New Mexico Clean Fuel Standard Economic Impact Analysis

Prepared for the New Mexico Environment Department

By

Adelante Consulting, Inc.
3483 Corrales Road
Corrales, NM 87048

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Executive Summary

> *Passage of the Clean Fuel Standard Act will create near-term demand for low-carbon transportation fuels in New Mexico, and serve as an accelerant for an array of low-carbon fuel projects that have either been announced or are currently being explored in state. These "quick start" projects alone will*
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> - *Create 1,641 permanent jobs and $470 million in wages between 2024 and 2030; and*
> - *Deliver $240 million of investment in New Mexico's low-carbon fuel production and delivery infrastructure.*

The 55th New Mexico legislature will consider proposed legislation to establish a clean fuel standard (CFS) for New Mexico in its 2022 session. The objective of the CFS is to reduce the carbon intensity (CI) of transportation fuels by a minimum of 20% by the end of 2030, and 30% by 2040. This report was prepared to:

- Examine whether a 20% reduction in transportation fuel CI by 2030 is feasible, given New Mexico's size and population density, transportation framework, and resource base, including its position as a major producer and exporter of petroleum and natural gas;
- Identify policy and market shifts that are anticipated to drive changes in the transportation sector between now and 2030, and identify existing and planned resources (feedstock and infrastructure) that New Mexico could leverage to adapt nimbly to such shifts; and
- Present a "quick start" roadmap to 2030 by mapping the expected policy and market shifts that will create near-term demand for low-carbon fuels, with New Mexico's feedstock and infrastructure resources, and with intelligence about low-carbon fuels projects that have either been announced or are currently being explored in state. The projects included in the roadmap are realistic and would jump-start progress toward the CFS's 2030 CI reduction goal.

This report is a follow-up to a report prepared in early 2021 to evaluate the CFS legislation considered during the 2021 legislative session[1]. That legislation was based on a 10% reduction in CI by 2030 and the report identified a potential for $46.3M/yr investment due to the CFS, considerably less than what is presented in this report. Aside from the difference in CI targets, this difference in investment value is due to the conservative approach used in the earlier report. That report only considered the value of CI reduction credits generated by the CFS, which would constitute the bare minimum level of investment. The current report presents a more realistic assessment, as it considers not only capital investment but also the value of direct and indirect jobs that

[1] New Mexico Clean Fuel Standard Evaluation, Adelante Consulting, Inc. January 7, 2021.

will be created. It is not overly optimistic in that it is considering only investment in projects that have been announced or are being considered.

Is a 20% Reduction in Transportation Fuel CI Feasible by 2030? Yes.

We examine the types, quantities, and CIs of transportation fuels currently used in New Mexico, as well as the types, availabilities, and CIs of alternative fuels to identify representative fuel use changes that would result in a 20% CI reduction. While there are virtually an infinite number of possibilities that would result in the target reduction, we selected a representative fuel use scenario that appears reasonable given current conditions. More importantly, it identifies which fuels could potentially have the greatest impact on CI over which time-frames.

Given the current predominant use of gasoline and diesel as transportation fuels in New Mexico, there are immediate opportunities for reducing CI by increasing the use of ethanol in oxygenated gasoline blends and by increasing the use of biodiesel (BD) and renewable diesel (RD). Opportunities exist for production of ethanol in New Mexico using cellulosic biomass, which has a much lower CI than ethanol produced using corn. New Mexico is already increasing in-state production of RD, and opportunities exist to potentially increase this further using existing petroleum fuel infrastructure. New Mexico has favorable geology for geologic storage of carbon dioxide, and carbon capture and storage (CCS) provides a means of reducing the CI of conventional fuels as well as reducing the CI of biofuels. Rapidly implementing strategies to reduce the CI of internal combustion engine vehicle (ICEV) fuels would then provide the time needed to increase the production and use of alternative vehicles and fuels. Additional detail on fuel use rates is presented in Section 2.0 of this report, and implementation strategies and opportunities are presented in Section 3.0.

