pumped hydro, battery storage, and flexible generation such as natural gas peaking plants (Robinson-Avila 2020).[57] The cost of storage technologies is also expected to decrease in the future (Baxter 2020).[58] In the near term, however, storage costs must be added to the costs of renewable energy generation; as seen in Figure 2.2, for example, the LCOE for onshore wind is $36.93/MWh and battery storage costs are $121.84/MWh. Reducing costs of storage and developing long-duration storage should continue to be a focus of considerable innovation investment.

Tribal development of renewable energy may offer an opportunity to expand participation in a low-carbon energy transition, but so far, the scale has been small relative to anticipated capacity buildouts to meet ETA goals. Tribal energy development in New Mexico is largely funded and supported by the federal government through the Department of Energy Tribal Energy Program (TEP). TEP has supported concepts for 20 indigenous renewable energy projects in New Mexico since 1994. Of those project concepts funded, there were nine solar projects, six general renewable energy projects, two energy efficiency projects, one hydropower project, one wind project, and one geothermal project. These projects varied widely in scope and timelines. Most projects at the feasibility and planning stages received DOE funding in the $100,000 to $200,000 range. Of those 20 projects, six have been implemented.

Figure 2.3: New Mexico net electricity generation by fuel type and total electricity sales.



Source: Pacyniak et al. 2020[59]

As noted, wind and solar energy are expected to play an important role in the state's future energy mix. They are clean and increasingly cost-competitive. However, the points summarized in Table 2.1 suggest a few ways to improve performance. First, resource intermittency poses a challenge for grid integration and drives up cost, especially in periods when wind or solar account for a large share of total generation. Ways of balancing this intermittent resource—such as battery or pumped hydro storage, dispatchable backup generation, and demand response—will be needed. Second, wind and solar are expected to create jobs with above-average wages, but other than construction jobs, these jobs do not generally match the skill sets of the conventional energy workforce in the state and are less well compensated for non-college educated workers than jobs in fossil energy. Interviews suggested that if policies incentivize utilities to invest more in maintaining wind farms and solar arrays, then maintenance jobs could expand substantially. Third, locating wind and solar in-state could strengthen the case for development of jobs, social equity, local resources and capabilities, and public revenue generation. These tradeoffs need to be assessed.

Table 2.1: Summary of Analysis for Wind and Solar

Dimension	Expected performance	How to improve
Economic cost	Increasingly affordable; intermittency is a challenge	Examine cost-effective options for balancing intermittency
High-quality jobs	Expected to create near-term construction and manufacturing jobs	Expand construction apprenticeship programs to ensure sufficient workforce; policy support could more strongly incentivize investments in maintenance and related job creation
Equity	Limited ability to replace jobs and revenue streams associated with traditional fossil fuels	Tribal and/or rural ownership and operation could spread benefits; locate in-state
Technical and system integration complexity	Intermittent generation will require balancing resources on the grid	Use existing natural gas capacity to balance intermittency while exploring potential for long-duration storage
Builds on existing resources and capabilities	Uses abundant local wind and solar resources; substantial prior experience in both, especially wind	Locate generation in-state, but may trade off with cost
Public revenue generation	Likely to be subsidized rather than generate revenue	Will need to identify alternative sources of public revenue

Geothermal resources are another potential opportunity for power and heat generation. New Mexico has the sixth-largest geothermal potential in the U.S. (Lopez 2012),[60] located in the southwest and central parts of the state (NREL 2018).[61] New Mexico can utilize these resources, as they provide an immediate, consistent, renewable source of energy with proven and improving technology that oil and gas companies are actively investing in.[62] Geothermal can provide emissions-free baseload and flexible power generation. It can be used to attract existing and new industries that need a consistent baseload load power. Geothermal can also go hand in hand with other pathways mentioned in this report, like hydrogen production (Mahmoud 2021),[63] refining and recycling processes for environmentally responsible mining, and balancing variable wind and solar resources.

Table 2.2: Summary of Analysis for Geothermal

Dimension	Expected performance	How to improve
Economic efficiency	Cost-competitive today, but potential is geographically limited	Optimize resource selection and development
High-quality jobs	Skill sets overlap with oil and gas mining/drilling. Generally less pay compared to coal/oil jobs	Develop local training programs and offer competitive coverage packages for workers
Equity	Lifetime GHG emissions less than fossil and other renewables. Large requirements for water-cooled processes, though other processes are less intensive and emerging	Include assessments of water resource availability and existing uses in siting decisions
Technical and system integration complexity	Dispatchable and can support local heating applications	Leverage state innovation and entrepreneurial ecosystem
Builds on existing resources and capabilities	Opportunity for local oil and gas workforce; could tie into rural transmission network for wind/solar	Connecting new facilities to existing transmission lines
Public revenue generation	Likely to be subsidized rather than a source of revenue generation	Will need to identify alternative sources of public revenue

As described in Table 2.2, geothermal has both advantages and drawbacks. First, it is cost-competitive (see graphic above, with levelized cost of $36.40/MWh) and dispatchable (EIA 2021),[64] but its potential is geographically limited. Second, compared to wind and solar, its technology and skill set positively overlap with the fossil fuel industry (MIT 2006).[65] Third, developing geothermal could leverage the state's innovation ecosystem to improve and demonstrate advances in the technology.

However, regardless of New Mexico's mix of renewable energy, the state will need to modernize its transmission grid and distribution systems to further enable these options and to increase the overall electrification of the economy. With the introduction of more distributed solar, the grid and distribution systems will need to adapt to bidirectional flows of electricity and improved cybersecurity measures (Pacyniak et al. 2020).[66] The planned solar arrays and wind farms will require new transmission systems to resource-rich areas, which will create construction and maintenance jobs, in addition to the legal work associated with the acquisition of rights-of-way for this infrastructure, but will also shift the grid composition to more intermittent sources (NMRETA 2021).[67] The grid will have to accommodate these intermittent sources by employing firm power from natural gas generation or other load-following plants, as well as batteries or other storage technologies (Pacyniak et al. 2020).[68] New Mexico will also have to integrate efficiency policies that will impact overall and time-of-day electricity demand (Pacyniak et al. 2020).[69] While the pathways presented here suggest next steps, they cannot be fully met without additional and substantial investments in New Mexico's energy infrastructure.

It should be noted that the infrastructure bill recently passed by Congress includes $65 billion to build thousands of miles of new, resilient transmission lines. This will facilitate and expand renewable energy (Conde 2021).[70] At the same time, a report by the National Renewable Energy Laboratory (NREL) released in early 2021 concludes that: "New transmission infrastructure is also expected with electrification, but local resources are increasingly relied upon to meet electrification-driven load growth, which mitigates the influence of electrification on the need for additional long-distance, inter-regional transmission expansion. However, the magnitude of short transmission lines to interconnect new renewable energy generators scales with electrification, and total transmission capacity expansion scales with renewable energy deployment levels" (T&D World 2021).[71] Depending on the outcome of congressional debates on infrastructure legislation, New Mexico officials should be prepared to compete for federal funding for transmission buildouts, especially for any funds that are available for shorter transmission lines to support its mandated increases in renewable generation.

2.2.2 Fossil and Biomass Generation with Carbon Capture and Storage

Coal and natural gas power generation together account for more than two-thirds of total generation and in specific months provide an even higher share of the generation, as shown in Figure 2.2. Because natural gas has roughly half of the carbon content of coal, switching from coal to natural gas generation reduces CO_2 emissions. Nationwide, coal-to-gas switching has delivered a large fraction of the GHG emissions reductions over the past 15 years (EIA 2021).[72] This is not, however, a long-term solution: reaching net zero would require limiting emissions from natural gas as well. Installing or retrofitting existing plants with carbon capture and storage could reduce CO_2 emissions from fossil generation by 90% or more. Bioenergy with carbon capture and storage (BECCS) also offers the possibility of net carbon withdrawals, as plant matter used as feedstock withdraws CO_2 from the atmosphere during cultivation.

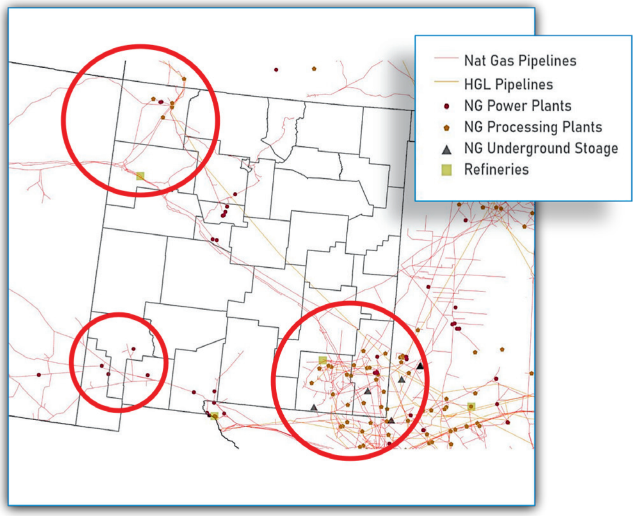
With a carbon price, these generation options may become economically attractive. Nineteen large-scale CCS facilities were operating globally as of 2019 (EFI 2021).[73] Yet the technology is currently not yet viable in most markets, because it requires complex integration of generation, transport, and storage infrastructures. Internal Revenue Code Section 45Q, the tax credit for carbon dioxide sequestration, is based on metric tons of qualified carbon oxide captured and sequestered (Jones and Sherlock 2021).[74] Qualified carbon dioxide must be prevented from being released into the atmosphere by equipment; emissions must be measured at capture and disposal, injection, or other use locations. 45Q can be an attractive incentive for greater investment in CCS, especially in an area like New Mexico, where there is strong potential for CCS development.

In New Mexico, conditions for CCS development are generally favorable. The sedimentary formations in southeastern and northwestern New Mexico could serve as CO_2 storage sites. Focusing on ways to use existing pipeline rights-of-way in the state could expedite the buildout transport for CO_2 as part of a larger CCS ecosystem (see Figure 2.4 for the extent of the current natural gas pipeline network, with (a) showing co-located infrastructure and (b) overlaying the locations of oil and gas wells). A CCS project being actively developed in Scotland suggests reusing an existing oil and gas pipeline for CO_2 transmission may cost 1–10% of the cost of constructing a new pipeline (ACT Acorn 2018).[75] CO_2 storage is also viable in New Mexico. New Mexico, along with Texas and Ohio, continues to investigate opportunities for underground carbon storage in saline formations and depleted oil and gas reservoirs, with DOE funding (DOE 2021).[76]

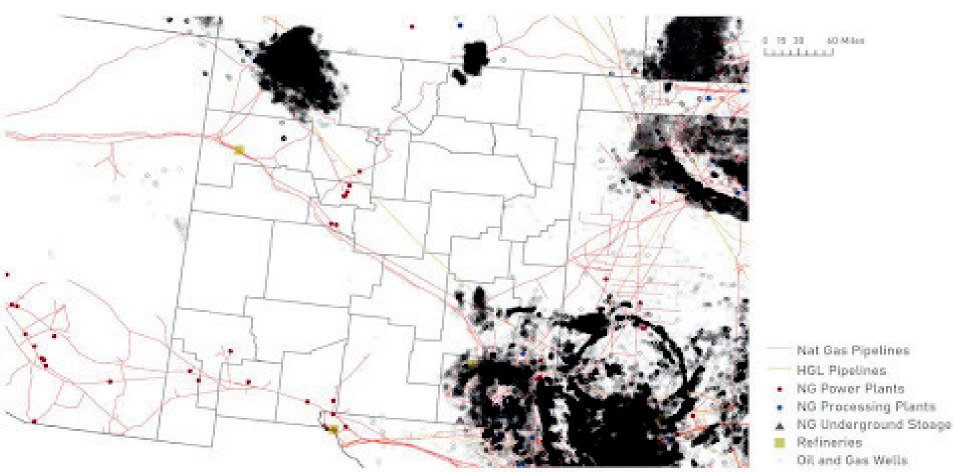
One possible pathway involves retrofitting the state's existing coal plants with CCS. San Juan Generating Station is the only coal plant in New Mexico for which CCS installation is being considered. However, the economic benefits of keeping SJGS open (state tax revenues and high wages) may not outweigh the community health and environmental damage its operation incurs. SJGS and the adjacent San Juan Mine need several billion gallons of water to run, even as the surrounding region faces drought (LANL 2019).[77] Enchant Energy has stated that they will work in good faith to preserve employment and maintain the tax base (Enchant Energy Corporation 2019).[78] Yet Enchant Energy's retrofit construction is running behind schedule, and planned layoffs under a decommissioning scenario are already underway (Grover 2021).[79]

Figure 2.4: Locations of (a) natural gas pipelines, natural gas power plants, natural gas processing plants, natural gas underground storage, and refineries and (b) oil and gas wells overlaid on the infrastructure and facilities in (a).

(a)



(b)



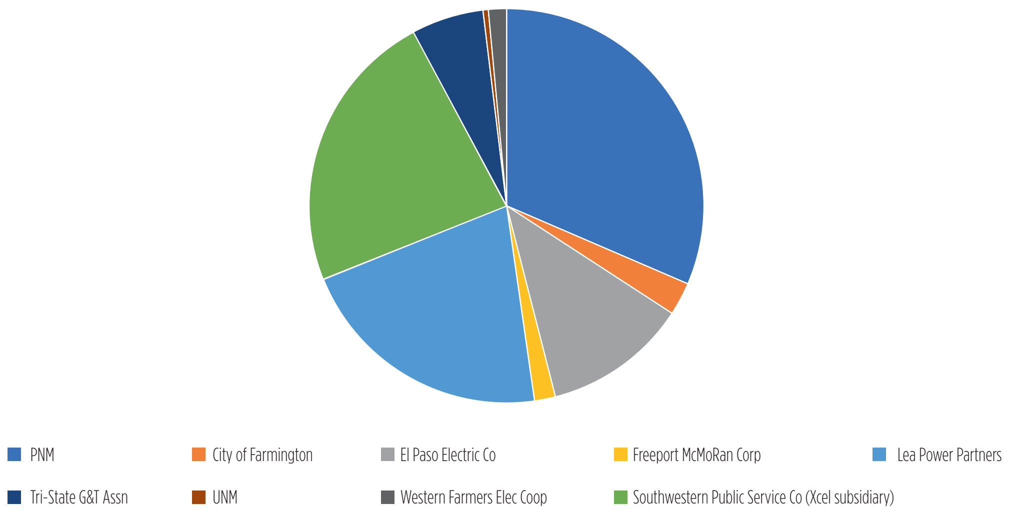
Source: U.S. Energy Information Administration[80]

Natural gas with CCS is a second possible pathway for significant emissions reductions. The state has 3.8 GW of natural gas by nameplate capacity, which supplies major population centers and is operated by multiple utilities (see breakdown in Figure 2.5a). Much of this natural gas is flexible generation that can ramp in less than one hour (36% of capacity; see Figure 2.5b).

Natural gas production and development accounts for a significant percentage of New Mexico's revenue and spending (NMOGA 2021).[81] Natural gas production and utility workers receive relatively high wages, even without postsecondary education (BLS 2020).[82] Fitting natural gas plants with CCS is relatively well-understood, and New Mexico has much of the appropriate regional infrastructure necessary, although it would need to build out a network to transport CO_2.

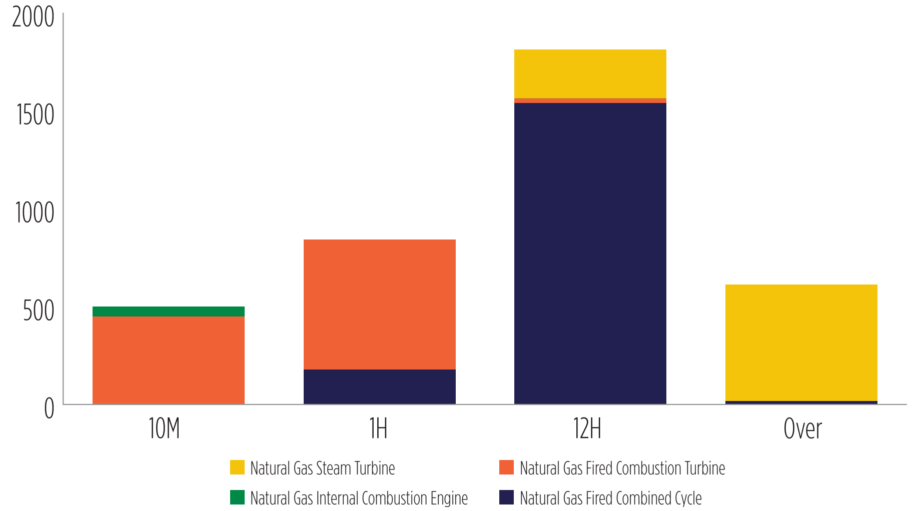
Figure 2.5: Natural gas generating capacity in New Mexico (a) by operator and (b) by time from cold shutdown to full load and by technology. The abbreviation "Over" in (b) refers to times from cold shutdown to full load exceeding 12 hours.

(a)



Source: EIA 2021[83]

(b)



Source: EIA 2021[84]

Biomass energy with CCS (BECCS) could also help New Mexico address several issues: GHG emissions reductions, jobs, and forest fire management. Drought and bark beetle infestations have left much deadwood in New Mexico's forests. Every county in New Mexico is in some degree of drought, exacerbating the danger of forest fires (Wyland 2021).[85] Left alone, the deadwood presents significant fire hazards.[86] This abundant dry deadwood could be used as a feedstock by converting wood into chips and pellets, which would create jobs and reduce forest fire danger.

Table 2.3: Summary of Analysis for Fossil or Biomass Generation with Carbon Capture and Storage

Dimension	Expected performance	How to improve
Economic efficiency	Pre-commercial—needs carbon price of at least \$60/ton CO_2; needs policy support; natural gas less expensive and less polluting	Connect with other goals such as fire prevention (biomass) and balancing intermittency of renewable generation
High-quality jobs	Could preserve jobs in fossil power generation (coal, NG) Could add forestry jobs (biomass)	Prepare existing workforce for CCS construction and operation
Equity	Jobs and revenues tied to indigenous communities preserved (coal, possibly NG); CCS would not address local pollution	Explore potential for tribal and rural communities to operate natural gas plants and build plants with CCS
Technical and system integration complexity	Needs complementary transport and storage network; regulatory support	Develop consistent state and federal regulatory framework for CCS
Builds on existing resources and capabilities	Suitable geologic storage options, pipeline network used for CO_2	Prove out pipeline use and storage capabilities
Public revenue generation	Would preserve resource revenue streams (coal, gas)	Limit or prevent tax exemptions for facilities

Table 2.3 characterizes BECCS along seven dimensions, highlighting both the opportunity and several drawbacks. BECCS is still precommercial, but abundant local feedstock could help to lower its cost. However, monetizing this deadwood may be difficult. Forestry jobs are not highly paid (BLS 2020),[87] and it is unclear how these jobs would be funded. Instead of generating public funds, BECCS will almost certainly need to be subsidized. Also, some conversion technologies could generate local pollution (Simões Amaral et al. 2016).[88]

The Intergovernmental Panel on Climate Change (IPCC) (2014) estimates that the marginal cost of carbon abatement with BECCS is 60–250 \$/tCO_2, with global sequestration potential ranging from 3–10 Gt CO_2/yr. It goes on to describe BECCS as an "essential component of the response strategy for climate change in the majority of scenarios in the literature, particularly in the context of concentration overshoot" (IPCC AR5 2014, 504).[89] Challenges include land requirements and competition with other bioenergy technologies (e.g., biochar) for available biomass. In 2014, 16 global BECCS projects existed, all in exploration stages. As of 2019, there were five operational BECCS facilities globally. Four of these were in the U.S., with only one of the projects, located in Illinois, actually storing its carbon (Consoli 2019).[90] While the potential and necessity of BECCS is high, more research and development is still needed to enable broader commercialization.