Policy and Market Shifts Driving Change

Policy shifts are on the near horizon that will significantly affect the demand for low-CI transportation fuels. We expect the adoption of a CFS will work in concert with other policies and market forces to increase the demand for low carbon fuels. Notably, New Mexico’s proposed Clean Car rule will take effect in the 2025 time-frame The rule would require manufacturers to meet California’s fleet average motor vehicle emission standards for new light- and medium-duty vehicles delivered for sale and provide approximately eight percent qualifying zero-emission motor vehicles to New Mexico’s auto dealerships. The result will be a substantial increase in battery electric vehicle (BEV) sales in New Mexico by mid-decade. Sales of other alternative fuel vehicles, including compressed natural gas (CNG) and hydrogen fuel cell electric vehicles (HFCEVs), will also increase. However, sales of alternative fuel vehicles will depend on the existence of a statewide refueling infrastructure to abate buyers’ legitimate concerns about “range anxiety”. The Federal Highway Administration (FHWA) is committed to establishing a national network of alternative fueling and charging infrastructure along national highway system corridors. New Mexico has already nominated approximately 2,550 miles of state and interstate highways as alternative fuel corridors (AFCs), and so we can reasonably forecast the buildout of at least 50 alternative fueling stations along these corridors, with electric charging station infrastructure being installed at 50-mile intervals, and infrastructure to deliver hydrogen and compressed/liquified low-CI fuels installed at 100-mile intervals. The level of interstate long-haul truck traffic along I-40 and I-10 suggests that early demand for alternative fueling stations will occur on these corridors followed by the I-25 corridor, with state highway buildout of such stations to follow.

Market shifts will also increase demand for the reliable availability of alternative fuels. The most significant such shift might be that by 2027 Daimler — the world's leading manufacturer of long-haul, heavy-duty trucks — will sell hydrogen trucks that cost less to buy and operate than its diesel trucks. By 2036, all of its long-haul trucks will be zero-emission vehicles[2]. Given the average 15-year life span for these vehicles, we forecast that demand for hydrogen fuel will begin to accelerate within five years. Similarly, the commitment of the major automobile manufacturers to electrify their lineups in the 2030 to 2035 time-frame will accelerate demand for electric vehicle (EV) charging infrastructure.

"Quick Start" Roadmap

The quick start projects – Summarized in Table 1 and described in greater detail in Section 4.0 of this report – represent a potential subset of projects needed to meet the 20% reduction in CI by 2030 by taking advantage of the unique resources and infrastructure available in New Mexico. The quick start projects alone would bring an estimated $470 million to New Mexico between now and 2030, as measured by the value of 673 permanent, direct, head-of-household jobs, 968 permanent indirect jobs, and nearly 2,300 construction jobs. The state would also see a $240M capital investment in production and manufacturing. These projects alone will not get the state over the 2030 finish line, and additional in-state production of alternative fuels and infrastructure to meet the 2030 target provides the potential for even greater opportunities.

New Mexico has a set of resources — feedstock and infrastructure — that it can leverage to help meet policy- and market-driven demand. Its immediately accessible feedstock resources include woody biomass, dairy manure, sunshine and wind, and natural gas. For example, hundreds of thousands of the state's forested lands require thinning to reduce the risk of catastrophic wildfire, and the resulting low- and no-value woody biomass no longer needs to be managed as a waste. Instead, it can be used as a feedstock for cellulosic ethanol, hydrogen, and bio-based co-products like carbon fiber, used widely in manufacturing. New Mexico is not only the nation's sixth-largest

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[2] World's Largest Long-Haul Truckmaker Sees Hydrogen-Fueled Future, Jack Ewing, New York Times, July 21,2021. https://www.nytimes.com/2021/05/23/business/hydrogen-trucks-semis.html

dairy state, but it also has the largest average herd size in the country, making it an ideal partner for manure-to-renewable natural gas projects in the Clovis-Portales, Roswell-Dexter, and Las Cruces areas. As the state's public utilities and electric co-ops expand charging infrastructure to support the growing adoption of BEVs, the revenue they generate from the sale of carbon credits will be used to further incentivize BEV adoption. Hydrogen can also be produced from New Mexico's abundant natural gas resources – and technologies are rapidly being developed that will re-use or sequester the carbon dioxide that would otherwise be emitted from steam methane reformation in further production of fuels or chemicals.

New Mexico's infrastructure resources could also contribute to meeting increasing demand for low-carbon fuels. Examples of such infrastructure include two existing but currently idled first-generation ethanol plants in Portales and Tucumcari. These facilities can be converted to second-generation, cellulosic ethanol plants by adding new processing equipment to the existing equipment. Another potential facility is Marathon's shuttered Gallup petroleum refinery. Although information isn't available to determine whether it would be economically feasible to convert it to an RD refinery, the possibility could be explored. HollyFrontier announced in 2020 the addition of a pretreatment unit and an RD production line to its refinery in Artesia, which will have an annual production capacity of 125 million gallons per year. Although the producer did not contemplate New Mexico at the time the expansion project was announced as the retail destination for its renewable fuel, some part of its annual RD production could be offered for sale in-state. Finally, REG started but did not complete a biodiesel production facility in the Clovis area, and this asset could be completed and expanded to an industry-standard 30 million gallons per year production capacity plant.

Table 1 presents the "quick start" alternative fuel project opportunities we identified, and their potential contribution to New Mexico's economy.

Table 1: Quick Start Transportation Fuel Projects and their Potential Contribution to New Mexico's Economy

Alternative Fuel		Annual Economic Contribution						
		2024	2025	2026	2027	2028	2029	2030
Cellulosic Ethanol[3]	# Construction Jobs	306	0	0	0	0	0	0
	Value Construction Jobs[4]	$18,975,000	$0	$0	$0	$0	$0	$0
	# Direct Jobs	38	38	38	38	38	38	38
	Value Direct Jobs	$2,375,000[5]	$2,375,000	$2,375,000	$2,375,000	$2,375,000	$2,375,000	$2,375,000
	# Indirect Jobs	65[6]	65	65	65	65	65	65
	Value Indirect Jobs	$2,675,200[7]	$2,675,200	$2,675,200	$2,675,200	$2,675,200	$2,675,200	$2,675,200
Value of CE		*$24,025,200*	*$5,050,200*	*$5,050,200*	*$5,050,200*	*$5,050,200*	*$5,050,200*	*$5,050,200*
RD/Biodiesel[8]	# Construction Jobs	242	0	0	0	0	0	0
	Value Construction Jobs	$15,000,000	$0	$0	$0	$0	$0	$0
	# Direct Jobs	30	30	30	30	30	30	30
	Value Direct Jobs	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000
	# Indirect Jobs	54[9]	54	54	54	54	54	54
	Value Indirect Jobs	$2,392,518[10]	$2,392,518	$2,392,518	$2,392,518	$2,392,518	$2,392,518	$2,392,518
Value of RD/BD		*$19,252,518*	*$4,252,518*	*$4,252,518*	*$4,252,518*	*$4,252,518*	*$4,252,518*	*$4,252,518*

[3] CAPEX for conversion of Portales plant (30MG/yr) and Tucumcari plant (3MG/yr) to cellulosic ethanol. $2.30/gal CAPEX for new construction, assume 50% cost for bolt-on conversion, then assume 50% construction wages from corn to cellulosic (https://www.piprocessinstrumentation.com/home/article/15551961/ethanol-plant-construct-costs-are-on-the-rise) = $34.5M Portales + $3.5M Tucumcari. Assume both plants will begin operation in 2024.
[4] For CE, RD/BD, RNG, and hydrogen, # construction jobs = value construction jobs/$62,000 avg annual age for construction worker.
[5] At average annual wage of $62,500.
[6] Regional Input-Output Modeling System (RIMS II), Bureau of Economic Analysis, Employment multiplier of 2.7087.
[7] RIMS II Earnings multiplier of 2.1264
[8] REG Clovis Investment assume $30M CAPEX, then assume 50% construction wages + 30 direct jobs * $62,000/job/yr
[9] RIMS II Employment multiplier 2.7916.
[10] RIMS II Earnings multiplier 2.2863.