This analysis leads to several insights. First, among the three CCS applications for electricity examined here, natural gas appears to be the most promising: it uses a relatively abundant, inexpensive, lower-carbon fuel that is produced in the state on indigenous and rural lands. Public revenues connected with natural gas production would be preserved. BECCS may be an attractive opportunity to demonstrate the technology while making use of the large deadwood resource in the state. While currently BECCS is more costly, New Mexico may have an advantage in developing and demonstrating the technology, due to a combination of factors: the size of the resource, local centers of energy innovation that could develop BECCS, and favorable geology for CCS.

2.3 Hydrogen

Hydrogen is a flexible fuel/energy carrier that can be produced from a range of primary sources—including from natural gas via steam methane reforming or from water via electrolysis—which can be powered with renewable energy. Blending a percentage of hydrogen into existing natural gas pipelines (up to 30%) may be a viable use of New Mexico's natural gas pipeline network without significant alterations, but blending limits will vary (Melaina et al. 2013).[91] Converting natural gas pipelines to deliver pure hydrogen would require more substantial modifications.

Hydrogen production is categorized using three colors, corresponding to different respective primary sources of energy. Those colors are grey for coal or natural gas, blue for natural gas with CCS, and green for electrolysis from zero-carbon electricity sources. Blue hydrogen is currently expected to be the most attractive in the near term, considering costs, water utilization, and ability to repurpose existing infrastructure (IEA 2020).[92] Existing pipelines can transport natural gas to methane reformation facilities that can export blended hydrogen and natural gas to industrial, residential, electrical, or transportation sectors (IOGP 2018).[93] The captured carbon can be then sent "back up the supply chain," to be used in Enhanced Oil Recovery (EOR) or to be permanently sequestered in a range of geologic formations (IEA 2020).[94] The captured carbon can also be used to make synthetic fuels and other services (IEA 2020).[95]

Green hydrogen, while still expensive—electrolyzer costs are about $1,000/kW, and the costs of green hydrogen are several times higher than blue hydrogen—is still an attractive option in some regions as the cost of electrolysis continues to decline and more renewables are added to the grid. Limited water resources in New Mexico could be exacerbated by green hydrogen from water; nevertheless, innovation investments are expected to reduce costs, and this could provide another solution to intermittency in the short to mid term (Hydrogen Council 2021).[96]

Table 2.4 summarizes how hydrogen production and use could be expanded in New Mexico. Lea, Eddy, and San Juan Counties have dense gas infrastructure that could serve as corridors for transporting hydrogen, which could be initially produced from natural gas at plants with carbon capture and storage. In the near term, hydrogen could be used in the refining and chemicals industry as a source of high-quality heat for cement and mineral processing, with limited modifications to existing facilities. In the longer term, it could serve as an alternative transportation fuel, which would require more expensive pipeline networks and new refueling and vehicle infrastructure. Figure 2.6 shows the colocation of resources and infrastructure that could form a basis for hydrogen hub development.

Table 2.4: Summary of Analysis for Hydrogen

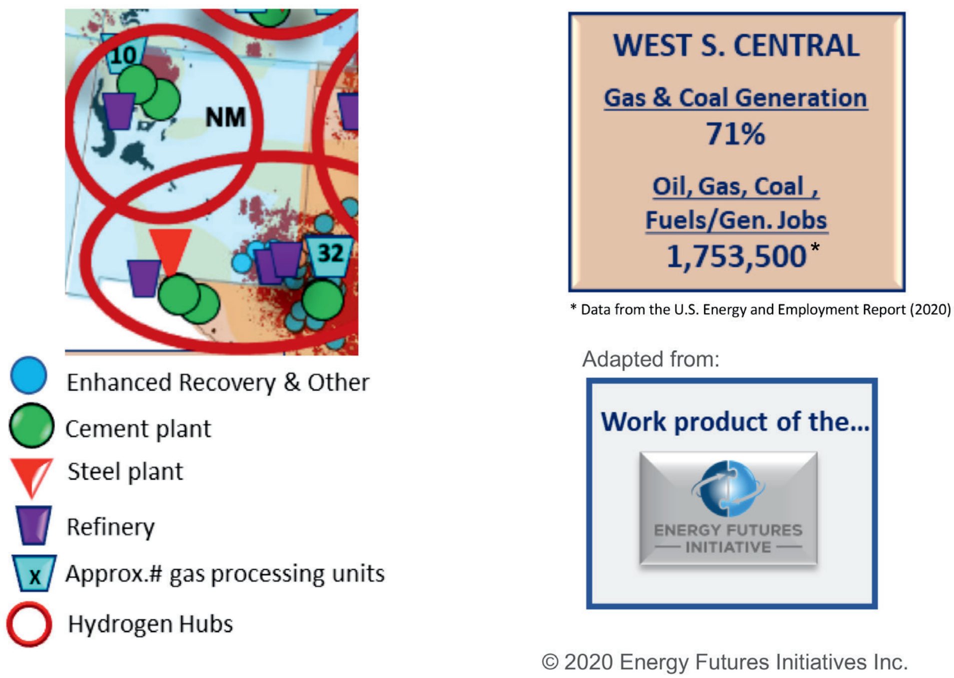
Dimension	Expected performance	How to improve
Economic efficiency	Production of hydrogen from local natural gas is cost-competitive; use in transportation is expected in heavy-duty vehicles by 2025	Develop an integrated plan for hydrogen hub development
High-quality jobs	Generates local, well-paying jobs; salaries higher than wind/solar, lower than traditional fossil	Partner with community colleges and national labs to increase the number of in-state specialists
Equity	Could allow existing power plant and pipeline infrastructure to be expanded and/or repurposed to generate hydrogen from natural gas	Engage oil and gas, electric power, and pipeline construction workforces; ensure training opportunities for indigenous groups; develop training pathways for existing energy workforce
Technical and system integration complexity	Very complex given dependence on economics of multiple systems	Differentiate pricing for green versus blue/grey hydrogen Evaluate blending viability of natural gas infrastructure; consider CCS colocation
Builds on existing resources and capabilities	High-quality renewable resources could support green hydrogen and mitigate intermittency; extensive pipeline network available	Develop early on a system-level vision for developing two hydrogen hubs in the state
Public revenue generation	Would displace use of fossil fuels in-state, reducing associated revenues	Consider a mileage tax or alternative sources of revenue

This case investigation suggests three conclusions for hydrogen production. First, the state has a significant opportunity to explore development of hydrogen hubs and repurpose some of the existing infrastructure in the state to support this option. Second, water use associated with green hydrogen should be carefully considered. Third, New Mexico's potential role as an exporter of hydrogen to neighboring states should be investigated.

The introduction of hydrogen and CCS hubs could also help to supplant large revenue streams that will be lost to some indigenous communities. As previously mentioned, both hydrogen and carbon can be transported in natural gas pipelines with sufficient modifications. The pipelines on indigenous lands could be a priority for modifications for both hydrogen and carbon transportation. These modified pipelines could prove to be financially sound, as there are numerous old and abandoned coal and oil mines on indigenous lands that could sequester carbon if the tribal governments deem them culturally appropriate and acceptable.

Underground carbon storage could also help to stimulate other remediation efforts and spur further research into the long-term effects of mining and electricity generation on aquifers and surrounding ecosystems. The broader range of skills and knowledge required for these new industries in hydrogen and carbon could also help to combat quality job losses, as these industries would need highly skilled workers at competitive pay rates, making them attractive for keeping skilled and educated workers in the state. These industries would also translate conventional energy jobs into new hydrogen and CCS jobs, as these new industries would require many of the same skill sets. The final location of these new hydrogen and CCS hubs would be determined by the suitability of underground storage formations (New Mexico has abundant and appropriate subsurface sites); the location of these and appropriate generation/production facilities would ultimately determine which indigenous groups might benefit most from the new hubs, but there will likely be a range of opportunities for tribal communities as New Mexico transitions to next-generation energy production, distribution, and storage. The Bipartisan Infrastructure Law is expected to support multiple regional hydrogen hubs and represents an important opportunity for New Mexico.

Figure 2.6: Colocation of New Mexico resources, including subsurface resources, and infrastructure important for developing hydrogen/CCS hubs.



One more important hydrogen production method that could be important for New Mexico and the clean energy transition is the production of hydrogen from coalbed methane (CBM). New Mexico has some of the largest CBM resources in the country—the San Juan basin has 43% of the country's proven reserves at 8446 bcf (National Research Council, 2010).[97] Australia and Botswana are exploring this option and analysis suggests it has, with innovation investment, the potential to meet several key objectives. A 2019 paper on the topic noted that "the theoretical calculation results show that it is technically feasible to produce hydrogen from underground CBM. Since the extraction of CBM is an imperative operation for mine safety, it is beneficial not only in terms of environmental protection, but also in terms of the development of hydrogen energy and economic benefits. Because CBM extraction is much lower than that of natural gas with the same calorific value, its cost of hydrogen production would be much lower than that of natural gas." (Wang 2019)[98]

2.4 Transportation

Transportation is the second-largest source of GHG emissions in the state and must be a focus for policymakers as they seek to deeply decarbonize New Mexico's economy. To reduce emissions from the transportation sector in New Mexico, two policy goals have been laid out in New Mexico's Climate Action Strategy: scaling electric vehicle adoption and reducing total vehicle miles traveled (VMT). This section reviews these two pathways.

2.4.1 Electric Vehicles

Electric vehicles (EVs) are a cornerstone of the state's plans to reduce transportation GHG emissions. Technical analysis from the New Mexico Department of Transportation's long-range plan indicates that only 0.14% of New Mexico's EV sales were electric or plug-in hybrids in 2018 (New Mexico 2045 Plan 2021).[99] The agency is forecasting, however, that by 2045, 21.2% of all vehicles registered in the state will be EVs, or about 245,000 vehicles. The Public Service Company of New Mexico (PNM) has projected that just within its service area, total EVs could range from 92,000 to 183,000 by 2040 (PNM 2021).[100] EVs are currently more expensive than similarly sized gasoline vehicles; the average sticker price of an electric car is $19,000 higher than the average gasoline car (NRDC 2020).[101] There is a $7,500 federal tax credit for EVs available to households in New Mexico. Also, EVs are expected to save drivers between $1,000 and $1,600 annually on fuel costs and by 2030 are projected to provide a total lower cost of ownership than conventional vehicles in New Mexico on an unsubsidized basis (Plug In America 2017; M.J. Bradley 7 Associates 2020).[102]

As noted above, although several state-level incentives exist for EVs, including the New Mexico Alternative Fuel Tax Exemption and Alternative Fuel Vehicle (AFV) Loan, New Mexico will also need to expand its charging station infrastructure, which is currently concentrated in its major cities and along the I-25 and I-40 corridors. The latest estimates from the DOE's Alternative Fueling Data Center indicate there are currently 147 public charging stations across the state (see Figure 2.7). The expansion of charging station infrastructure will be greatly supported by the state's new tax incentive for EV charging in residential and commercial buildings that went into effect on January 1, 2021. The credit uniquely focuses on existing and newly constructed buildings and should accelerate meeting deep decarbonization goals.

The state will also have to decarbonize its power sector to ensure that its EVs are running on clean electricity.

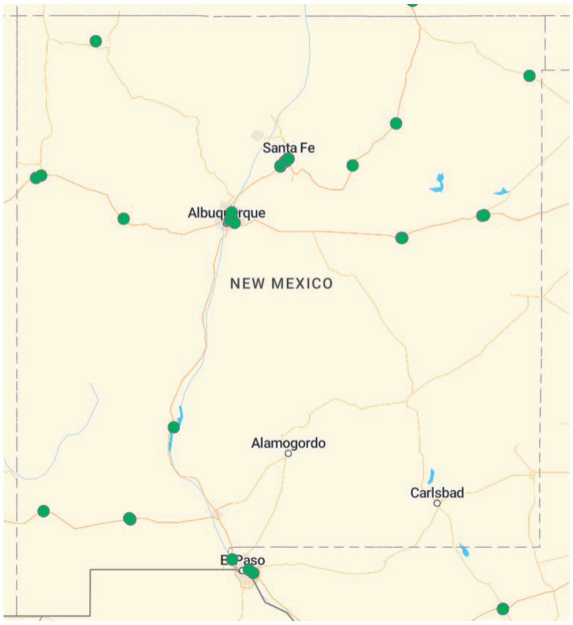
There are few technology options for reducing emissions from heavy-duty vehicles; innovation is needed for this subsector. A recent analysis found that medium-duty vehicles and heavy-duty vehicles, primarily for commercial trucking and other uses, account for over 25% of the state's transportation emissions, while aviation represented less than 4% (Energy and Environmental Economics Inc. 2020).[103] Freight trucking in particular has experienced notable growth in the state: for example, annual border crossings at Columbus and Santa Teresa have grown by 227% between 2009 and 2019 (NMDOT 2021).[104]

In addition, greater adoption of EVs will diminish revenues from state gasoline taxes. State agencies are considering two policies to offset these losses: (1) a flat registration fee for EVs and (2) a road use charge based on miles driven. The state must consider the equity implications of these policies to ensure they are not regressive and that they do not disincentivize even higher EV penetration.

Table 2.5: Summary of Analysis for Electric Vehicles

Dimension	Expected performance	How to improve
Economic efficiency	Not cost-competitive with conventional vehicles today without subsidies; wealthy consumers may value	Costs may fall with time, improving competitiveness
High-quality jobs	Will generate jobs for EV technicians but reduce jobs at gas stations and in after-sales services	Anticipate EV technician needs and develop training programs; encourage entrepreneurship and economic diversification
Equity	EVs may be least affordable to rural and low-income households	Ensure that any subsidy programs support access to clean transportation options
Technical and system integration complexity	Need for charging infrastructure makes EVs challenging for long-distance travel	Subsidize EV charging corridors along highways, combine with service and convenience stores and eventually hydrogen refueling
Builds on existing resources and capabilities	Limited relationship to existing activities in NM	Look for technical skills matches to EV-related jobs
Public revenue generation	Negative impact on public finance due to lost gas tax revenues	Difficult; mileage charge as an alternative would be highly regressive

Figure 2.7: Public, non-proprietary EV charging stations in New Mexico.



Source: Alternative Fueling Data Center, 2021[105]

These actions will be needed to support and enable the new tax incentive for EV charging in residential and commercial buildings. This incentive is made available through the Sustainable Building Tax Credit.

2.4.2 Reducing Vehicle Miles Traveled

Lowering total vehicle travel could also play a crucial role in reducing transportation-related GHG emissions and pollutants in New Mexico. For much of the state's population, however, this is not seen as a viable option: New Mexico is the fifth largest state by land area, and households and businesses are heavily dependent on vehicle transport. Only 1% of New Mexicans use public transit to travel to work and transit ridership within the state's 29 local and regional transit systems has fallen by as much as 23.9% since its peak in 2013 (NMDOT 2021).[106] Meanwhile, over 80% of New Mexican commuters drive alone, according to the latest estimates from the New Mexico Department of Transportation. Vehicle miles traveled (VMT) reduction strategies will vary between rural areas, which lack the density to expand transit services, and urban regions, where population growth is expected to concentrate; 84% of the state's population growth is projected to come from just three counties: Bernalillo, Sandoval, and Doña Ana (NMDOT 2021).[107]

To support VMT reduction, municipalities, regional metropolitan planning organizations (MPOs), and NMDOT are developing a suite of strategies to encourage walking and biking. These include investing in pedestrian safety and bicycle infrastructure and integrating Complete Streets urban design. Agencies are also supporting the expansion of vanpooling services to help close transit gaps in certain areas (NMDOT 2021).[108] In high-growth and denser communities, integrating land use and transportation planning may enable VMT reduction by improving network connectivity and guiding development alongside transportation investments. In Albuquerque, for example, planners are prioritizing coordination with the regional Metropolitan Transportation Plan for transit connectivity, street design, and funding and aligning anticipated development patterns with transportation improvements (City of Albuquerque 2017).[109]

However, modal shift will likely be difficult in a state that is heavily dependent on automobiles. In fact, a recent public survey by NMDOT found that respondents "generally revealed an unfavorable perception or level of acceptance of new mobility options beyond the private automobile" (NMDOT 2021).[110] This preference suggests the potential for modal shift may be limited in the New Mexico context. Nevertheless, to the extent that certain demographic and socioeconomic groups rely more on transit and non-auto forms of transportation, improving transportation services for those groups would ensure that they remain an attractive option, relative to purchasing and driving vehicles that are typically older and less efficient on average.

More recently, Senate Bill (SB) 11 proposed a low-carbon fuel standard (LCFS) as an additional strategy for reducing transportation GHGs, similar to the one introduced in California. The proposed LCFS would have required a reduction in the average carbon content of the fuel mix of 10% by 2030 and 28% by 2040, relative to 2018 levels, which could be met by altering the fuel mix or purchasing carbon credits from a wide range of sectors in the state's economy. The bill has stalled in the House but may be revisited in 2022.

An LCFS has pros and cons. An LCFS similar to the one proposed in SB 11 could support electrification and hydrogen-based transportation, but the generous offset provision could mean that fuel producers comply by supporting carbon reductions elsewhere. Moreover, an LCFS may not necessarily lead to absolute reductions in GHG emissions—for instance, if travel demand grows and mode shifts (e.g., from cars to trucks) decrease fleet-level efficiency. Meanwhile, if an LCFS leads to increases in the price of conventional fuels, it could place a greater burden on low-income households.

This case study reaches several conclusions about transportation. Policies that support electric vehicles and VMT reduction have the potential to adversely affect less affluent rural households. Policies that subsidize clean transportation options for these households may help to offset these regressive effects. Relevant state agencies should evaluate the equity implications of greater EV penetration, from the siting of charging infrastructure to the distributive effects of proposed mileage tax and EV registration fees. Electrified transportation should also be coordinated with broader transportation and mobility planning, including investments in transit expansion, promotion of active transportation wherever possible, and strategies for reducing emissions from heavy and commercial segments. Hydrogen (e.g., fuel cell) vehicle options should also be investigated in connection with the development of hydrogen hubs across the state, discussed above.

2.5 Non-Energy Opportunities: Agriculture, Forestry, and Mining

New Mexico has an opportunity to support a clean energy transition in the state and beyond through innovations in agriculture, forestry, and mining, based on the state's unique resources and capabilities in these areas.

2.5.1 Agriculture

Several opportunities for reducing emissions from agriculture are explored in this case investigation. These include agricultural biogas and biochar, including the possibility of scaling beyond current isolated, small-scale examples. Opportunities for renewable gas production in New Mexico are mostly in the south, southeast, and around Albuquerque.

In New Mexico, agriculture is responsible for roughly 8% of annual GHG emissions (Bharadwaj et al. 2020).[111] This includes methane produced in enteric fermentation during ruminant animal digestion, manure management, and soil management (Bharadwaj et al. 2020).[112] To reduce these emissions, New Mexico can focus on the following pathways, including improved carbon storage of soil, reduced N_2O emissions, managed enteric fermentation, and improved manure management. To manage enteric fermentation, a range of additives can be introduced to animal feed to reduce enteric fermentation, with varying commercialization ease, efficiency in methane reduction, and co-benefits and risks (Curnow 2020).[113] These reductions could be monetized as offsets under an eventual cap-and-trade system in the state or nation (New Mexico Interagency Climate Change Task Force 2020).[114]

Table 2.6: Summary of Analysis for Agriculture

Dimension	Expected performance	How to improve
Economic efficiency	**AD:** Abundant resources with proven technology. Provide year-round production and reduce methane emissions and electricity/heating emissions. **Biochar:** Enhance soils moisture retention and nutrient content; carbon negative.	Improve supply chains for food/animal waste and establish markets for biofuels and biochar. Explore biochar with direct heat capabilities.
High-quality jobs	**AD:** Range of agriculture jobs for both education and pay. Jobs available in rural areas. **Biochar:** Primarily in research and development with some ag jobs.	Further research and development for technologies.
Equity	**AD:** Expanded agricultural job basis, reduced emissions from waste and beneficial coproducts. Overall improves community health. **Biochar:** Same as AD, in addition to enhanced soil and water management.	Facilitate training and entrepreneurial pursuits for rural and agricultural areas.
Technical and system integration complexity	**AD:** Biofuels can be pumped in natural gas lines with some added filtering. **Biochar:** N/A	Explore biofuel integration in natural gas lines; understand effects of biochar in semi-arid agricultural regions
Builds on existing resources and capabilities	**AD:** Farms already collect animal waste with collection practices compatible with AD. **Biochar:** Waste collection also compatible with pyrolysis.	Better and more efficient practices still needed in manure management and pyrolysis techniques.
Public revenue generation	**AD:** Taxes from facilities and sales/purchases of food and animal waste. Farmers save money on electricity/ fertilizers. **Biochar:** Similar taxes from property and sales as AD, with the added benefit of improved solid moisture retention.	More research needed to encourage growth; but still extract maximal public benefits.

Anaerobic digestion and biochar production (Huber 2018)[115] offer important options for the remaining pathways and create economic output. Anaerobic digesters (ADs) turn animal and food waste into biofuels, utilizing microbial organisms. These biofuels can then be used to generate electricity, heat, or renewable fuel for vehicles. Anaerobic digesters also produce by-products that can be used as fertilizers and bedding for animals, while also improving manure management practices (U.S. EPA 2019).[116] Biochar is produced from biomass, which is then turned into a charcoal-like substance through pyrolysis. This process can be carbon negative. Biochar can improve soil moisture, nutrient levels, and biodiversity when used as a soil additive, overall improving soil's carbon storage and reducing the need for fertilizers and net N_2O emission (Idowu et al. 2018).[117]

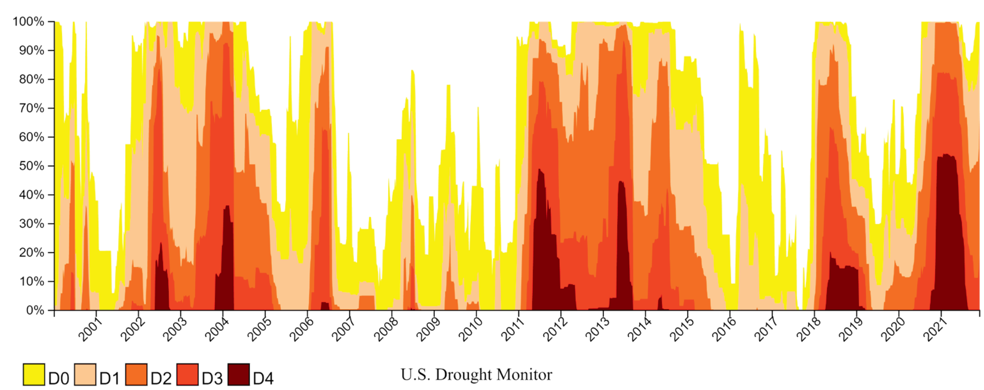
Renewable gas generated from ADs could be most beneficial when used for transportation in the long term. The biogas could decrease emissions without eliminating revenue streams from fueling taxes or jobs associated with internal combustion engine vehicles. Biogas refueling stations could replace existing fossil fuel stations to maintain current levels of employment, with the possibility of taxation on biofuel. Additionally, as biofuel would still require a type of ICE vehicle, service and maintenance jobs would still be required, unlike in a full transition to EVs. Given the complex equity considerations for EVs, biofuel could be a viable option for New Mexico's transportation sector. Renewable gas can also utilize existing natural gas infrastructure.

New Mexico's farmers may also benefit from solar technology. Agricultural photovoltaics (APV) is the dual use of PV and farming land, specifically PV that has been elevated on durable support structures to enable farming activities below. Using solar energy, which has been explored as a passive means to obtain energy across many proven projects worldwide (Kwon et al. 2020),[118] farmers need only maintain their panels very little while reaping financial benefits, either in energy credits or funds from the local utility or in on-site utilization. Further, some crops thrive in partial shade, enabling farmers to grow non-native crops (Marrou et al. 2012).[119] Farmers may choose APV because it occupies minimal plant-growing area. Dust accumulation on panels is less of a concern with APV, as root structures hold more soil in place, resulting in less airborne dust and soil.

2.5.2 Forestry

New Mexico has abundant forests. Much of the state routinely endures severe drought and has had a bark beetle infestation for several years. This has left large quantities of deadwood in the state's forest, which creates fire hazards for surrounding communities and native species. The U.S. Drought Monitor reports that currently 21.2% of the state is in Extreme Drought conditions, which is defined by "extreme" fire danger. Reported historical drought data from 2000 is found in Figure 2.8.

Figure 2.8: Historical drought conditions in New Mexico from 2000 to present, showing drought conditions from Abnormally Dry (D0) to Exceptional Drought (D4).[120]



As noted, two possible methods of addressing such hazards include removal of deadwood and reforestation. Deadwood removal may have additional economic and energy benefits if deadwood is used as wood chip fuel in a BECCS process, as discussed in Section 2.2.2. Reforestation can restore native flora and fauna in areas previously devastated by forest fires, help prevent erosion, and grow forests that will act as carbon sinks (Woods 2020).[121]

This case investigation suggests options the state should consider for forestry. First, on state forest lands, New Mexico should consider conducting a feasibility study on the possibility of removing deadwood at scale, which might include scaling up road systems, employment, and wages. Increased employment and wages might be goals for a program such as a Climate Corps within the state. Second, on federal forest lands, a program that focuses on deadwood collection with the support of both federal and state authorities could provide a major employment opportunity for rural residents.

Table 2.7: Summary of Analysis for Forestry

Dimension	Expected performance	How to improve
Economic efficiency	Recommend feasibility study	Recommend feasibility study
High-quality jobs	Forestry jobs are not highly paid: U.S. median wage $31,000/year (BLS 2020)[122]	Focus on creation of part-time or seasonal jobs with state or federal support
Equity	**Removing deadwood:** Local communities are likely to benefit from decreased risk of forest fires **Reforesting:** Reforestation can help areas recover faster from forest fires, reduce erosion	Engage local populations with interest in deadwood removal Prioritize reforestation where communities suffer from previous fires' effects
Technical and system integration complexity	**Removing deadwood:** Road system not suitable for large-scale effort **Reforesting:** More seed collection is required from a new crop of trees for reforestation efforts to succeed	Explore expanding forest roads for ease of access Support the 2020 Forest Action Plan, and include deadwood removal in the plan
Builds on existing resources and capabilities	**Removing deadwood:** NM has abundant dry deadwood and a system in place for forest monitoring **Reforesting:** The John T. Harrington Forestry Research Center provides expertise in steps needed for reforestation and coordination of local efforts	Explore options for biomass boilers that use wood chips, minimizing pollution Increased seed collection from newer crops of trees
Public revenue generation	Needs a feasibility study	Needs a feasibility study

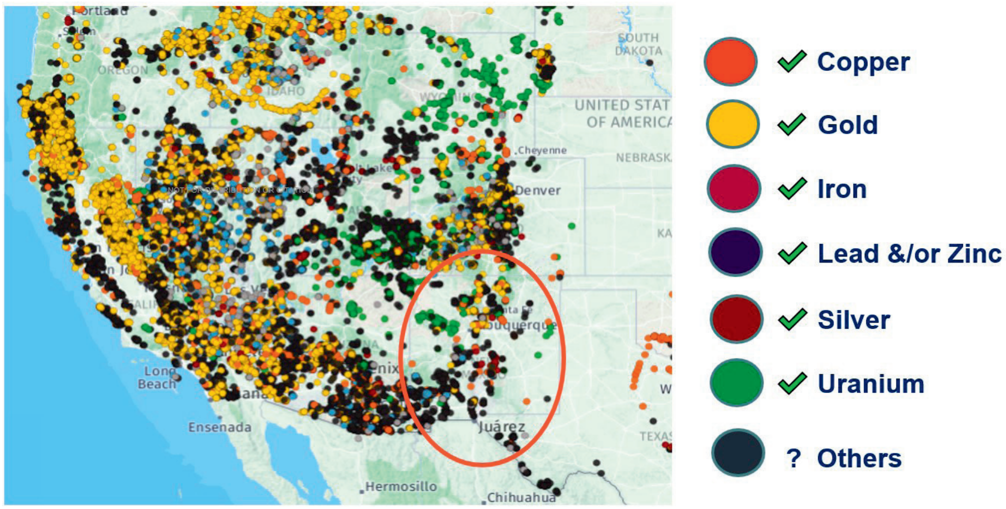
2.5.3 Environmentally Responsible Mining

In 2017, the United Nations Environment Program (UNEP) calculated that low-carbon technologies will need over 600 million metric tonnes more metal resources in a 2°C scenario compared to a 6°C scenario where fossil fuel use continues on its current path. Aluminum and copper are critical inputs for solar PVs and wind technologies; lithium, cobalt, nickel, and manganese are needed for batteries; and dysprosium and neodymium are components for EV batteries. Rising demand for key minerals and metal resources has become a growing critical supply chain challenge.

New Mexico ranks among the top fifth of mineral-producing states in the country and registers high production volumes of copper, zeolite, perlite, potash, coal, and uranium. Non-fuel mining across the state is shown in Figure 2.9. In 2016, New

Mexico ranked second among U.S. states in copper production (worth more than $840 million) and first in potash (worth $269 million) (NM Bureau of Geology and Mineral Resources 2019).[123] Copper in particular has applications in manufacturing materials and equipment in clean energy, including solar PVs, onshore and offshore wind cabling, and electric vehicles. The state also has modest deposits of silver and gold as well as prospects of rare earth elements.

Figure 2.9: New Mexico has abundant mineral resources, including many elements necessary for clean energy supply chains.[124]



Renewable energy technologies, battery storage, and EVs all demand high volumes of mineral resources. Given its available resources (Figure 2.9), New Mexico can position itself to be a leader in environmentally responsible mining, following prominent examples in Australia and Canada.

The Australian Centre for Sustainable Mining Practices says that “sustainable mining depends on excellence in mine safety and health as well as optimizing the extraction of the mineral resource, or resource efficiency” (Australia Unlimited 2013).[125] Practices include extensive environmental and safety regulations at each stage of the life cycle of a mine, ranging from exploration, construction, and operations, to closure.

The Mining Association of Canada launched the Towards Sustainable Mining initiative in 2004, creating a new industry standard for responsible business practices (Trade Commissioner Service 2021).[126] Trade commissioners help mining companies examine each stage of decision-making through ethical, environmental, social, security, and health and safety lenses. The initiative’s guidelines were developed in collaboration by a great diversity of stakeholders.

An effort in New Mexico to follow these leaders in environmentally responsible mining will require deploying low-impact mining techniques, rehabilitating and restoring mining sites, enforcing strict regulations on mining activities, protecting water supplies, and ensuring meaningful community input and participation. Recycling metals and improving the efficiency of material use will also be important strategies in mitigating the resource impact.

Table 2.8: Summary of Analysis for Mining

Dimension	Expected performance	How to improve
Economic efficiency	The state is among the top fifth of mineral-producing states in the country and registers high production volumes of copper, zeolite, perlite, potash, coal, and uranium. It has also developed local expertise in resource extraction and management, mining, and nuclear. However, the U.S. has much more stringent environmental regulation when compared to other countries.	The state should take steps to position itself to be a leader in environmentally responsible mining and resource management by leveraging its core competencies, marshalling its educational and private sector expertise, and exploring pathways for innovation.
High-quality jobs (BLS 2021)	Generally, mining and extraction industries have higher wages than the state average; however, minerals mining has a much smaller economic footprint than oil and gas extraction (all are typically reported together).	Remediation, especially for uranium mine sites, offers a potential growth industry and could translate to other demands for environmental cleanup and the state's broader strategy for environmentally responsible mining (Rohrer et al. 2020).[127]
Equity	Historically, the mining industry's environmental burdens have been unevenly shouldered by Native communities (Lewis et al. 2017). The patchwork of land ownership and cultural relationships to land are critical factors to consider.	Engage and involve Native communities and frontline groups; prioritize cleanup sites on tribal lands; develop an inclusive workforce strategy and remediation practices built on an environmental justice framework.
Technical and system integration complexity	New technologies, such as artificial intelligence and recycling practices and standards, will continue to develop in the mining sector.	Develop mining best practices that account for broader ecosystem and natural resource impacts.
Builds on existing resources and capabilities	State has ample resources of minerals but must deal with abandoned and unused mines, as well as legacy of the uranium industry.	Integrate state's mining strategy with the broader regional and national technology supply chain.
Public revenue generation	The mining sector (excluding oil and gas extraction) contributed over $2 billion to the state's GDP in 2019.	Coupled with remediation, potential role in economic diversification strategy.

This case study identifies several opportunities for mining. First, a feasibility study for environmentally responsible mining in the state could identify various target commodities and potential linkages to U.S. and international clean energy and manufacturing supply chains. Second, there may be an opportunity to couple any long-term mining development strategy with remediation of defunct mining sites on indigenous lands.

2.6 Conclusion

This chapter has used seven dimensions to examine options for reducing GHG emissions in New Mexico. It has highlighted opportunities for the state's economy and energy system in a low-carbon future. The case analysis points to several promising pathways. In particular, it suggests that pursuing a combination of renewable energy with natural gas—eventually with CCS—may be able to reduce the cost of a renewables-only strategy while supporting a transition to net zero emissions in the power sector by 2050. Not examined in depth here, but clearly also important, is the need to reduce fugitive methane emissions from oil and natural gas production and distribution. Clean hydrogen produced and used in hubs in the northwest and southwest corners of the state could help to facilitate deep decarbonization in industry and transport. Provisions to limit the cost of alternative transportation fuels and mileage-reduction policies on rural and indigenous communities will likewise be important. Finally, the state faces a substantial non-energy opportunities in a low carbon transition, including opportunities for innovation in agriculture, forestry, and mining. Evaluating each opportunity on multiple dimensions will allow policymakers to assemble a mix of cost-effective strategies for addressing climate change that simultaneously build broad support for a transition among the state's diverse industries, workers, and communities.

Chapter 3: Engaging the State's Workforce and Innovation Assets

- New Mexico's traditional energy sector—defined as fuels, electric power generation (EPG), and transmission, distribution, and storage (TDS)—comprises 5.3% of New Mexico's state employment; with a total of 44,100 workers. This is over twice the national average of 2.3%, demonstrating how New Mexico is uniquely exposed to dynamics of the energy transition; this does not include associated jobs, which employ 3.5–4 times more workers.
- Energy jobs in New Mexico are concentrated in a handful of counties, many of which owe their economic growth to activities in fossil and renewable energy, including construction, manufacturing, and professional services related to wind and solar expansion and oil and gas exploration and production.
- Substantial near-term employment opportunities exist in construction. Workers that have completed training and apprenticeship programs in the building and construction trades will be in high demand in a clean energy transition, and skilled worker shortages are likely to occur in the near term.
- There is a skill and wage mismatch between the jobs expected to be displaced (in coal mining and coal power generation near term and in oil and natural gas longer term) and those being created today in wind, solar, and energy efficiency. In these emerging fields, jobs available to those with no postsecondary education tend to pay less and offer fewer benefits.
- Clean energy job creation has, thus far, been concentrated in urban areas. Opportunities to expand these jobs in rural areas—for instance, in geothermal power, alternative fuel vehicle maintenance, methane remediation in oil and gas fields, biomass collection, and environmentally responsible mining—should be considered.
- Opportunities to continue operating fossil generation or generating hydrogen from natural gas with CCS could provide quality jobs for non–college educated workers and existing workers in oil and gas.
- In contrast to wind and solar, hydrogen development is expected to more directly engage the state's traditional energy workforce, given the overlap in skill sets related to natural gas production and conversion, pipeline maintenance, and thermal process engineering.
- New Mexico's existing knowledge and innovation institutions will be crucial in developing the talent pipeline, training and education programs, and business sector support for the state's clean energy transition. Public-private partnerships and collaboration involving businesses, academia, and government can work to bolster the state's entrepreneurial capacity and engage diverse stakeholder groups in the state around specific thematic areas, opportunities, and challenges of the energy transition.

A clean energy transition at scale will require the diverse strengths of New Mexico's workforce. The challenge will be to go beyond conventional (re)training to support the most direct, reliable, and time-efficient preparation for existing workers, to ensure that they can continue to advance their careers and enjoy an improved quality of life as transition progresses. This chapter provides background on New Mexico's workforce, discusses jobs and skills needs that the opportunities discussed in Chapter 2 are expected to generate, and examines innovative ways that the state could prepare workers to navigate the transition and succeed.

3.1 New Mexico's Economy: Historical Context

Over the past century, New Mexico's economy has evolved from relying on its natural resource wealth to becoming more diversified and regionally differentiated. In the first half of the last century, agriculture was New Mexico's dominant industry, as new migrants established themselves as farmers and ranchers. That began to change during the Great Depression, as an influx of New Deal funding created thousands of new federal jobs. Since the 1940s, military training and weapons research have become key to the state's economic development. Jobs supported by federal funds expanded during World War II when Los Alamos National Laboratory was established, followed by the opening of Sandia National Laboratories in 1948. From 1940 to 1950, nonagricultural employment in the state almost doubled, from 83,800 jobs to 151,000. The 1950s saw expanded oil and gas development following the construction of a pipeline from the San Juan Basin to California, sparking a boom that generated substantial severance tax revenues for the state. In the years that followed, the agricultural town of Farmington developed from a few thousand people to a boomtown of almost 20,000 people, as it began to establish itself as one of the state's major fossil fuel production hubs.

Diversification followed. During the 1970s, manufacturing increased by 60.8% and began to play a larger role in the state's economy (Giannettino 1999).[128] Subsequently, in the 1980s, tourism and travel boomed. In that decade, high-tech jobs also arrived in large numbers with Intel's manufacturing facility—the largest chip-manufacturing plant in the world—opening in Rio Rancho (J. & Ryan 2008).[129] At the turn of the millennium, volatility in global oil prices continued to affect New Mexico's employment.

New Mexico, like many other states, saw its manufacturing sector decline in the latest wave of globalization. Since 2000, manufacturing has lost some 15,000 jobs. The education and retail sectors also experienced job losses during this time. The industries with the highest job growth in this period have been healthcare, hospitality, professional services, and the extractive industries. Today, the state's largest industries by absolute employment numbers are healthcare, hospitality, and retail (see Figure 3.1).