RNG[11]	# Construction Jobs	363	0	0	0	0	0	0
	Value Construction Jobs	$22,500,000	$0	$0	$0	$0	$0	$0
	# Direct Jobs	30	30	30	30	30	30	30
	Value Direct Jobs	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000
	# Indirect Jobs	51[12]	51	51	51	51	51	51
	Value Indirect Jobs	$1,682,370[13]	$1,682,370	$1,682,370	$1,682,370	$1,682,370	$1,682,370	$1,682,370
Value of RNG		*$26,042,370*	*$3,542,370*	*$3,542,370*	*$3,542,370*	*$3,542,370*	*$3,542,370*	*$3,542,370*
Hydrogen[14]	# Construction Jobs	0	0	0	339	185	258	600
	Value Construction Jobs	$0	$0	$0	$20,992,000	$11,484,000	$15,968,000	$37,180,000
	# Direct Jobs	0	0	0	32	64	128	280
	Value Direct Jobs	$0	$0	$0	$1,984,000	$3,968,000	$7,936,000	$17,360,000
	# Indirect Jobs	0[15]	0	0	55	110	221	483
	Value Indirect Jobs	$0[16]	$0	$0	$1,305,869	$2,611,738	$5,233,475	$11,426,352
Value of H2		*$0*	*$0*	*$0*	*$24,281,869*	*$18,063,738*	*$29,127,475*	*$65,966,352*
BEV Charging Stations[17]	# Constr/Direct[18] Jobs	35	53	71	88	106	141	176

[11] 3 AD projects operational in NM by 2024 with CAPEX of $15M each; assume 50% of CAPEX is construction jobs.10 full-time jobs/facility at avg annual salary of $62,000

[12] RIMS II Employment multiplier of 2.7087

[13] RIMS II Earnings multiplier of 1.9045

[14] CAPEX for 4 Plants in 2027; 8 in 2028, 16 in 2029, 35 plants in 2030; Assume 50% of CAPEX is construction jobs. CAPEX cost estimate from industry survey: approx $50M for first 5 MT/day production capacity, then $3M/MT/day production capacity. 8 jobs/plant @ $62000/ea

[15] RIMS II Employment multiplier of 2.7087

[16] RIMS II Earnings multiplier of 1.9045

[17] 225 installed in 2024, 337-2025, 450-2026, 562-2027, 675-2028, 900-2029, 1125-2030; assumes 50-50 split Level II@$5K/ea and DC fast chargers@$40K/ea. Construction jobs for both BEV charging stations and alternative fuel stations are assumed to be direct jobs, filled by permanent employees of the charging network or alternative fuel providers. These employees will both construct new stations and maintain/resupply existing stations. Does not include public utility and co-op costs to upgrade power distribution system.

[18] Counted in totals as direct, permanent jobs.

	Value Constr/Direct Jobs	$2,514,512[19]	$3,807,690	$5,100,867	$6,322,202	$7,615,379	$10,129,891	$12,644,403
	# Indirect Jobs	37[20]	57	76	94	113	151	188
	Value Indirect Jobs	$2,274,376[21]	$3,444,055	$4,613,734	$5,718,431	$6,888,110	$9,162,487	$11,436,863
Value BEV Chg Stations		*$4,788,888*	*$7,251,745*	*$9,714,602*	*$12,040,633*	*$14,503,490*	*$19,292,378*	*$24,081,266*
Alternative Fueling Stations[22]	# Constr/Direct Jobs[23]	0	0	59	119	178	119	119
	Value Const/Direct Jobs	$0	$0	$5,000,000	$10,000,000	$15,000,000	$10,000,000	$10,000,000
	# Indirect Jobs	0[24]	0	63	127	190	127	127
	Value Indirect Jobs	$0[25]	$0	$4,522,500	$9,045,000	$13,567,500	$9,045,000	$9,045,000
Value Alternative Fuel Stations		*$0*	*$0*	*$9,522,500*	*$19,045,000*	*$28,567,500*	*$19,045,000*	*$19,045,000*
TOTAL ANN. PERM. JOBS CREATED		***340***	***378***	***537***	***783***	***1,029***	***1,155***	***1,641***
TOTAL ANN. VALUE		***$74,108,976***	***$20,096,833***	***$32,082,190***	***$68,212,590***	***$73,979,815***	***$80,309,941***	***$121,937,706***
TOTAL VALUE JOBS THRU 2030	***$470,728,050***[26]							