New Mexico stands out nationwide in terms of the role that public administration plays in the state's employment. Across all sectors, the federal government is the single largest employer in New Mexico, with federal agencies employing some 30,000 individuals, while national labs in the state provide 18,500 more federally funded jobs. Government jobs in New Mexico make up 18.4% of all jobs, compared to a national average of 12.2%. The University of New Mexico's Bureau of Business and Economic Research estimates that, including all indirect jobs supported by federal funds, federal spending supports 38% of New Mexico's total employment. According to the U.S. Census Bureau, in 2010, federal spending amounted to $13,500 per resident, over $3,000 more than the national average (Think New Mexico 2013).[130]

Figure 3.1: Employment and share of total in New Mexico (2018).

Industry Composition
(Employment and Share of Total)
2018

All Industries	New Mexico 822,351		Metro 559,693		Non-Metro 262,658	
Health Care & Social Asst.	140,970	17.1%	101,116	18.1%	39,854	15.2%
Accommodation & Food Svcs	94,132	11.4%	65,212	11.7%	28,920	11.0%
Retail Trade	92,185	11.2%	63,706	11.4%	28,479	10.8%
Educational Services	74,320	9.0%	49,837	8.9%	24,483	9.3%
Public Administration	60,271	7.3%	41,845	7.5%	18,426	7.0%
Professional & Tech. Svcs	58,292	7.1%	39,142	7.0%	19,150	7.3%
Construction	50,845	6.2%	34,975	6.2%	15,870	6.0%
Admin. Support & Waste Mgmt	45,918	5.6%	33,449	6.0%	12,469	4.7%
Manufacturing	27,152	3.3%	20,498	3.7%	6,654	2.5%
Mining & Oil & Gas Extraction	24,598	3.0%	5,160	0.9%	19,438	7.4%
Transp. & Warehousing	24,340	3.0%	15,810	2.8%	8,530	3.2%
Finance & Insurance	22,828	2.8%	16,594	3.0%	6,234	2.4%
Other Services	21,469	2.6%	15,270	2.7%	6,199	2.4%
Wholesale Trade	21,051	2.6%	15,253	2.7%	5,798	2.2%
Arts, Entert. & Recreation	17,063	2.1%	12,505	2.2%	4,558	1.7%
Information	13,064	1.6%	9,413	1.7%	3,651	1.4%
Agriculture	11,583	1.4%	4,652	0.8%	6,931	2.6%
Real Estate	10,404	1.3%	7,525	1.3%	2,879	1.1%
Utilities	6,219	0.8%	3,485	0.6%	2,734	1.0%
Mgmt of Companies	5,644	0.7%	4,248	0.8%	1,396	0.5%

Source: McCamley 2020[131]

3.2 Energy Sector Employment

As described briefly in Chapter 1, the traditional energy sector—defined as fuels, electric power generation (EPG), and transmission, distribution and storage (TDS)—makes up 5.3% of New Mexico's state employment; with a total of 44,100 workers, this is over twice the national average of 2.3%. Fuels—which includes mainly coal, oil, and natural gas and to a lesser extent corn ethanol, biomass, and "other fuels"—employs almost half of the traditional energy workforce (25,100 workers). This is followed by TDS and EPG, which have 13,660 and 5,320 employees, respectively. A significant portion of these clean energy jobs are in the construction industry; these jobs are reported to have a higher average annual wage than do other occupations.

As shown in Table 3.1, energy jobs are concentrated in only a handful of counties. In these counties, energy—specifically construction, manufacturing, and professional services related to wind and solar expansion and oil and gas exploration and production—has been a major source of employment growth over the past decade. The expansion of oil and natural gas production in particular has been an important driver. In 2017, over 50% of energy-related employers in New Mexico hired new employees. Before COVID-19, New Mexico projected future growth higher than the national average, with 6% per year growth anticipated in the traditional energy sectors. Pre-COVID projected future growth by employment category is shown in Table 3.1 and ranges between 2.0% for motor vehicles to 9.1% for electric power generation.

Interviews conducted for this case study suggested that substantial near-term employment opportunities exist in construction. Construction jobs will include building out solar arrays and wind farms, as well as building energy-efficiency retrofits. It was difficult to find data that disaggregated construction jobs from manufacturing, operations and maintenance (O&M), and services jobs by sector.

However, this distinction is critical: many construction trades require a common set of skills, which will make the transition for much of the state's existing construction workforce relatively straightforward. Workers that have completed training and apprenticeship programs in the building and construction trades will be in high demand in a clean energy transition, and skilled worker shortages likely to occur in the near term—although these jobs will depend on the timing and duration of construction demand.

Table 3.1: Energy Employment in New Mexico

Industry	Fuels	Electric Power Generation	Transmission, Distribution & Storage	Energy Efficiency	Motor Vehicles
Total Jobs by Sector	25,123	5,321	13,668	6,099	7,882
Top Three Highest-Employment Counties	Lea Eddy San Juan	Bernalillo Santa Fe McKinley	Bernalillo San Juan Lea	Bernalillo Doña Ana Santa Fe	Bernalillo San Juan Doña Ana
Projected Annual Growth	6.9%	9.1%	3.3%	8.5%	2.0%
Relative Hiring Difficulty	37.5% Very difficult	25% Very difficult	60% Somewhat difficult	66.7% Somewhat difficult	66.7% Difficult

Source: USEER County Data 2017[132]

3.2.1 Fuels Jobs

Fuels represent the largest share of jobs in New Mexico's energy sector, made up of 25,123 workers (New Mexico: Energy and Employment 2020).[133] In terms of fuel source, petroleum employs 15,000 workers and natural gas employs 8,500 workers. Coal mining employs 1,121 workers. In fuels, the majority of workers are involved in mining and extraction (87%). Employment in fuels is highest in San Juan, Lea, and Eddy Counties.

Transition-related job losses in the fuels sector are expected to disproportionately affect minority and rural populations. In San Juan County, 39.6% of residents belong to indigenous groups. San Juan county is also where a large share of the state's Navajo population resides and is home to the San Juan Generating Station (SJGS) and the coal mines that serve it. If the plant's remaining two units close in 2022, an estimated 450 workers will be displaced, many of them of indigenous and minority heritage (Reese 2020).[134]

The U.S. median hourly wage for mining and extraction for energy workers is $36.32, which is 90% above the overall national median wage (USEER: Wages, Benefits, and Change, 2021).[135] This is significantly higher than the median hourly wage for San Juan County of $22.59 (Vance-Sherman 2020).[136] In addition to paying well, these jobs also come with health and other benefits.

3.2.2 Electric Power Generation (EPG) Jobs

Solar accounts for most of the EPG employment in New Mexico, with 3,370 workers. This is more than twice the number of workers involved in wind energy technologies in the state. Manufacturing and construction employ the most people in the EPG sector, with 28% and 25.8% of the workforce, respectively. Both categories of jobs depend on continued growth in solar power. The highest EPG employment is concentrated in Bernalillo, Santa Fe, and McKinley Counties. Like San Juan County, McKinley County has a large indigenous population, with a reported 76.7% identifying with a tribal nation.

EPG manufacturing jobs differ in skill requirements from the fuels sector, which is primarily mining and extraction. These differences will make it difficult for displaced workers in mining and extraction to shift to clean energy manufacturing or construction jobs (USEER: Wages, Benefits, and Change 2021).[137]

Workers in the electric generating sector often have more skill transferability than those in the fuels sector, and those in mining and extraction may require more training and resources in the future to prepare for jobs in a clean energy economy (Foster et al. 2020).[138] Renewable energy workers' median incomes are still higher than the national median (USEER: Wages, Benefits, and Change 2021).[139]

As noted, fossil fuel workers are concentrated in rural areas. This has generated concern that these workers will not have access to clean energy opportunities and that positions will go instead to Santa Fe and Albuquerque residents (University of New Mexico 2020).[140] Building trades unions have discovered that finding workers to install and maintain clean energy technologies in rural areas is difficult (Foster et al. 2020).[141] However, interviews also suggested that this may represent an opportunity for rural residents to work close to home, if they are able to receive appropriate training.

3.2.3 Transmission, Distribution, and Storage (TDS) Jobs

TDS employs 13,660 workers in New Mexico, with 44% of these jobs in construction (US Energy and Employment Report 2020).[142] Traditional transmission and distribution contribute over 9,600 jobs, with microgrids accounting for an additional 4,000 TDS jobs in the state. According to USEER's Wage Report, traditional TDS workers earn $34.24 per hour, which is 68% higher than the national average median wage. Jobs in the sector have increased by 10% in the past two years. TDS jobs are concentrated in Bernalillo County and, to a lesser extent, Lea and San Juan counties, where they are associated with fossil fuel mining and extraction. Bernalillo County employs nearly one-third of all microgrid workers. Other high-employment areas include the counties of Lea and San Juan, where, as noted, jobs are concentrated in fossil fuel mining and extraction.

3.2.4 Energy Efficiency (EE) Jobs

Energy efficiency jobs are rapidly growing and are estimated to employ 6,099 workers in New Mexico with a concentration in Bernalillo, Doña Ana, and Santa Fe Counties. In 2019, employment jumped over 4.8% and is expected to increase an additional 3% in 2020. These jobs pay a wage premium up to 25% above national wages (USEER: Wages, Benefits, and Change 2021).[143] Jobs are concentrated in building energy efficiency (e.g., lighting and HVAC systems), industrial energy efficiency, and demand response; these are mainly energy-efficiency engineers and energy auditors.

However, much of the job growth in EE activities is currently concentrated in urban areas and is very limited in rural areas (USEER County Data 2017).[144] Also, many Pueblo and reservation residents continue to live in traditional structures that are not optimized to conserve power or heat. Several tribes' strategic energy plans, such as the Acoma Pueblo's, have recognized that there is substantial room for energy efficiency improvements. Community-led efficiency programs have been established in a range of small and rural communities, such as the "Hui Up!" initiative in Molokai, Hawai'i, enabling program participants to upgrade to more efficient refrigerators, light bulbs, and other appliances (Hawai'i Energy 2017).[145] Replication of these programs may be of interest in New Mexico.

3.2.5 Motor Vehicles Jobs

The motor vehicles sector, which employs nearly 7,900 workers, includes the production and assembly of cars, light-duty and heavy-duty trucks, and trailers, as well as the manufacturing of component parts. Repair and maintenance constitute the largest sub-segment in New Mexico, according to the latest U.S. Energy and Employment Report (USEER 2020).[146] Employment growth in the sector is slower compared to other energy-related industries: job growth for 2020 reached just 0.8%. Employers in New Mexico also reported the most significant hiring difficulty in motor vehicles when compared to other energy sectors like EPG, fuels, and energy efficiency. Moving forward, the greater deployment of electric vehicles and the potential for hydrogen fuel may present employment opportunities for the state. For example, the buildout of EV infrastructure, particularly in rural areas, and the need to service a growing hybrid and EV fleet present opportunities in the near term. However, as explored in the next section, the state's significant repair and maintenance labor force is at risk as EVs displace traditional ICE vehicles.

3.3 Energy Employment Opportunities in New Mexico's Transition

Chapter 2 examined technology pathways for the state in a low-carbon transition. This section considers in detail what these pathways could mean for employment in the state. It also flags inequities that may arise in a transition if not explicitly recognized and addressed in the design of transition assistance and training programs.

The analysis draws on the latest available estimates of wages and expected net job creation for each of the pathways, summarized in Table 3.2. Many of these estimates are uncertain and drawn from a variety of sources. Nevertheless, they provide a basic framework to construct a skills crosswalk between existing energy employment and opportunities created by the pathways introduced in the previous chapter.

Several observations can be made. First, there is a skill and wage mismatch between the jobs expected to be displaced (in coal mining and coal power generation near term and in oil and natural gas longer term) and those being created today in wind, solar, and energy efficiency. In these emerging fields, jobs available to those with no postsecondary education tend to pay less and offer fewer benefits. Construction may be one area where these discrepancies are smaller. Second, clean energy job creation has, to date, been concentrated in urban areas. Opportunities to expand these jobs in rural areas—for instance, in geothermal power, alternative fuel vehicle maintenance, methane remediation in oil and gas fields, biomass collection, and environmentally responsible mining—should be considered. Third, finding ways to continue operating fossil generation or generating hydrogen from natural gas with CCS could provide quality jobs for non–college educated workers.

The following sections discuss the expected employment opportunities created by each pathway in more detail and opportunities within each to engage workers dislocated by a transition. The time scale on which these opportunities are expected to materialize, and implications for the design of training programs, is also discussed.

3.3.1 Electric Power

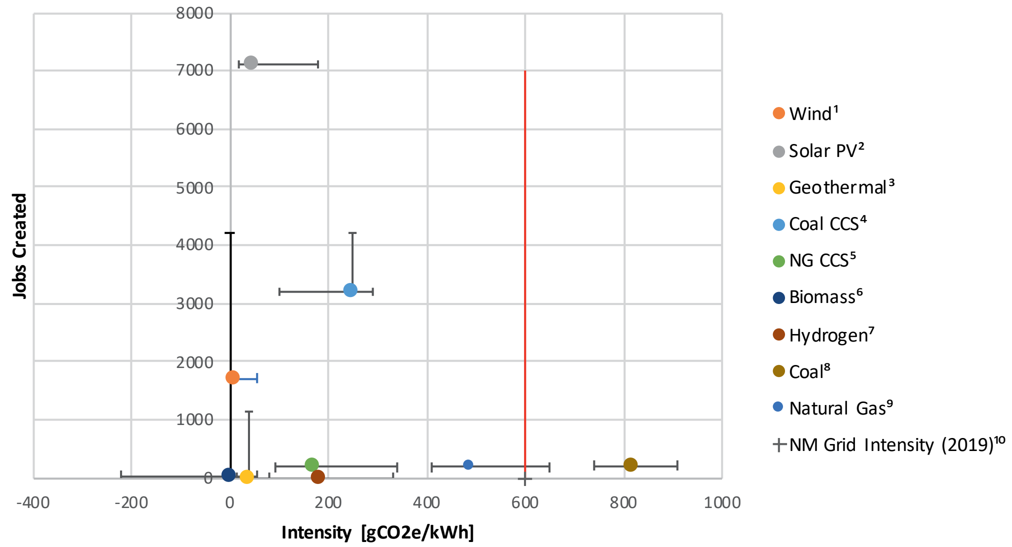
Electric power is likely to be the first sector to decarbonize, given that CO_2 reductions can be achieved with a broad range of generation technologies that are projected to be more cost-effective relative to other sectors. Coal plant closures are already affecting workers employed in coal fields and generating stations, such as SJGS. At the same time, EPG jobs are growing rapidly (9.1% annually), largely due to the expansion of wind and, more recently, solar PV in the state. Renewable energy expansion in rural areas is also necessitating transmission buildout. Many of these jobs are in construction and system maintenance.

Looking ahead, renewable energy for electricity generation represents the greatest near-term job growth prospects. This job creation is already happening. Figure 3.2 shows the relationship between the decarbonization potential of various electricity generation types and expected job creation, based on available studies. Wind and especially solar are clearly attractive, with no CO_2 emissions during operation and a relatively high potential to add jobs, especially if construction jobs are included.

Table 3.2: Job Opportunities for New Mexicans in a low-Carbon Transition

Pathway	Wages (annual mean)	Training	Time frame	# jobs created
Wind	$73.6 k	Postsecondary or apprenticeship	Happening now	1,710 (to meet ETA goals)
Solar	$36.2 k (no training); $97.7 k (BS)	Either no training or additional degree or BS	Happening now	7,120 (to meet ETA goals)
Geothermal	$37.7 k (>1 yr training); $54 k (5+ yr training)	1–5+ year on-job training	Highly dependent, but mid to long term	0–1,100 (low confidence)
Coal with CCS	$55–60 k	High school diploma plus certified apprenticeship	<5 years in construction	100–150 k
NG with CCS	$50–60 k	High school diploma plus certified apprenticeship	<5 years in construction	CCS could create new jobs in hydrogen and DAC
Biomass: agriculture (biochar)	Varies, needs further study	Varies	Medium term (>15 yrs)	Needs further study 0–4,212 (low confidence)
Biomass: forestry	$35–45 k	On the job	Immediate	Too early to say
EV	$70 k+ (mechanical technicians)	Apprenticeships and graduate education	Immediate to long term	3,250–6,250 potential job gain
Biomass: anaerobic digesters (biofuel)	$92.6 k	>12 months on-job training	Highly dependent, mid to long term	0–3,838
Mining	$65 k–120 k (mining machine operators, mining/geo-engineers)	Varies	Medium term (>15 yrs)	Needs further study

Figure 3.2 Relationship between job creation potential and GHG intensity of low-carbon pathways in electric power.



[1]Intensity (IPCC, 2014); Job creation for 1831 MW added capacity (New Mexico Clean Energy Workforce Development Study 2020). [2]Intensity (IPCC, 2014); Job creation for 1997 MW added capacity (New Mexico Clean Energy Workforce Development Study 2020). [3]Intensity (IPCC, 2014); Job creation projects for industrial manager and installation, maintenance, and repair worker for NM (ONet 2021). [4]Intensity (IPCC 2014; DOE 2020); Job creation for SJGS remaining in operation (DOE 2020). [5]Intensity (IPCC, 2014); Job creation assuming no jobs added/lost from current natural gas electricity generation (USEER 2020). [6]Intensity for 10MW feasibility study in NM for biochar, with biofuel and forestry within bounds (EMNRD 2018); Job creation using 36 jobs/10 MW from EMNRD and assuming 35.3 trillion btu/yr potential bio-resources in NM (EMRD, n.d.) for biochar, with biofuel and forestry estimates within bounds. [7]Intensity using blue hydrogen as median, green as minimum error and grey as maximum error (Hydrogen Council, 2021); No NM-specific job estimations. [8]Intensity (IPCC 2014); Jobs preserved (USEER, 2020). [9]Intensity (IPCC 2014); Jobs preserved (USEER 2020). [10]Intensity (EPA 2019).

3.3.1.1 Renewable Energy Jobs

Installation, maintenance, and construction jobs associated with solar do not require any prior work experience and can be done with a high school diploma or equivalent degree plus a certified apprenticeship. Solar energy–related jobs, which include manufacturing and servicing, often require up to one year of on-the-job training, where higher pay and positions can then be acquired through certifications. For people with a high school diploma or equivalent, these jobs pay $30–40,000.[147] For solar jobs requiring bachelor's degrees, pay ranges from $70–120,000, with highs of $200,000 and lows of $45,000 (CareerOneStop, n.d.)[148] or $70,000 (CareerOneStop, n.d.).[149] Wind energy–related jobs, however, tend to require a postsecondary nondegree award and/or a multiyear apprenticeship program (BLS, n.d.).[150] In New Mexico, someone with the right qualifications may expect to make roughly $60,000 per year (CareerOneStop, n.d.).[151] With a bachelor's degree, pay can increase to $98,000, with possibilities of pay at $146,000 (MyNextMove, n.d.).[152] Geothermal jobs, like solar, generally do not require additional education beyond high school, but can require prior work experience or on-the-job training. Without additional education, salaries average around $37,000 annually (CareerOneStop, n.d.),[153] and with several years of experience, average salaries increase to $54,000 (CareerOneStop, n.d.)[154] in New Mexico.

All of these jobs are physically demanding for workers and require a high level of hand-eye coordination, dexterity, depth perception, near-perfect vision and problem-solving capabilities. Many of these jobs are performed outside, where weather conditions can inhibit work, and unexpected issues can demand weekend and night hours. In addition, renewable energy jobs require a firm grasp of the English language for both oral and written modes of communication, placing some members of the state's Hispanic population and others that lack access to strong formal English-language training at a disadvantage.

For most solar, wind, and geothermal jobs, healthcare and retirement are provided at either full or partial coverage and firm contributions (USEER: Wages, Benefits, and Change, 2021).[155] As community solar continues to be supported and advanced in state legislation, more small-scale solar projects will be built, offering high economic benefits to communities and creating jobs, although largely in urban and suburban areas (Solis et al. 2021).[156]

Solar and wind projects would generate and require numerous construction jobs; a large push to build out capacity could quickly expand employment opportunities in the state. These jobs are likely to draw workers from non-energy as well as energy-related employment. Scaling up too rapidly could lead to a shortage of qualified in-state workers. In contrast, the knowledge and practice of mining and drilling could map well from fossil fuel production to geothermal energy development, hydrogen, pipeline buildout, and CCS.

For New Mexico to reach its ETA goals, an estimated 8,830 jobs would be created through wind and solar expansion (NM Clean Energy Workforce Development Report 2020).[157] With the rise of community solar, an estimated 12.1 jobs could be created directly, indirectly and induced through the development of a 2-MW system and 37.6 jobs created for a 5-MW system (Solis et al. 2021).[158] Projections of a 4% yearly increase in geothermal energy would lead to 8,000 new jobs by 2035 in the U.S. (National Research Council 2013).[159] Because geothermal resources are limited to a few locations, New Mexico would see some job growth. However, job growth must continue on all educational levels to support the growing industries.

The construction of new transmission lines may further add jobs in the state. The New Mexico Renewable Energy Transmission Authority (RETA) estimates that 3,700 construction jobs, and 600 to 800 permanent jobs, would be created by 2032 for the construction of 900–1,300 miles of high-voltage transmission lines. These grid expansion measures would add 11,500 MW of renewable capacity, allowing New Mexico to meet ETA goals but still leaving hundreds of GW of renewable energy available to New Mexico for future expansion and renewable energy exportation to other western states (ICF 2020).[160]

Apprenticeships and community colleges make up the existing training institutions for clean energy workers (see Figure 3.2). In 2019, there were over 2,400 active apprentices in New Mexico in 81 recognized apprenticeship programs. In the past year, 18 additional apprenticeship programs were added (DOL 2019).[161] While there is still a need for more training centers, New Mexico holds two recognized training centers in clean energy. Mesalands Community College is recognized for its wind turbine technician training, and Santa Fe Community College is known to be one of a handful of microgrid and smart grid training programs.[162] In terms of general energy-based training, there are 10 recognized institutions in the state. These two-year institutions, in addition to San Juan College, which is highly recognized for preparing fossil fuel workers in the region, provide a foundation to build out its workforce skilling network. The New Mexico Energy Manufacturing Consortium noted that a lack of information about clean energy jobs and lack of worker baseline skills are additional hurdles to attracting more workers to clean energy.[163]

3.3.1.2 Electricity Generation with CCS

Installing or retrofitting fossil generation with CCS could impact traditional EPG employment in two ways. First, it could preserve high-quality jobs by delaying or avoiding the closure of existing generators. This may be especially true for natural gas generation, which is cleaner than coal generation. Second, starting early to train this workforce in the development, demonstration, and operation of CCS could ensure traditional EPG jobs survive the deadlines of carbon neutrality policies. Today, members of the EPG workforce without postsecondary education receive family-sustaining wages (BLS 2020).[164] CCS technology will require time and resources to develop. Signaling early plans to continue operating natural gas generation as a balancing resource for wind and solar and to retrofit capacity with CCS in the coming decades would provide greater certainty for both EPG and fuels (natural gas production) workers.

Beyond preserving jobs in EPG, both the plant retrofit process and the necessary upgrades for existing pipelines (for transport of CO_2) would create jobs, mostly in construction, though such jobs might be temporary and fulfilled by non-residents, depending on specific contracts signed by plant owners. Training for coal and gas workers today is normally conducted through industry, through apprenticeship models, employers, or unions.[165]

The value chain for BECCS might look somewhat different. Jobs in collection, removal, and processing of deadwood would certainly be required for this pathway, and they would not require higher educational degrees, but forestry jobs in general do not offer high wages (BLS 2020),[166] although they are highly labor-intensive. One draw for workers might be security and benefits, if the federal government is the employer; another might be a match with the skill sets and interests of rural communities, as deadwood removal is "hands work" compatible with seasonal work in agriculture and land management and would reduce forest fire risk.

3.3.2 Hydrogen

Hydrogen-related jobs are expected to span a wide range of occupations and educational backgrounds and skill levels, from fuel cell engineers to hydrogen system installers and technicians. Many of these jobs do not yet exist but are feasible targets for workforce development, as they require building up the necessary skilling and training infrastructure.

In contrast to wind and solar, hydrogen development is expected to more directly engage the state's traditional energy workforce, given the overlap in skill sets related to natural gas production and conversion, pipeline maintenance, and thermal process engineering. The state is home to over 9,400 workers in oil and gas extraction, 1,700 chemical manufacturing workers, and over 600 workers in pipeline transportation, according to the latest estimates from the Bureau of Economic Analysis (BEA 2019).[167] Moreover, many of these jobs pay well: in New Mexico, oil and gas service unit operators have an average annual wage of nearly $64,000 (higher than the $49,650 average across all occupations). Many of these jobs are at risk as the state transitions away from coal, natural gas, and oil, but the skills and experience of many in these industries may be well-suited to the demands of the hydrogen sector.

Much of this, of course, depends on the extent to which hydrogen production and application is localized in the state and the success of attracting hydrogen firms.

New Mexico may be able to leverage its numerous national labs, knowledge institutions, and union training programs, combined with its fossil fuel clusters in regions like the Permian Basin, to develop a training and workforce development pipeline for the emerging hydrogen economy.

3.3.3 Transportation

The greater deployment of electric vehicles presents challenges and opportunities from the workforce perspective. Existing infrastructure currently supports over 14,500 jobs in motor vehicles and parts dealerships and 7,900 employed in gas stations; trucking employs an additional 13,200 New Mexicans (BEA 2019).[168] As noted by the Congressional Research Service, greater EV deployment may displace traditional autoworkers, especially in assembly and parts manufacturing (Canis 2019).[169] Electric vehicles have fewer moving parts and require less maintenance and repair services than ICE vehicles. Targeted workforce development policies, including retraining and reskilling, may be needed to mitigate the disruptive effects of electrification in New Mexico's auto sector.

Nevertheless, as the state pursues policies to expand EV ownership and reduce VMT, New Mexico's transportation workforce has the opportunity to move into the demands of an electrified transportation supply chain. Chemicals, battery production, software engineering, and utilities are some of the industries that are expected to benefit from expanded EVs. Construction and maintenance of EV infrastructure will also generate employment demands in the near and long term. Creative policies are already being proposed: the New Mexico Clean Energy Workforce Development Study highlighted the potential to place charging stations near tribal hotels and gaming operations to spur economic development in key indigenous community sites (New Mexico Department of Workforce Solutions 2020).[170] In the long term, existing gas stations may be repurposed as hydrogen fueling stations.

3.3.4 Jobs in Clean Energy Supply Chains and Entrepreneurship

The supply chain and innovation economy opportunities described in Chapter 2 may offer a range of opportunities for workers. Connecting efforts to create jobs in these areas with a comprehensive vision for the state's energy and economic future could help to build momentum for the transition and support the state's broader agenda of economic diversification.

3.3.4.1 Agriculture

The introduction of both anaerobic digesters (AD) and biochar could expand employment in the state's agricultural sector. If AD was fully implemented in New Mexico, the USDA, EPA and DOE predict 3,599 construction jobs and 239 permanent jobs created from 144 biogas systems (American Biogas Council State Profile, n.d.).[171] These job counts do not include biofuel distribution jobs. If biofuels were used to decarbonize the transportation sector rather than, or in tandem, with EVs, current service and maintenance jobs counts could be maintained. Also, biochar could be implemented in tandem with biogas production, as they require similar inputs. Similarly, like AD, biochar can also be used to produce electricity and heat (Ussery 2019)[172] or as fertilizers for nutrient and moisture retention. More research needs to be done to fully optimize biochar usage in semi-arid climates in agricultural practices (Idowu et al. 2018).[173] But as a heat source, coupled with a microgrid, it is already being utilized in El Rito to offset costly propane heating (Ussery 2019).[174]

Many agricultural jobs and biofuels-related positions only require a high school diploma or equivalent. An agricultural worker can expect an annual salary of around $28,000 (BLS 2021),[175] with managerial potential increasing pay to $68,000 (BLS 2021).[176] Biofuels and waste management opportunities require on-job training or licensing and have a salary range of $49–90,000 (BLS 2021; ONet 2021),[177, 178] with biomass plant technicians making a higher salary on average (ONet 2021).[179] The addition of a bachelor's degree in biofuel-related fields can increase pay averages to $109–112,000 yearly (ONet 2021).[180, 181] The expansion of AD to the agriculture sector will increase job opportunities by creating a new job market that pays, on average, higher wages than typical agricultural jobs with moderate or no change in educational status.

3.3.4.2 Reforestation

As noted in Chapter 2, New Mexico's forests have been decimated by drought and insect infestations. The process of reforestation in New Mexico has been studied in depth by the John T. Harrington Forestry Research Center and is detailed in the state's 2020 Forest Action Plan (EMNRD 2020).[182] Processes including seed collection and planting should not require extensive training but may be high labor and low wage. If forestry jobs are filled with a Forestry Corps or Climate Corps funded by the federal government, this effort could become widespread and multistate. Federal jobs may give workers additional benefits to compensate for lower wages.

3.3.4.3 Mining

The Biden administration's commitment to securing the domestic supply chain in critical minerals and rare earth metals is a potential opportunity to expand related employment in New Mexico, where the mining and mining support industries employ over 23,000 workers (BEA 2019).[183] Previously untapped deposits of rare earth metals in New Mexico are actively being researched for future development and exploration (McLemore 2018).[184] However, concerns related to water use and land management, as well as mining's checkered legacy in indigenous communities, present challenges to the sector.

Practicing and ensuring environmentally responsible mining will require strict oversight and enforcement, close coordination across the relevant state, tribal, and federal agencies, and iterative and participatory processes for public input. A potential pathway is to more closely link mining and remediation/reclamation workforce development efforts and training in order to develop local expertise in, for example, green remediation (EPA 2012).[185] The legacy of uranium mining, including 1,100 abandoned mining and drilling sites that have disproportionately burdened indigenous communities in northwest New Mexico, demonstrates the need to better align mining and environmental cleanup activities in the state (Rohrer et al. 2020).[186] This case study recommends involving the state's technical colleges, universities, and national labs in specialized training and safety certification for environmentally responsible mining.

3.4 New Mexico's Innovation Assets

New Mexico has a wide range of innovation assets: three major research universities (New Mexico State University [NMSU], NM Tech, and the University of New Mexico [UNM]), three national laboratories (the Air Force Research Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory), a variety of two- and four-year degree and apprenticeship programs, a growing presence of leading technology corporations, and programs to incubate new businesses in diverse settings across the state.

3.4.1 Fostering Innovative Industries

To encourage businesses to relocate to New Mexico, the state offers tax breaks, research facilities, a job training incentive program, and funding to attract new enterprises. The state offers low effective tax rates for manufacturers, a high-pay jobs tax credit, and a rural tax credit. The high-pay jobs tax credit helps workers and companies by granting employers an 8.5% tax credit for each high-wage economic base job. The tax credit is adjusted for rural and urban areas to reflect pay differences. The rural tax credit includes the rural jobs credit.

Aside from tax breaks, New Mexico's accessible infrastructure and workforce training initiatives attract rising tech businesses. The state has 20 federal, state, and privately financed laboratories, a science and technology park, railroad connections, and the first FAA-certified unmanned aircraft system test center. A six-month salary reimbursement program for newly generated employment in expanding or moving firms funds classroom and on-the-job training.

Due in part to these advantages, New Mexico's tech footprint is growing. As these activities have low carbon intensity, they are poised to grow in a clean energy transition, offering an additional source of job growth. Intel, Facebook, and Boeing, all prominent technology innovators, have operations in New Mexico. The state is luring major corporations to develop or move. Netflix, for example, is investing $1 billion in New Mexico to develop its present studio into one of the most high-tech film facilities. The Netflix facility alone is projected to create 1,500 construction employment and 1,000 production opportunities in the next decade (Rodriguez 2020).[187] Facebook recently announced that they are investing over $1 billion in a new 2.8-million-square-foot data center that will be powered by 100% renewable energy. The Los Lunas Data Center is estimated to employ 1,100 construction jobs at its peak and support community activities such as the public library, Rural Education Advancement Program, and public schools (KRQE Staff 202).[188]

New Mexico is also developing a strong presence in the commercial space industry. Southern New Mexico serves as home for several U.S. commercial space flight and rocket launch programs, with Spaceport America being the world's first purpose-built spaceport. The spaceport began construction in August 2009, close to three air force bases and near Truth or Consequences. Leading commercial flight companies, including Virgin Galactic, UP Aerospace and Armadillo Aerospace, have conducted several launches since 2006. On July 11, 2021, Virgin Galactic made a maiden voyage to space on the VSS *Unity* with founder Richard Branson, the first billionaire to travel to space.

Access to four military bases and unrestricted airspace is attractive to the commercial space and aerospace industries, bringing research and operations to the state. In November 2020, the Albuquerque Planning Commission approved a site plan for Group Orion, an aerospace company that aims to model Earth with satellites (Albuquerque Planning Department 2020).[189] The projected campus would include a two-million-square-foot manufacturing center, laboratory space, and supporting operations like food and hotel developments. It is estimated that it will create up to 2,500 jobs and be worth $3 trillion by 2045.

3.4.2 Leveraging National Laboratories

New Mexico's national laboratories have a central role to play in numerous aspects of the clean energy transition, from supporting the development of the opportunities outlined in Chapter 2, to sparking the innovative entrepreneurial growth described in this chapter, to informing the next wave of policy initiatives, technical standards, and supporting institutions to decarbonize sectors outside electric power, as discussed in Chapter 4. The work of Los Alamos National Laboratory is organized in six pillars: materials for the future, nuclear and particle futures, science of signatures, complex natural and engineered systems, weapons systems and information, science, and technology. In energy research, the laboratory is advancing research in grid manufacturing, biofuels, extreme-environment materials, fuel cell technology, and subsurface energy. In addition to its highly technical work, Los Alamos held over 7,000 projects with small businesses, created 11,267 jobs, and attracted millions in financing, supporting the local community over the past 20 years. Environmentally friendly materials, fuel cell technology and subsurface energy are among the lab's energy research priorities.

Sandia National Laboratory conducts research mainly in two categories: nuclear related and non-weapons related. Nuclear-related work is aimed at maintaining the reliability and safety of nuclear weapon systems, R&D in arms control, nonproliferation (nuclear disarmament) technologies, and solutions for hazardous waste. Non-weapons-related projects are advancing the bounds of computational biology, math, materials science, and alternative energy and going into new areas such as psychology and cognitive science. There are three Sandia-operated facilities in Albuquerque, Livermore, and Hawaii. The most notable laboratory assets include ASCI Thor's Hammer, one the world's fastest supercomputers, and the Z machine, the most powerful and efficient lab radiation source in the world, designed to test materials in extreme conditions. Sandia also has substantial research in areas that can support the clean energy transition.

The Air Force Research Laboratory (AFRL) also conducts work in several areas relevant for the clean energy transition. The Information Directorate specializes in control, intelligence, and communication technologies (Air Force Research Laboratory, n.d.).[190] Advanced manufacturing technologies research and AFRL's technology transfer office, which promotes technology and knowledge transfer, will be critical in the adoption of newer renewable energy systems; many microgrids depend on fiber-optic communications to better relay energy data to transmission facilities for improved analytics (Air Force Research Laboratory, n.d. and 2004).[191, 192] It should be noted that the state's army bases are another component of the state's knowledge infrastructure that may be able to serve as a test bed for technologies that may play an enabling role for clean energy, such as battery storage.

3.4.3 Universities as Catalysts

In addition to advancing research on clean energy technology and policy, the state's universities are helping to catalyze the energy transition by preparing students to join the clean energy workforce, participating in technology demonstrations, and supporting entrepreneurial activity. **New Mexico State University**'s I-CREW program (short for the Innovation and Commercialization for Regional Energy Workforce program) aims to strengthen job training in the energy sector across the state (Acosta, 2020).[193] The initiative is funded through the U.S. Economic Development Assistance program and done in partnership with the North American Intelligent Manufacturing Initiative (NAIMI). Currently, NAIMI and NMSU are working on developing a clean energy roadmap by 2022 that will be done in three parts (NAIMI, n.d.).[194] The first part will include a needs assessment on current economic, technical, and workforce issues. The second will create twelve groups across New Mexico to gain insight on how to establish a clean energy future. And third, the roadmap will gather all feedback and develop a set of recommendations for the future energy transition.

NMSU's Arrowhead Center encompasses many innovation- and entrepreneurship-related activities. For instance, the American Indian Business Enterprise Center (AIBE) is an accelerator that supports native-owned businesses. Also included is the Arrowhead Innovation Network, which works on commercializing technology. And finally, there is Arrowhead Park, which is in southern New Mexico and serves as a hub for innovation for various sectors. The Park offers land for up-and-coming businesses as well as access to tax incentives (Arrowhead Center, n.d.).[195]

New Mexico Tech is focused on science, technology, engineering, and math (STEM fields), with several research divisions that work with private industry, government agencies and other universities. It is further home to a mining institute and the state geologic service. These knowledge assets are likely to be important if the state decides to develop its geothermal energy potential. To investigate the resource and its potential opportunities, New Mexico Tech could leverage the Bureau of Geology and Mineral Resources (New Mexico Tech, n.d.).[196] This state service has a history of evaluating geology, mineral, and energy resources as well as serving any individuals who are interested in learning more. More recently, the service is increasing research initiatives in environmental geology and geohydrology. There are ongoing studies looking at geothermal resources and creating a publicly available database of New Mexico's geothermal landscape (New Mexico Bureau of Geology & Mineral Resources, n.d.).[197]

Similarly, New Mexico Tech can play a role with its Petroleum Recovery Research Center. The center conducts research on CCS, including using artificial intelligence to characterize reservoirs, conduct sequestration studies, and convert natural gas to hydrogen (New Mexico Tech, n.d.).[198] It also works on Go-Tech, which oversees historical and monthly updated oil and gas data in New Mexico (New Mexico Tech, n.d.).[199]

New Mexico Tech also has a Climate and Water Consortium, which looks at how climate change impacts weather, rain, and aquifers in the state (Climate & Water Consortium 2017).[200]

The University of New Mexico has several ongoing research initiatives that can play a role in the transition. For instance, the Established Program to Stimulate Competitive Research, also known as EPSCoR, is exploring research and workforce training opportunities related to electric generation and delivery through the New Mexico SMART Grid Center (New Mexico EPSCoR, n.d.).[201] The SMART Grid Center is also identifying what challenges an energy transition will have on current electricity infrastructure. Based on the recognized needs, the Center will create education programs that will train the next generation of workers. UNM also will play a role with its Earth Data Analysis Center, which manages the New Mexico Resource Geographic Information System and geospatial data (NM RGIS, n.d.).[202] The university also houses several innovative research initiatives related to healthcare and other industries.