[19] Based on $34.54/hr wage for IBEW journeyman electrician in NM in 2021.
[20] RIMS II Employment multiplier of 2.0699
[21] RIMS II Earnings multiplier of 1.6582
[22] CAPEX approx $2,000,000 per station (https://afdc.energy.gov/fuels/natural_gas_infrastructure.html); construction jobs =50% of CAPEX and captured under value direct jobs. # direct jobs = value direct jobs/($40.55/hr * 2080) for union pipefitter in NM (https://www.indeed.com/cmp/Ua-Local-412-Plumber-and-Pipefitters/salaries/Plumber/New-Mexico).
[23] Counted in totals as direct, permanent jobs.
[24] RIMS II Employment multiplier of 2.0699
[25] RIMS II Earnings multiplier of 1.9045
[26] Value of construction, direct, and indirect jobs only; does not include state taxes paid; does not include CFS credit value.

NEW MEXICO CLEAN FUELS STANDARD ECONOMIC IMPACT ANALYSIS

1.0 Introduction

New Mexico is considering legislation to create a Clean Fuels Standard (CFS) that would require reducing the carbon intensity[27] (CI) of transportation fuels by 20% by 2030, and by an additional 10% by 2040. This report was prepared to examine issues related to implementing a CFS in New Mexico. Although other states have implemented, or are implementing similar programs (e.g., California's Low Carbon Fuel Standard and Oregon's Clean Fuels Program), New Mexico faces unique challenges due to factors such as its size and population density, transportation framework, and resource base, including its position as a major producer and exporter of petroleum and natural gas. Section 2.0 looks at the types, quantities, and CIs of transportation fuels currently used in New Mexico, as well as the types, availabilities, and CIs of alternative fuels to identify fuel use changes that could achieve a 20% CI reduction. Section 3.0 looks at the changes that would be needed for each fuel type to identify issues associated with making those changes and strategies for achieving the changes. Section 4.0 then discusses potential economic impacts associated with the implementation strategies and opportunities for economic growth associated with each affected fuel type. This document is a companion to the NM Clean Fuel Standard District Analysis dated December 31, 2021, which presents series of maps and feedstock summaries for each NM House and Senate district to forecast which districts have the potential to support one or more types of clean fuels projects[28].

2.0 Estimated Fuel Use Rates to Meet Clean Fuels Standard Targets

The future use rates of conventional and alternative vehicle fuels resulting from implementation of a CFS for New Mexico were estimated to provide a framework for evaluating opportunities for economic development from the CFS. The CFS would set a target for reducing the CI of transportation fuels by a total of 20% by the end of 2030, starting in 2024. Because the current CIs of conventional transportation fuels (e.g., gasoline and diesel) are greater than the annual target CIs, meeting the targets would require implementing increased use of low-CI alternative fuels, as well as reducing the CIs of conventional fuels. A spreadsheet model was developed that calculated the overall annual CIs resulting from assumed fuel use rates and CIs of conventional and alternative fuels. Although there are numerous potential fuel use scenarios for meeting targets, the scenarios used in the model were chosen to be representative of achievable levels of alternative fuel use within the model timeframe. More importantly, they provided insight into which fuels could potentially have the greatest impact on CI over which time frames.

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[27] Carbon intensity is the quantity of life cycle greenhouse gas emissions associated with production, distribution, and use of a transportation fuel, per unit of fuel energy, expressed in grams of carbon dioxide equivalent per megajoule (gCO2e/MJ).
[28] New Mexico Clean Fuel Standard District Analysis, Adelante Consulting, Inc. December 31, 2021.

The transportation fuels evaluated included gasoline and gasoline substitutes for light-duty vehicles and diesel and diesel substitutes for medium- and heavy-duty vehicles. The baseline CI for gasoline was calculated using lookup table CIs for gasoline blendstock and ethanol from the California Air Resources Board (CARB) Low Carbon Fuel Standard (LCFS) regulations[29] assuming a blend of 10% by volume ethanol. The baseline CI for diesel is equal to the LCFS lookup table CI for diesel[30] and assumes no blending with biodiesel. For the purpose of this exercise, target CIs for each year were based on a linear reduction of the gasoline and diesel CIs by 20% over 7 years from 2024 to 2030 (i.e., 2.86% per year).