An example of how universities are catalyzing economic development and job creation in New Mexico is **Innovate ABQ**, located in the seven-acre innovation district in Albuquerque. The project is divided into four phases, with an estimated completion date of 2024. Innovate ABQ has built a makerspace and the UNM rainforest building in downtown Albuquerque. The FUSE makerspace is a 13,400-square-foot room with rapid prototyping, industrial, and fabrication lab facilities available to select community colleges and the local community. The Rainforest building is a six-story building with the first floors dedicated to technology transfer and with office space for UNM, Sandia National Laboratory, UNM Innovation Academy, and the Air Force Research Laboratory. Above that are two-bedroom apartments that are designed to be leased to students, two of which are solely reserved for members of the Navajo Nation enrolled at UNM to provide a comfortable cultural environment. An abandoned church building is being renovated into additional lab, incubator, and community space to meet the requirements of early-stage enterprises and groups that serve marginalized populations. Phases 2–4 will build additional sites with specific missions, such as cybersecurity or creative economy.

3.4.4 Leveraging Innovation Assets to Support New Clean Energy Jobs and Businesses

Efforts to diversify the economy and foster entrepreneurship can broaden the range of choices workers face and increase the chances that they find occupations and industries that align with their expected wages and existing skill sets. Any effort to support innovation-oriented entrepreneurial growth should recognize and draw on both local resources and capabilities—in particular the state's universities and national labs—while leveraging federal and out-of-state resources and networks.

This case study revealed several existing models that are contributing to innovation-led growth in the state. Public-private partnerships, such as Innovate ABQ, streamline technology transfer processes and help to seed new businesses. Strengthening the innovation ecosystem in New Mexico enables the development of both nascent companies and industries and encourages the development of industry clusters.

Large local and federal buyers may be able to help create demand in the state for cleantech and high-tech businesses. For example, the concentration of military bases in New Mexico could serve as a testing ground and possible early buyer for advanced energy storage and clean transportation solutions. New Mexico can also attract high-tech industries by leveraging its existing natural resources. For example, New Mexico may be able to learn from both El Salvador (Gans 2021)[203] and Wyoming, which provided clean power for the cryptocurrency industry (Marcus 2021).[204] Both El Salvador and Wyoming attracted the multibillion-dollar industry with their clean and renewable energy supplies and are working on government structures to secure reliable state revenue and increased job markets. Cryptocurrencies can have flexible loads, allowing them to shift demand to off-peak hours and to provide reserved capacity during black swan events (Square 2021),[205] making potential complement for all forms of renewables, including geothermal. Cryptocurrencies act as one example of the expansive tech industry that could be drawn to the state. These two options together are examples of the opportunities available to New Mexico, with its extensive and growing innovation infrastructure combined with its existing natural resources.

A strategic public-private-academic partnership, anchored by a leadership team comprising representatives from one or more local universities, both national labs, and the state's growing entrepreneurial ecosystem is recommended as a way to scan the horizon for promising business models and support them in connection with the state's clean energy transition. The partnership would be charged with engaging diverse stakeholder groups in the state around specific thematic areas under the banner of clean energy transition and economic diversification, building familiarity across ethnic, rural-urban, and socioeconomic lines, and generating tangible, local beneficiaries supportive of the transition agenda.

3.5 Workforce Training

The case research revealed a modest but growing number of training and apprenticeship programs focused on clean energy. Interviews suggested that these activities are being developed independently across institutions, leading to variation in quality and ability to signal preparation. As a result, participants' employment prospects remain uncertain. Table 3.3, from the UNM Clean Energy Workforce Development Study (2020), shows the current workforce training programs focused on clean energy. It underscores that for wind, solar, and biofuels, training programs are not available in all regions, which could limit access for less mobile populations. Furthermore, while campuses across the state offer generalized training in energy technology (right column of Table 3.3), case research did not find much coordination in terms of curriculum requirements and responsiveness to industry demand. Nationally, in the wind energy field, a "workforce gap" has been identified, where employers have difficulties finding qualified workers, while educators report graduates not finding or entering into wind-related jobs after graduation (Keyser 2019).[206] These findings highlight the need to further coordinate green energy education with industry needs, while also increasing recruitment for programs and resources for students in those programs to help reduce these gaps.

Table 3.3: Green Energy Job Training Centers for Solar, Wind, Biofuels, and Other Energy Technologies

GREEN ENERGY-FOCUSED PROGRAMS				
	Solar	Wind	Biofuels	Energy Technology
Northwest	†			Navajo Tech Univ San Juan College*
North Central	Northern NM* UNM-Los Alamos			Northern NM UNM-Taos
Central	Santa Fe CC* CNM*		Santa Fe CC*	Santa Fe CC
Central West				NMSU-Grants
East		Mesalands Clovis CC*		ENMU-Portales
South	Dona Ana CC NMSU-Alamogordo			Dona Ana CC NMSU-Alamogordo Western NM*

*Programs eligible for WIOA funding for green job training

†San Juan College has solar curriculum, but is not currently offering courses.

Source: UNM Clean Energy Workforce Development Study 2020[207]

One state initiative that can help to interrelate education and industry is the Job Training Initiative Program (JTIP). This program allows qualified companies to apply for training reimbursement for new, full-time positions that may qualify for the High Wage Job Tax Credit (i.e., salaries of $60k in populous municipalities, or $40k elsewhere). The program will help to either: (a) reimburse 50–75% of new employees' wages for six months during approved on-the-job training courses, (b) establish a custom classroom training program with a public New Mexico post-secondary educational institution and reimburse up to $35 per hour per trainee, with a cap of $1,000 per trainee, for classroom training services (not including tuition), (c) create a combination of both on-the-job training and classroom courses, or (d) reimburse a percentage of interns' wages for up to 640 training hours. Financially stable, New Mexico–located, expanding manufacturing or non-retail service companies qualify for the program. Green industry companies, like those engaged in the non-extractive pathways discussed here, will generally qualify for the JTIP. Companies are reimbursed as each qualified trainee completes the program (EDD F.Y. 2022).[208] Initiatives like this one can help to alleviate the "workforce gap" by putting industry and education in a needs-based dialogue aimed at producing qualified workers.

To realize opportunities in a clean energy transition, this chapter has shown several needs for future workforce development. First, there is only a limited understanding of how skill sets in traditional energy and other domains may transfer to the clean energy economy in New Mexico—and a need to distinguish job creation potential in construction, which has the greatest potential to expand employment in the near term, from other job categories within each set of clean energy opportunities discussed in Chapter 2. Second, barriers beyond required skills—such as how training needs vary across the state's diverse population, cultural preparation and fit, and commuting requirements—need to be better understood. In Chapter 5, we discuss two recommendations: (1) to create consortia around the pathways explored in Chapter 2 focused on newskilling, reskilling, and upskilling workers to match workers with jobs and the need for ongoing evaluation of skills matches and (2) to establish processes for ongoing evaluation of progress along these pathways.

Chapter 4: Institutions, Policies, and Processes for the Low-Carbon Transition

- New Mexico's General Fund, which supports most state agencies, universities, and public schools, generates over 20% of its revenue from severance taxes on minerals, principally from oil and gas.
- New Mexico receives far more federal funding than it contributes in federal taxes, royalties, etc. In fact, New Mexico is the single most "federally dependent" state in the nation on a per-capita basis: in 2019, it received $31.7 billion in federal revenues.
- A loss of revenues from fossil fuels in a decarbonized future could have significant and uneven impacts on local education and other services, pointing to the need for thoughtful economic diversification plans.
- The state government is partially insulated from such volatility thanks to its permanent fund, but local and tribal governments lack such a cushion. Some tribal governments would be particularly impacted by a loss of oil and gas royalties paid for production on tribal lands.
- The case of the Energy Transition Act (ETA) reveals the tensions in stakeholder positions on the low-carbon transition. Some citizen and environmental groups oppose the ETA, due to what they perceive to be a circumvention of Public Regulation Commission (PRC) oversight functions in a deal made on abandonment costs for the closure of San Juan Generating Station (SJGS) in northwest New Mexico. Lessons learned from the ETA could aid state policymakers as they consider a range of initiatives to decarbonize other sectors of the state's economy.
- Our interviews suggested that many groups want the energy transition to be done "with them," not "to them." State government should explore appropriate ways to expand the meaningful participation of a wide variety of stakeholders—including affected communities—in planning and decision-making for the state's energy transition.

This chapter focuses on the implementation of New Mexico's energy transition. It examines the state's institutional and policy landscape to understand how stakeholders, organizations, and political influences are shaping the transition's form and implementation.

After an overview of state and tribal government structures, this analysis reviews the central role that fossil fuels play in state finances. It then examines the laws and policies that state leaders have advanced to pivot New Mexico towards a low-carbon future, focusing on the state's signature clean energy legislation, the Energy Transition Act (ETA). A qualitative research analysis based on the ETA's recent legislative history describes issues that are preventing a smoother implementation of the clean energy transition. The chapter concludes by proposing options that state agencies may wish to examine in order to pursue more effective transition planning processes.

4.1 Policymaking in New Mexico

New Mexico's historical, cultural, and political context is shaping its pivot towards a low-carbon future. The recent push towards low carbon had its genesis in the early 2000s, when Governor Bill Richardson directed the state government to lead on reducing greenhouse gas emissions (Cottrell 2009).[209]

Many other influencing factors are older. The state's fiscal dependence on fossil fuels can be traced at least as far back as the 1960s (Clark 1987).[210] Looking back further, for at least a century, New Mexico's politics and policymaking have been shaped by the cultural interplay between Anglos, Hispanics and Native Americans (Vigil et al. 1990).[211] These historical developments provide the context and processes for today's clean energy transition. Today, the diverse and overlapping state, tribal, and federal decision-making authorities in the state present challenges for coordinating plans for a low-carbon transition, especially one that is seen as fairly representing the interests of the state's diverse constituencies. The following sections review the state's unique combination of government structures engaged in policymaking.

4.1.1 State Government Structures

In the late 1970s, in response to a growing population and economic factors, the state government was reorganized. In that decade, education, welfare, and resource management grew in importance as political and policy issues. Under the 1977–78 administration of Governor Apodaca, internal reorganization led to the consolidation and streamlining of hundreds of autonomous agencies and to the placing of more accountability in the governor's hands. Some 390 departments, offices, agencies, boards, commissions, committees, and councils were consolidated into 12 cabinet departments (New Mexico Legislative Finance Committee 2016).[212] The proliferation of agencies directed by boards or commissions has historically created openings for special interest influence in state government, making it difficult for governors to develop and implement their policy goals.

Several cabinet departments are of particular interest to this analysis of the distributional impacts of energy transition, including the New Mexico Environment Department (NMED), the Energy, Minerals and Natural Resources Department (EMNRD), the Economic Development Department (EDD), Department of Workforce Solutions (DWS) and the Indian Affairs Department (IAD).

Legislative processes and budgetary decisions are central to implementing the energy transition. There is significant interplay between the executive and legislative branches for establishing the state's budget: executive agencies submit budget requests to the Legislative Finance Committee in late summer, executive and legislative branches hold parallel budget hearings in the fall, and in January, the newly convened legislature is presented with an executive recommendation, reflecting the governor's decisions on the budget. State agencies are typically given great weight in the legislative process.

4.1.2 Tribal Government Structures

There are 23 Indian tribes in New Mexico, each with its own government.[213] The Navajos and Apaches have the largest current membership and are located on reservations of significant size, primarily in northwestern New Mexico, although the Mescalero Apache reservation is in the south-central part of the state. There are also 19 Pueblos, mostly located along the Rio Grande Valley (Garcia et al. 2006).[214] These Pueblos were formerly organized under the All Indian Pueblo Council, made up of leaders from each Pueblo, until its dissolution in 2013. The AIPC was restructured as the All Pueblo Council of Governors (APCG).

Tribal and Pueblo governments are not established by federal or state governments; they instead have historical origins and a trustee relationship with the federal government. This complex set of independent entities leads to a complex and sensitive relationship between the tribes and federal and state governments.

Tribal governing bodies generally take the form of a tribal council, which is usually elected by the adult members of a tribe, along with a chairperson or governor. The tribal council has policymaking authority over tribal affairs, while the chairperson administers policy and represents the tribe in negotiations with the federal or state government. In New Mexico, law enforcement, court jurisdiction and public education are areas where state and tribal governments share responsibility. Despite similarities between tribes, each tribe and Pueblo has unique features that derive from their own social and governmental traditions (Vigil et al., 1990).[215]

4.2 Fossil Fuels and Fiscal Structure

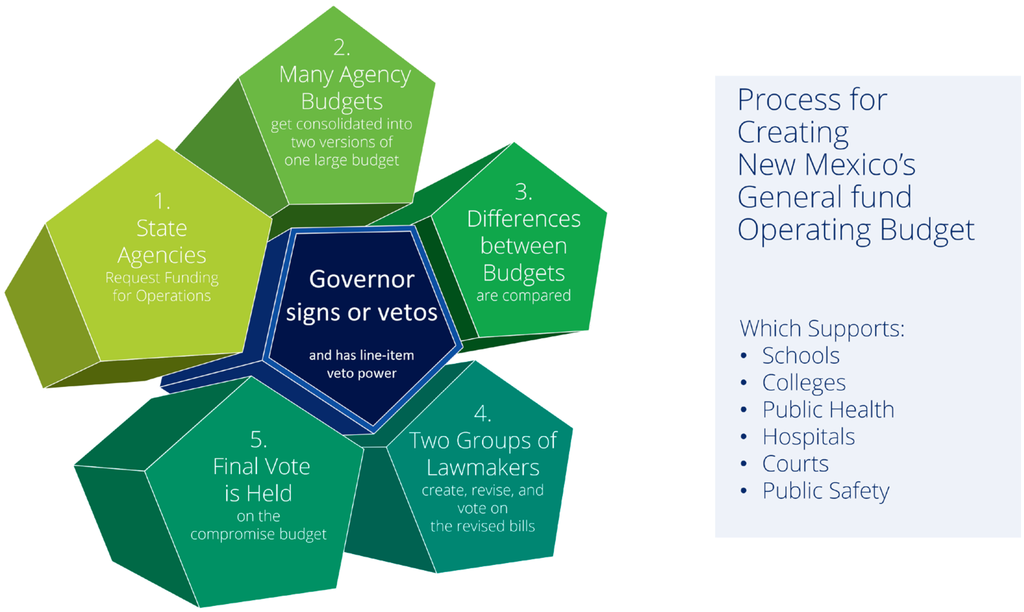
This section describes how New Mexico's state budget is organized, where state funds are generated, which state services are supported by the state's budget, and the level of the state's fiscal dependency on oil and gas and federal funding.

The state budget comprises four main funds: the General Fund, the Road Fund, the Land Grant Permanent Fund, and the Severance Tax Permanent Fund. The General Fund is the state's principal operating fund, made up of most state tax revenue and investment income from federal mineral royalties. Funding is used to support public school education, higher education, Medicaid, public welfare programs, government operations, environmental protection, tourism support, and promotion and economic development efforts. The largest expenditure from the General Fund is public schools (42%), followed by health and human services (27%), higher education (13%), and courts and public safety (11%) ("State of New Mexico" 2017).[216] The second-largest operating fund is the Road Fund, which receives gasoline and diesel taxes, weight distance taxes, vehicle registration fees, and some federal funding. Expenditure from the Road Fund is dedicated to the maintenance and construction of roads.

Around 75% of total state taxes collected in New Mexico is from three sources: general sales taxes (36%), income taxes (22%), and mineral revenues (17%) (New Mexico Legislative Finance Committee 2016).[217] New Mexico relies more heavily on sales taxes (which apply to services as well as goods) than most other states, ranking eighth in the country for the share of revenues from this source (Garcia et al. 2006).[218] Federal funds account for approximately one third of the state's total spending.

A number of state agencies and legislative committees are responsible for making decisions about major public investments. These include: the NM Department of Finance Administration (DFA); the Legislative Finance Committee (LFC); the NM House Appropriations and Finance Committee (HAFC); the Senate Finance Committee (SFC); the NM Board of Finance; NM State Investment Council (SIC); NM State Land Office (SLO); and NM State Treasurer's Office and Economic Development Department (EDD). The process of creating New Mexico's General Fund Operating Budget is depicted below.

Figure 4.1: The process for creating New Mexico's General Fund Operating Budget, which supports most of the state's ongoing programs and services, including schools and colleges, public health, hospitals, courts and public safety.



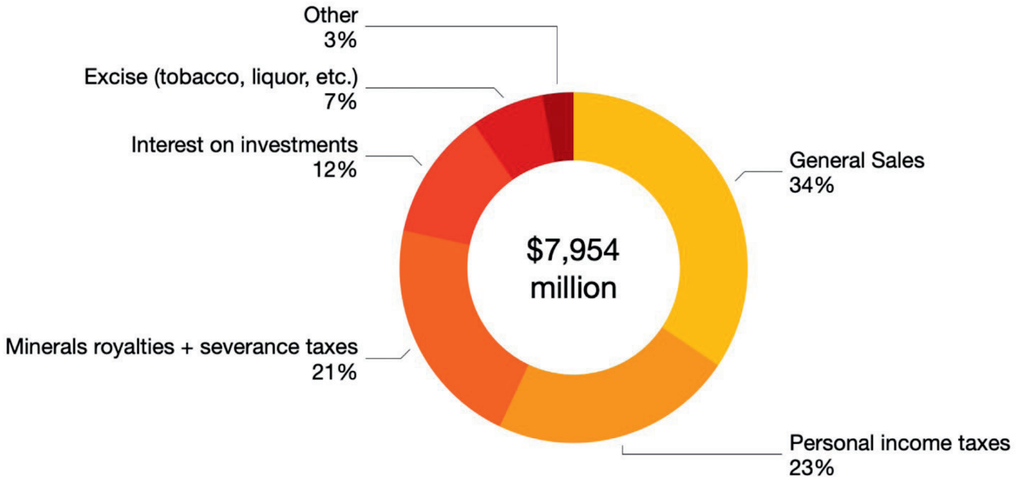
Source: Adapted from Jimenez et al. 2021 and New Mexico Voices for Children 2021[219, 220]

New Mexico is one of the few states in the nation in which both the executive and the legislative branches produce budget proposals. For the coming fiscal year, the DFA sends out budget request guidance to other departments. These petitions are sent to the governor and LFC. The governor and LFC create an executive budget that is separate from the LFC's independent budget; these two iterations of the budget proposals are presented to the legislature. Following this, the DFA and LFC prepare "difference sheets," which are submitted to the House and Senate. The budget is then presented to the legislature as a bill. Hearings on the budget proposals are held by the HAFC and the SFC; the HAFC conducts hearings on each agency's budget, finalizing each, and the House votes on the amended House Bill 2 (HB2). It is then sent to the Senate, where the Senate Finance Committee conducts hearings for major agencies, considers amendments, and votes on the bill on the Senate floor. If both groups reach agreement on the bill, it is published as a new version of HB2. The conference committee version of HB2 is voted on by majority vote on the House and Senate floors. The bill is then sent to the governor for signature, where the governor has line-item veto power. While the legislature has the sole power to appropriate, this line-item veto gives the governor the power to remove or reduce appropriations. After the budget is enacted, it is translated into an operating budget for each agency.

New Mexico's principal operating fund, the General Fund, funds most state agencies, universities and public schools (see Figure 4.1). In 2019, it amounted to \$7.95 billion. Over one fifth of its revenues come directly from severance taxes on minerals, principally from oil and gas. A 2014 New Mexico Tax Research Institute analysis found that at least one-third of the state's general fund comes from the complex set of taxes and royalties paid by the industry.

As noted, New Mexico receives far more federal funding than it contributes in federal taxes, royalties, etc. Federal funds support the state's four military bases, its two national laboratories, and research at universities as well as federal programs such as Medicare, Medicaid, and other government assistance programs. New Mexico is the single most "federally dependent" state in the nation on a per-capita basis (Kiernan 2020).[221] In 2019, it received $31.7 billion in federal revenues (Stebbins 2019).[222]

Figure 4.2: General Fund revenues (2019).



As noted, for several decades, New Mexico's state finances have depended on income from oil and natural gas extraction that has been subject to the boom-and-bust fortunes of these globally traded commodities. Oil and natural gas extraction is by far the most important fossil fuel industry in the state, although coal has until recently also been an important contributor. Natural gas production is concentrated in four counties in the northwest corner of the state (McKinley, San Juan, Rio Arriba, Sandoval). Oil production is concentrated in four counties in the southeast corner of the state (Lea, Roosevelt, Chaves, Eddy). These counties have benefited from oil and gas jobs, gross receipts taxes, and production and equipment taxes and could be disproportionately impacted by clean energy policies. More broadly, all counties across the state have benefited from corporate and personal income taxes from related jobs, severance taxes, and royalties that comprise General Fund revenues.

Since January 1998, oil prices in the United States increased from $10 per barrel to a peak of more than $145 in July 2008, dropped 80% in the following six months, started a relentless drop in mid-2014 to under $40 due to booming U.S. shale oil production, and fluctuated between $50 and $80 in 2016 before crashing to $18 in April 2020 (Deloitte 2020).[223]

A loss of revenues from fossil fuels in a decarbonized future could have significant and uneven impacts on local education and other services, pointing to the need for thoughtful economic diversification plans. The state's economy is depressed by low oil prices and revenue reductions associated with COVID-19, forcing it to reconsider some policies. In 2018, for instance, the state had promised free tuition for college students through a program to be funded by revenue from hydraulic fracturing in the Permian Basin, but the plan did not materialize and has since been scaled back (Kesslen 2020).[224] The state government is partially insulated from such volatility thanks to its permanent funds, but local and tribal governments lack such a cushion. Some tribal governments would be particularly impacted by a loss of oil and gas royalties paid for production on tribal lands. Since 1982, for example, the Jicarilla Apache Indian Tribe has imposed severance taxes on oil and natural gas extracted from reservation lands, which has financed education and other local services (Bureau of Reclamation 2018).[225]

New Mexico's leaders across the political spectrum have long appreciated the problems of dependency on energy commodities with a history of price volatility. In the 1970s, political leaders sought to insulate the state from price volatility through the creation of two investment funds: the Land Grant Permanent Fund and the Severance Tax Permanent Fund. Given the way the state has structured taxes since 1973—when the Severance Tax Permanent Fund for oil and gas severance taxes was introduced—economists from the New Mexico Tax Research Institute see few options for the state to reduce dependence on oil and gas revenues. Today, oil and gas revenues account for some 86% of the Severance Tax Permanent Fund. Taken as a whole, this means that approximately one-third of all state revenues are from the oil and gas industries, subject to year-to-year fluctuation. In 2018, the last year for which full details are available, the industries contributed $2.2 billion (or 32.3%) of the total State General Fund recurring revenue, including a total of $822 million for funding public schools, $290 million for health and human services and $240 million for public colleges and universities. The impact of deep decarbonization on state finances will be substantial if revenues from fossil fuels diminish in the coming years. Therefore, state leaders need to proactively diversify the economy to seek stable, long-term revenue replacement.

With New Mexico's fiscal health exposed to the booms and busts of oil and natural gas markets, successive state government administrations have examined possibilities for economic diversification beyond oil and gas. In 2015, Republican governor Susana Martinez launched a report on diversification of New Mexico's economy through other forms of energy production. In 2019, Democratic governor Michelle Lujan Grisham prioritized economic diversification as a major component of her plans to create a more resilient economy for the future. Among state policymakers, there is an increasing understanding that New Mexico must seriously rethink its general fund revenues. In recent years, growing supply from the U.S. shale industry has put downward pressure on global prices, and New Mexico's fiscal health has been further threatened.

In the transition to a clean energy future, the replacement of fossil fuel revenues with alternative revenues will be a central issue of concern. For example, even in its most optimistic scenario, the New Mexico Legislative Finance Committee puts the average price of oil at only $43.50 per barrel through fiscal year (FY) 2022. A downturn in the oil and gas industry may have lasting impacts across the state into the coming decade. With oil prices likely to remain low in the coming years, New Mexico's fiscal health would benefit from a diversification of revenue sources.

4.3 Lessons on Delivering the Clean Energy Transition

The implementation of a clean energy transition needs the support of a broad coalition of stakeholders if it is to be delivered without delay and sustained over time. Perspectives on the ETA, as the state's landmark legislation, provide a helpful snapshot of stakeholder positions on the transition. Since the passage of the ETA in 2019, the issue of public opinion on the transition has gained prominence in media, policy discussions, and civil society broadly. A range of perspectives are held on the ETA, from groups that support it as it currently exists, to those who would like to see it continue with amendments, to other groups that oppose it entirely.

Groups supporting the ETA include New Mexico's largest utility, the Public Service Company of New Mexico (PNM), and some environmental and labor groups. Interviews conducted for this analysis identified several organizations that advocated strongly for the ETA, including the Conservation Voters of New Mexico (CVNM) and the Coalition for Clean Affordable Energy (CCAE) and its members (350.org, Center for Advancing Sustainable Architecture, Environment NM, NRDC, NM Public Interest Research Group, Partnership for Responsible Business, Rio Grande Chapter of the Sierra Club, Southwest Energy Efficiency Project, Southwest Research and Information Center, Union of Concerned Scientists, Western Environmental Law Center, Western Resource Advocates). Additionally, the State Association for Cooperatives and the San Juan Citizens Alliance (SJCA) both continue to support the ETA.

Case study interviews also identified a number of organizations focused on worker and community dislocation issues. For instance, Sierra Club's Rio Grande Chapter and CCAE are both advocating for more transition assistance. Some state agencies, including the Department of Workforce Solutions (DWS), also advocate on behalf of workers. Other advocacy groups, including SJCA and educational institutions, similarly provide important community support and advocacy.

Groups from across the political spectrum in New Mexico have opposed the ETA, creating significant headwinds for a rapid and effective decarbonization of New Mexico's economy. Case research and interviews revealed a significant degree of opposition to the ETA—including from groups that support a clean energy transition—a reality that poses challenges for the goals of decarbonizing by 2050.

Some citizen and environmental groups oppose the ETA due to what they perceive to be a circumvention of Public Regulation Commission (PRC) oversight functions in a deal made on abandonment costs for the closure of San Juan Generating Station (SJGS) in the northwest corner of New Mexico. PNM's securitization of the coal plant, based on those abandonment costs, has incurred significant opposition from New Energy Economy (NEE), Citizens for Fair Rates and the Environment (CFRE), Diné Citizens Against Ruining Our Environment (CARE), and their political allies. Some of these groups—all of which support a clean energy transition—are challenging the legality of the ETA in the state's supreme court. In research interviews, many argued that in the circumvention of crucial oversight functions, legislators and PNM failed to secure a fair deal for ratepayers and alleged that it involved an antidemocratic bailout that favors PNM that was negotiated behind closed doors. Some conservative groups also oppose the ETA, arguing that carbon neutrality by the ETA's target dates is not feasible and, in some cases, rejecting the scientific consensus that overwhelmingly confirms climate change to be a global emergency.

Several new policies and rules are now being implemented to more aggressively reduce emissions from transportation, buildings, industry, agriculture and other sectors and sub-sectors. In March 2021, for instance, the New Mexico Senate passed a Clean Fuel Standard Act (Senate Bill 11) which, if enacted, would aim to decarbonize the transportation sector through a 10% reduction in greenhouse gas emissions by 2030 and a 28% reduction by 2040. In April 2021, after a year of debate, the state enacted a new rule that calls for the oil and gas industry to capture 98% of its methane by 2026.

Lessons learned from the ETA could aid state policymakers as they consider a range of initiatives to decarbonize other sectors of the state's economy. In this regard, this research and the associated interviews generated the following observations:

1. **The transition could help overcome existing social, economic, and environmental injustices if the benefits and burdens of the transition are equitably shared.** A thoughtfully planned energy transition could help to move in the direction of overcoming the uneven social and economic impacts of the transition by, for instance, providing transition assistance pay to affected workers, economic development assistance for affected communities, and environmental remediation for areas impacted by resource extraction, such as coal mining. Some measures in the ETA are designed to address these issues in the electricity sector, for instance, through provisions of transition assistance. Some interviewees from citizen groups—for instance, the San Juan Citizens Alliance—expressed optimism that transition measures in the ETA, such as renewable energy deployment, could provide new opportunities for the region as it transitions to cleaner energy.
2. **New Mexicans want an energy transition done "with them," not "to them."** A wide range of actors were interviewed across the state that are interested in, involved in, or helping to guide the clean energy transition. Many have valuable knowledge and experience on how to effectively deliver change in their communities or constituencies. However, some felt sidelined: for example, some indigenous groups interviewed felt that they were not fully informed about PNM's plans to close the San Juan Generating Station, whose workforce is largely indigenous, and that they had few opportunities to influence or have input into those plans. Some citizen groups interviewed felt that they should have been able to present their interests before the PRC. They were also concerned that the PRC's authority had been circumvented by the legislature, preventing effective scrutiny of key decisions that would affect New Mexicans for decades to come. Some citizen groups felt that the securitization options that the ETA offered to utilities would provide a "bad deal" to ratepayers. Overall, many groups perceived that it was simply not possible to deliver a "just transition" without deliberation and decision-making that included voices from across communities affected by the transition. Effective implementation of the state's energy transition will best be achieved through open, transparent decision-making processes. There are already promising moves being made in this direction: most recently, legislation such as Senate Bill 84, the Community Solar Act, has demonstrated how citizens can meaningfully participate in drafting an energy transition bill that has wide-reaching support and little opposition. State government should explore appropriate ways to expand the meaningful participation of a wide variety of stakeholders—including affected communities—in planning and decision-making for the state's energy transition.

4.4 Towards Inclusive and Effective Transition Processes

This section addresses the issues identified in interviews and research by proposing measures that state agencies could adopt to adjust the processes through which the state's transition is being planned and delivered. It is recommended that state agencies examine the feasibility of two mutually reinforcing ways of improving inclusion in planning and decision-making for the ongoing transition. The first of these—a proposed Transition Advisory Council—responds to concerns about the equitable sharing of the benefits and burdens of the transition by soliciting input from industry, business, research, and tribal and local governments.

The second—a proposed People's Transition Assembly—responds to the interest expressed by many in the need for greater transparency and inclusion in transition processes to date by establishing a mechanism that engages New Mexicans in planning a vision for the future. These options have been deployed successfully in other parts of the U.S. and internationally to boost support for the clean energy transition, taking advantage of a diversity of ideas, and ultimately promoting a transition that gains forward momentum. Together, these proposals aim to improve transition planning in a way that is both top-down, through formal, established organizations, and bottom-up, through new options that incorporate the voices of citizens. The proposals are described below.

Transition Advisory Council

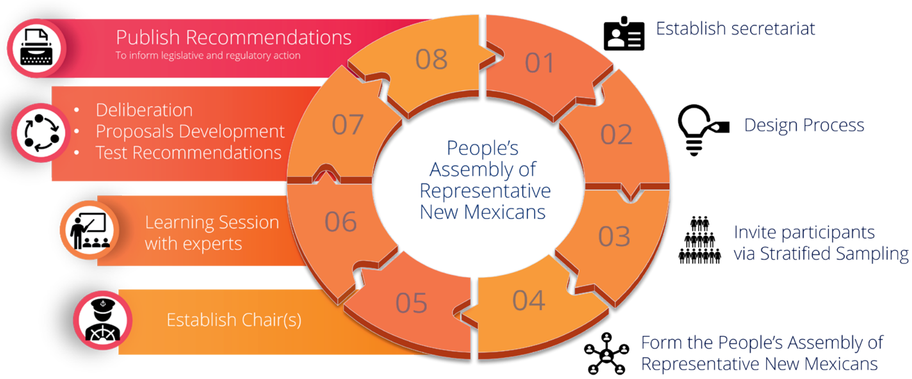
The purpose of the proposed Transition Advisory Council would be to provide state institutions with thoughtful input for critiquing, informing, and shaping New Mexico's transition to a decarbonized economy from a diverse set of organizations that are committed to advancing the state's transition. Feeding into the strategic planning work of the state's Interagency Climate Change Task Force, the Council would bring to bear a wide range of expertise at the forefront of technological innovation, citizen action, and implementation modalities (New Mexico Interagency Climate Change Task Force 2019).[226] In this proposal, the Interagency Climate Change Task Force would appoint an independent chair and invite business and industry leaders, investors, academics, youth, and civil society groups to participate as members of the Advisory Council. The Advisory Council would be given a mandate to undertake work that is complementary to, and feeds into, the work of the Interagency Climate Change Task Force's strategic action areas by revealing where needs and knowledge gaps are most pressing. The Advisory Council would be tasked with working over a period of six to twelve months to make independent practical recommendations to the Interagency Climate Change Task Force, with the recommendations published in a public report. The Task Force would subsequently publish a response detailing the ways that it intends to address or incorporate the recommendations.

While the independent recommendations would not be legally binding, commissioning, receiving, and responding to them publicly has a range of benefits. First, the process promotes idea generation on practical and affordable measures for regulatory, policy, and technology pathways that draws on expertise beyond that of the NMED and EMNRD alone, thereby gaining access to the latest thinking on effective transition. Second, it promotes collaboration between stakeholders whose support could ultimately benefit implementation in practice. Third, it promotes inclusion in a context where it has thus far been lacking, suggested by the research and interviews for this case study. The model of an Advisory Council has been deployed to promote transition to decarbonization in other contexts, such as the Climate Change Advisory Council established by the Irish Government in 2016 (Climate Change Advisory Council 2021)[227] and the Just Transition Commission established by the Scottish Government in 2018 (Scottish Government 2021).[228] Experience in those contexts suggests that New Mexico can benefit from a Transition Advisory Council to promote integration of high-quality practical ideas while also promoting stakeholder inclusion.

People's Transition Assembly
The second component of this study's proposal to promote more inclusive planning and policymaking comprises the establishment of a people's (or citizens') assembly. In recent decades, established democracies have used people's assemblies as an important tool to build trust in government action on complex policy and political issues. Notable examples include national governments and state governments establishing such assemblies to deal with electoral reform in Canada and decarbonization in the United Kingdom. There is recent evidence that citizens' assemblies are gaining popularity in the United States in a context of diminishing trust in elected bodies: a Pew Research Center poll showed that 79% of Americans were in favor of the federal government convening assemblies for ordinary people to discuss and recommend laws.[229]

In citizens' assemblies, participants are selected on a voluntary basis through quasi-random processes that ensure balance in geography, ethnic and racial diversity, gender breakdown, and income level. The first state-wide assembly to focus on climate change in the United States took place in Washington State over the course of several months in early 2021. Washington's Climate Assembly, which was conducted virtually, had participants address the question: "How can Washington State equitably design and implement climate mitigation strategies while strengthening communities disproportionately impacted by climate change?" The assembly's 148 recommendations, each approved by at least 80% of assembly members, were to be brought for consideration in a final report delivered to state legislators in mid-2021.

Figure 4.3: A proposed process for designing and conducting a New Mexico People's Transition Assembly



Based on the procedural equity issues that this research identified, a number of steps towards shaping the institutional design of a possible New Mexico People's Transition Assembly are identified. First, state government authorities should establish an independent secretariat function to oversee the operations of the assembly. Second, the secretariat should undertake the design of the process, drawing on best practice, and tailoring to New Mexico's specific geographical, demographic, and cultural context. Factors to consider in the process design stage include subject matter and scope, content preparation, rules and standards, language, modes of internal engagement and communication, outputs, external media, and whether the process is conducted virtually or in person. Third,

participants should be invited and selected through a stratified random sampling method to generate an assembly that is representative of the state population. A range of organizations have published on the process for selecting a representative sample for a citizens' assembly (see, e.g., Gerwin 2018; Mellier and Wilson, 2020).[230, 231] Fourth, the assembly is brought together and introduced. Fifth, an effective chair, or chairs, should be established to manage the deliberations. Sixth, a series of sessions with experts, or subject matter leads, can be conducted that frame issues and introduce extant knowledge on the matters that the assembly will deliberate on. Subsequently, assembly members should deliberate over proposals and iterate until reaching consensus on a series of recommendations that they wish to publish and make public. The published recommendations are usually intended as an input to inform legislative and regulatory action.

As state policymakers focus on decarbonizing beyond the power sector in the coming years, this research demonstrates that they have an opportunity to deliver on their stated commitment to a fair and just transition by deepening their focus on equitable policy and planning processes. As this chapter has shown, the passage and implementation of the ETA raised a number of issues relating to the transparency and equity of the processes by which it became law. The diverse and overlapping state, tribal, and federal decision-making authorities in the state make for a complex transition policy landscape. The proposals described here—to implement a Transition Advisory Council and People's Transition Assembly—offer an example of how New Mexico might build on its existing policy and institutional landscape to promote a clean energy transition that recognizes the state's diversity and range of stakeholders.

Chapter 5: Conclusions and Recommendations

By combining technology, policy, and inclusive decision-making processes, New Mexico could prosper in a low-carbon transition. A national carbon charge, such as the one assumed in the Roosevelt Project, would encourage low-carbon, least-cost transition. This case study starts from projected least-cost pathways in state, national, and global studies and considers their impacts on a range of attributes, including local job creation, public revenue generation, and distributional equity. The result is a set of recommendations on pathways grounded in New Mexico's context that consider all of these dimensions, which will help to support broad participation and distribute the benefits of transition across the state's diverse population and economy.

This case study supports eighteen recommendations. These can be divided into recommendations related to decarbonization of energy systems; recommendations on mitigating other greenhouse gases, pursuing green supply chain opportunities, and diversifying the economy; recommendations for state decarbonization policy; and recommendations to support equitable and inclusive governance of the transition process. These recommendations may not reflect very recent policy changes or additions.

5.1 Energy Recommendations

Recommendation 1: Advance a long-term vision and targets for power sector decarbonization that recognize the need for firm power to balance the intermittency of wind and solar energy as it expands to meet Energy Transition Act (ETA) goals. This vision should include the role of natural gas with CCS, hydrogen as a fuel for power generation (with CCS for blue hydrogen), bioenergy with carbon capture and storage (BECCS), renewable natural gas, and geothermal generation.

The ETA sets aggressive targets for the share of power generation from renewable energy. Wind and, more recently, solar power are expanding rapidly, generating construction, manufacturing, and services jobs in the state. This expansion should be commended and accelerated. To expand to meet ETA targets, high shares of grid-connected renewable energy will require firm backup power, storage, and demand response.

Among these options, firm backup power could be provided from New Mexico's natural gas plants without substantial additional cost or technology investment while preserving well-paying jobs and public revenue streams. Losing these jobs and revenue streams would place a disproportionately heavy burden on native and rural communities, including workers and communities engaged upstream in natural gas production. Natural gas generation with CCS, hydrogen-based generation (with CCS for blue hydrogen), or BECCS could provide long-term options compatible with carbon neutrality, while making use of existing pipeline rights-of-way and local geology suited to CO_2 storage. This vision should be supported by clarifying in the ETA that power generation technologies with pre- or post-combustion carbon capture can be deployed to meet the goals of the state's renewable portfolio standard (Recommendation 11).

In this regard, the state needs a detailed analysis of daily, weekly, and seasonal variations in wind and solar generation. As noted, in California, there were 90 days in one year with little to no wind. The difference between its summer and winter wind and solar generation is 3.1 TWh. New Mexico needs an in-depth review of its weather patterns to inform what types of backup generation will be needed in the near- to mid-term and to inform investments in innovation for long-duration storage in the longer term. This is critical for informing the implementation and implications of the ETA.

This recommendation could be the topic of one of the roadmapping workshops to be held by the Grid Modernization Advisory Group, established in response to the passage of the Energy Grid Modernization Roadmap Law in 2020.

Recommendation 2: Support ongoing efforts to expand distributed energy on public lands, for homeowners, and on indigenous lands.

This recommendation reinforces recent legislative efforts to foster development and innovation in distributed energy in the state. Large areas of low population density, concerns about wildfires, and abundant renewable energy resources make the state a prime location for innovation in distributed energy resources—including renewable energy—and microgrids. Two legislative initiatives could lay the foundation for this growth: the Solar Market Development Income Tax Credit (Senate Bill 29), which provides relief for taxpayers that install solar thermal or PV systems, and Senate Memorial 63, which establishes a working group of stakeholders to examine paths for future legislation to enable community solar in New Mexico. In addition to spurring innovation in distributed energy systems, these community solar initiatives have the potential to broaden citizen participation in the clean energy transition by making it both local and tangible. They could also create additional demand for in-state manufacturing and installation/servicing of solar components and systems, expanding related jobs. This recommended work should also consider and be further informed by the implementation of HR 233, the Energy Grid Modernization Roadmap Act, which became law last year and tasks the EMNRD with developing an electric grid modernization plan.

Recommendation 3: Reinforce the state's existing commitment to phasing out unabated coal power, while strengthening provisions to address the dislocation of jobs and public revenues resulting from coal plant closures.

Dramatically reducing or eliminating coal-fired power generation would put pressure on employment and public funds, with outsized effects on indigenous communities. Retrofitting coal with CCS has the potential to preserve revenue streams and employment, with appropriate worker retraining and transition assistance. The ETA's provisions for workers are a good start. The distributional effects on communities linked to coal plants need to be assessed holistically, considering developments in the wider energy system, economy, and adjacent technologies, as well as direct community impacts. Industry-standard severance pay should be guaranteed to older workers. Public revenue impacts need to consider any subsidies required to keep plants open and support CCS retrofits, which will offset the public revenue they generate in the future.

Recommendation 4: The Climate Change Task Force and transportation planning agencies in the state should develop a roadmap to advance the shift to a diversified mix of low-carbon transportation fuels, vehicle efficiency, and public transit options.

This analysis concludes that the state's two preferred pathways for transport decarbonization, vehicle electrification and VMT reduction, could place a disproportionate burden on low-income and rural households. A broader portfolio of near- and long-term alternative fuel options should be defined, with explicit attention to the distributional impacts to users of introducing them in the state. With the low-carbon fuel standard (LCFS) expected to be considered in the upcoming legislative session (see Recommendation 12), a clear understanding of these impacts could inform policy design, including subsidies to low-income households, to make clean options affordable. The roadmap should also consider the timing and need for investments in electric vehicle charging and hydrogen refueling infrastructure, as well as expanded availability of public transit options.

Recommendation 5: The state's Climate Task Force, in collaboration with the state's national labs and universities, should support and accelerate efforts to create hubs for clean hydrogen production with CCS around San Juan Generating Station/Four Corners (power, gas processing), the Escalante Plant east of Gallup (a shuttered coal plant), and along the Texas-New Mexico border (natural gas processing, oil refinery). Production would initially focus on using the state's natural gas resources with carbon capture and storage and evaluate green (renewable) sources of hydrogen.

Natural gas accounts for 40% of New Mexico's electric power generation and, after coal, contributes substantially to the sector's GHG emissions, making it the next target of power sector decarbonization efforts. To avoid stranding these assets, dislocating workers, and eliminating revenue streams, the feasibility of converting or connecting these plants to production of clean hydrogen (initially from natural gas with CCS)—in addition to retrofitting them with CCS (Recommendation 1)—should be explored, and funding, including federal funding, should be supported and pursued.

The state possesses extensive natural gas distribution infrastructure that could be used to transport hydrogen (at low blend levels) or to more rapidly establish dedicated infrastructures using existing rights-of-way (ROW) for hydrogen and CO_2 transport in the future. The state could lead the country by doing an in-depth analysis of what actions are needed at the federal, regional, and state levels to understand the value of existing ROWs and what policies are needed to enhance their value in the clean energy transition.

Taken together, today's natural gas and coal generation, pipeline network, and processing facilities could become part of H_2/CCS hubs that combine and evolve these existing assets to support carbon capture, transport, utilization, and storage from hydrogen production and fossil-fired power generation. The feasibility study would consider prospects for business models, local job creation, revenue generation, and equity impacts on low-income, indigenous, and minority groups in the northwestern and southeastern corners of the state, where existing fossil energy generation and transport infrastructures are concentrated.

The current governor, Michelle Lujan Grisham, has launched an effort to make New Mexico a major hydrogen hub. Activities she is supporting include economic incentives; information on targeted sectors; standards and guidelines for storing hydrogen and for carbon sequestration; safety standards; and creation of clean hydrogen highways.

This analysis suggests two additions to this proposal that could enhance its role in the clean energy transition. First, CCS and the associated infrastructure, including pipelines, is critical for near- to mid-term decarbonization. To avoid stranding these critical pipeline assets, incentives should be developed to make them hydrogen-compatible—hydrogen embrittles pipelines—to provide a clear pathway and infrastructure for a green hydrogen future. Union pipeline experts should be consulted to ensure the incentives are appropriated for pipeline repurposing. Also, New Mexico's substantial innovation infrastructure should be supported in efforts to lower the costs of green hydrogen production and to help design a distributed system to support green hydrogen production and uses at remote locations. Distributed green hydrogen production could, for example, support mining activities for the minerals needed for a clean energy future, (e.g., copper) and help meet some of the associated needs for water.

Also, the pipelines on indigenous lands should be priority for modifications of both hydrogen and carbon dioxide transportation, and they should prove to be financially sound, as there also exist numerous old and abandoned coal and oil mines on indigenous lands, making them attractive targets for carbon storage. The state should work with tribal governing bodies to assess the value of these infrastructures and potential sequestration sites to help meet the state's decarbonization goals.

Recommendation 6: The NM Energy, Minerals and Natural Resources Department should conduct additional analysis and a feasibility study on agriculture and bioenergy decarbonization pathways for the state and generate recommendations for near- and long-term opportunities.

In rural areas, there are several technology pathways worth exploring that could broaden opportunities for participation in a clean energy economy: for instance, generating biogas (on farms or ranches) or harvesting deadwood in the state's forests for use in developing bioenergy with CCS (BECCS). BECCS would simultaneously address both major fire hazards and jobs in rural areas, while offering additional opportunities to reduce the GHG footprint of the electricity sector. In fact, BECCS could provide a source of net carbon negative generation, which would contribute to sector, state, and national efforts to achieve carbon neutrality by 2050, a target that —according to most credible analyses—will require net negative technologies to meet.

Recommendation 7: As a major energy exporter, the state of New Mexico should consider regional collaborations with other states on hydrogen/CCS hubs where appropriate, grid modernization, repurposing of existing rights-of-way, and other areas where regional collaboration would help accelerate the clean energy transition.

New Mexico, working with neighboring states, should explore the use of existing federal authorities for creating interstate compacts. According to a recent study on the formation of CCS hubs, "There are many relevant examples of interstate compacts formed to support environmental protections and issues that span multiple states." One such compact—the Ohio River Valley Water Sanitation Compact—was established "for the purpose of maintaining waters in the river basin in a satisfactory condition, available for use as public and industrial water supply after reasonable treatment, suitable for recreational use, and capable of maintaining healthy aquatic communities." The establishing of such a compact should be explored to expand current collaborations through the state's participation in the Western Interconnect Regional Electricity Dialogue (WIRED).

5.2 Economic Development, Innovation, and Supply Chain Opportunities

Three recommendations are designed to harness technological innovation and supply chain opportunities in a clean energy transition, given the state's strong innovation infrastructure.

Recommendation 8: Evaluate prospects and develop roadmaps for environmentally responsible mining and materials processing in the state, to support renewable energy and battery manufacturing.

These efforts should be informed by activities in other regions that are focused on environmentally responsible mining. The activities of two countries, Canada and Australia, are focused on this, and these countries have many similarities with New Mexico, including significant mineral resources, large indigenous populations, and commitments to deep decarbonization.

In Canada, for example, there is a significant focus on mining and ESG action, including a focus on mining and indigenous businesses and communities, which may have examples that could inform activities in New Mexico. Canada has also launched "Our Clean Future," described as "a climate change, energy and green economy strategy with a commitment to develop mining intensity targets for placer and quartz." Similarly, the Australian government released a handbook in 2020, the *Guide to Leading Practice Sustainable Development in Mining*, which notes that, among other things: "Sustainability requires that the complex relationships between various risks be well understood, especially the potential for links between environmental, social, political, economic and reputation risks." This handbook elaborates several focus areas: community engagement activities as a focus of mining senior management; continual monitoring of contractors and subcontractors to ensure compliance with sustainability objectives; opportunities for indigenous peoples; and development of effective monitoring frameworks. These approaches and frameworks may be highly relevant for New Mexico.

Environmentally responsible mining could also provide a source of revenues to help meet shortfalls in the state's budget as fossil fuel use and the associated revenues paid to the state decline during the clean energy transition. This should be included in the state's evaluation of environmentally responsible mining.

The state should also explore financial support for battery recycling options, with a specific focus on creating recycling expertise, training, and centers in small rural towns that will lose jobs and commerce from auto repair businesses that will be affected by the transition to electric vehicles.

Recommendation 9: Continue and strengthen ongoing efforts to limit agricultural methane emissions and fugitive methane releases from oil and natural gas wells, combined with incentives that encourage monetization of recovered methane.

Methane remains a major contributor to overall GHG emissions in New Mexico, well above the national average for U.S. states. The state has enacted a goal of reducing 98% of natural gas waste by 2026, which is estimated to increase the sector's profitability and public revenues. More work should be done to characterize fugitive methane releases, given the substantial uncertainty in current estimates and plans developed to curb them, with a focus on employing oil and gas and rural workforces to support these efforts. Capturing fugitive methane emissions from oil and gas systems could provide additional revenues to the state as it works to transition to clean energy.

Recommendation 10: New Mexico's state and tribal governments should explore ways to encourage entrepreneurship that is uniquely suited to opportunities in both urban and rural areas and that leverages the state's existing innovation assets. Initially, this effort could focus on enabling clean energy business models. A matching program to leverage private funds from in and outside of the state could be funded from a recycled carbon tax (via the Roosevelt Project's proposed national carbon charge).

Entrepreneurial initiatives, such as Innovate ABQ, should be further developed and strengthened. However, incubators and accelerators that help to launch startups are disproportionately concentrated in urban areas. It is recommended that a partnership be established for enabling clean energy and economic diversification that engages the entrepreneurial ecosystem in Albuquerque, the National Labs, one or more universities, and leading innovators in the state. This effort would focus on expanding both energy and non-energy opportunities, working in tandem with the workforce development efforts described in Recommendations 13 through 15. The goal of such an effort would be to provide support to local entrepreneurs and help to build a broader entrepreneurial "infrastructure" in the state.

One area that the latter effort could usefully address is the need for new metrics to measure the performance of advanced, IT-enabled energy systems with respect to efficiency, security, reliability, and decarbonization. Organizations like Change Labs are fostering and supporting native innovators who are tackling issues that their home communities face, including sustainable agriculture, distributed solar, energy-efficient HVAC, etc. Organizations like Roanhorse Consulting are increasing access to capital for small-business owners. The recommendation builds on ongoing state legislative efforts to support economic diversification. In developing its strategy, the partnership should explicitly consider broad participation of the state's diverse indigenous, minority, rural-urban, and socioeconomic groups, as well as potential to create in-state benefits alongside commercial potential.

5.3 Policy and Workforce Development

Recommendation 11: New Mexico's executive and legislative branches should consider broadening the ETA and adjusting its near-term targets to achieve net zero grid emissions by 2050.

Flexibility in reaching deep decarbonization targets for 2050 will help to offset the costs, which will rise at the margin as GHG emissions are reduced. The recommended clarification to the ETA's renewable portfolio standard goal would allow near-zero carbon sources of electricity, in particular natural gas with carbon capture and storage, to contribute to reducing GHG emissions from the electricity mix. The legislation should further clarify that carbon dioxide removal (CDR) technology or certified offsets could be used for a limited percentage of remaining GHG emissions in 2050.

Recommendation 12: Support new legislation and executive actions that will complement the ETA by reducing GHG emissions in non-power sectors, especially transportation, GHG-emissions-intensive industry (including oil and gas), and agriculture. The low-carbon fuel standard offers an important starting point for deeper cuts in transportation sector emissions but should carefully consider the distributional impacts.

In transportation, a petroleum-based fuel surcharge that is partially rebated to offset the impacts on low-income households could incentivize vehicle- and fuel-switching and support VMT reduction, while supporting improvement of transit services. This should include support for ongoing state activities with other states on adopting low-emissions vehicle and zero-emissions vehicle standards. Also, New Mexico should analyze the impacts of its recently implemented incentive program for charging infrastructure in existing and new buildings to determine the program's effectiveness and adjust or expand it as necessary.

Legislation that supports deep decarbonization at the state level should complement a federal carbon tax proposed by the Roosevelt Project and focus on specific state-level opportunities and challenges.

The clean fuels standard considered in the legislature earlier this year and the governor's proposal for a low-carbon fuel standard would help decarbonize the state's transportation sector. As noted, however, this could have a substantial impact on low-income and rural residents. The proponents should consider adopting provisions similar to those in the California Clean Fuel Rewards Program, a program that is funded with credits for the states' LCFS to support a $1,500 per vehicle incentive for purchasers of EVs.

Recommendations 13 through 15 are focused on supporting job and skill transitions in the New Mexican workforce.

Recommendation 13: State and federal funding should be directed to form a strategic partnership among universities, national labs, labor, industry representatives, government, and civil society groups that can, among other functions, support the design and implementation of training programs aligned with the near- and long-term transition opportunities laid out in Chapter 2.

Recommendation 14: Conduct a comprehensive state-sponsored survey to crosswalk traditional fossil energy jobs to low-carbon energy skill sets, including construction, renewable energy, energy efficiency, blue and green hydrogen, and CCS. One endpoint of this study could be to help employers plan for worker transitions and for facilitating time and access to retraining opportunities.

The partnership mentioned in Recommendation 13 could use these data to support career advising and retraining for workers in affected industries, enabling them to connect with new employment opportunities created by transition pathways. Ongoing and detailed analysis of state employment data, career trajectories, and skills matches demographics is needed to inform the design and evaluation of "new-skilling, reskilling, and upskilling" programs for the state's workforce in a transition. Recommendation 14 provides for the creation of such a capability. The consortia could support a service, run as a public-private partnership, to guide new or unemployed workers to opportunities in the state's clean energy economy. This service could leverage federal or state transition assistance to support its mission, adapt approaches from other contexts, and advise the executive branch and legislature on the design of transition assistance programs. To overcome barriers to mobility cited in our interviews, this service could work with specific efforts on how to address language and cultural diversity in the design of training and apprenticeship programs.

In addition to crosswalking skill sets, the study should seek to meet the goals established in Senator Heinrich's legislation, introduced earlier this year, that would "assist federal fossil fuel producing states like New Mexico as revenues decline in the coming years due to market forces and policies to curb carbon pollution. The *Schools and State Budgets Certainty Act* would provide a predictable transition for states, counties, and Tribes and give those governments time to transition their budgets to more sustainable and reliable sources of revenue."

Recommendation 15: The New Mexico state and local governments should enact and enforce laws and policies that ensure existing wages and benefit structures, apprenticeship opportunities, building standards, and worker safety requirements are expanded and improved.

Given that the clean energy transition is poised to create substantial job opportunities, especially in construction in the near term, this recommendation emphasizes that these should be quality jobs in alignment with recent national legislative efforts.

Recommendation 16: Reinforce efforts set forth in recent state legislation to replace fossil energy revenue in the state budget. Focus in the near term on mitigating effects of transition on low-income communities.

Existing efforts under SB 112 are considering how to replace fossil energy revenue in the state budget over the next five years. The effort should go beyond shielding the state from the effects of fluctuating commodity prices and consider the implications of an energy transition explicitly, with an early focus on limiting revenues lost to low-income-serving organizations.

Recommendation 17: Increase federal and state funding for clean energy projects on indigenous lands, while encouraging tribal ownership and management whenever possible. This recommendation is intended to be synergistic with, and go beyond, Recommendation 2 on distributed energy. In connection with Recommendations 13 through 15, establish and expand training programs to equip early- and mid-career employees from nearby communities to participate and succeed in clean energy activities.

There is an opportunity to expand tribal participation in developing both community and grid-scale renewable energy projects. Federal funding on a much larger scale than previous renewable energy projects could help native and minority populations to become less dependent on jobs rooted in the fossil energy economy—from vehicle servicing to gas stations to coal power plants—which are major sources of employment on native lands and in rural areas.

5.4 Enabling an Equitable Transition

Recommendation 18: New Mexico's executive branch should instruct the appropriate government agencies to assess the feasibility of proposals that have promise to improve the inclusiveness of decision-making processes for the next stages of the clean energy transition.

Chapter 4 proposed two options for overcoming the difficulties that energy transition implementation has encountered to date. The first of these—to appoint an independent Transition Advisory Council and task it with developing specific recommendations—aims to draw on the breadth of expertise in the state to promote an equitable sharing of the benefits and burdens that the transition offers across social groups and geography. The second—to form a People's Transition Assembly—aims to overcome the barriers to change that have arisen from a perceived lack of inclusion and transparency in decision-making to date.

These options have been used with success in energy transition contexts in Europe and North America. State authorities should study and, as necessary, adapt them to suit the cultural, demographic, and political context in New Mexico. It is recommended that the executive branch instruct the Interagency Climate Change Task Force (and other relevant agencies that it deems appropriate) to assess the feasibility of these measures, along with other measures it sees as promising. If government agencies fail to learn from the experiences around planning and policymaking on the transition to date, there is a risk that legislative and executive action on the transition will continue to encounter opposition from across the political spectrum, thereby slowing or blocking implementation of the transition and leaving critical issues of distributional equity unaddressed. By contrast, if government agencies implement lessons from the barriers encountered in seeking to advance the energy transition to date, there is potential for a more rapid, effective, and equitable transition to deep decarbonization.

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