CI-reduction scenarios for gasoline and substitutes included the following:

- Increased use of ethanol blending.
- Increased use of battery electric vehicles (BEVs) and increased use of low-CI electricity for BEV recharging.
- Introduction and increasing use of hydrogen fuel cell electric vehicles (HFCEVs) with increased production and use of low-CI hydrogen.
- Reduction of gasoline CIs through actions such as use of low-CI hydrogen in refining and carbon capture and storage (CCS).
- Reduction of ethanol CIs through increased use of cellulosic ethanol and other low-CI ethanol sources.

CI-reduction scenarios for diesel and substitutes included the following:

- Increased use of biodiesel blending.
- Increased use of renewable diesel, with reductions in CI over time through use of lower-CI feedstocks.
- Increased use natural gas vehicles (NGVs).
- Increased use of renewable natural gas (RNG) in NGVs.
- Introduction and increasing use of HFCEVs for long-haul trucking with increased production and use of low-CI hydrogen.

2.1 Light-Duty Vehicles

2.1.1 Blended Gasoline

A baseline blend rate of 10% ethanol by volume was assumed, corresponding to the current use of E10 blend for most of the gasoline sold in New Mexico. The total blend rate used in the model was increased to 15% in 2025 and to 20% in 2030. The increased blend could result from a combination of increased use of E15 blends and increased use of E85 flex-fuel vehicles. The total use of ethanol would increase from 101 million gallons per year (MGY) in 2024, which is equal to the current consumption, to 204 MGY in 2030. Total gasoline blendstock use would decline from 909 MGY in 2024 to 816 MGY in 2030.

Based on the assumed sizes of the BEV and HFCV fleets (discussed below), blended gasoline would remain the primary fuel for light-duty vehicles in New Mexico, providing

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[29] Title 17, California Code of Regulations (CCR), section 95488.5(e), Table 7-1.
[30] Ibid.

approximately 97% of the total energy use in 2030. In order to meet CI reduction goals, therefore, the model included not only replacing gasoline vehicles with EVs and HFCVs, but also reducing the CI of gasoline and ethanol. The model assumes the CI of gasoline would be reduced by 1% per year, from a baseline value of 100.82 gCO2e/MJ in 2024 to 94.92 gCO2e/MJ in 2030. The model assumed an initial CI for ethanol of 90 gCO2e/MJ, which corresponds to the LCFS regulation temporary pathway CI for corn ethanol[31]. Use of this value for the baseline assumes an initial low availability of lower-CI ethanol in New Mexico due to high demand in California. The model assumes a gradual reduction of ethanol CI by 5 to 10 gCO2e/MJ per year to a value of 40 gCO2e/MJ in 2030. For comparison, the 350 ethanol pathways currently approved by CARB[32] have a mean value of 63.6 gCO2e/MJ and a median value of 67.3 gCO2e/MJ and the 53 cellulosic ethanol pathways currently approved by CARB[33] have a mean value of 29.8 gCO2e/MJ and a median value of 28.3 gCO2e/MJ.

2.1.2 Battery Electric Vehicles (BEVs)

The evaluation focused on BEVs, assuming they would be the primary type of electric vehicle, and did not specifically address plug-in hybrid electric vehicles. The total number of BEVs registered in New Mexico in 2021 was 2620[34]. Given current national trends for increased BEV use, and the expected increase in New Mexico resulting from the proposed clean cars rule[35], the model assumed 5% of the yearly new automobile sales in New Mexico in 2022 and 2023 will be BEVs (assuming an average vehicle lifetime of 12 years), resulting in a fleet size of 2890 by 2024. The model then assumes the yearly new vehicle sales percentages will increase to 7.5% in 2025, 10% in 2036, 12.5% in 2027, 15% in 2028, 20% in 2029, and 25% in 2030. This rate of increase would result in a fleet size of approximately 51,000 BEVs by 2030.

Along with increasing the number of BEVs with time, the model also assumes a reduction in CI of the electricity used for BEV recharging. The current CI for grid electricity[36] was taken as the regional grid average for Arizona and New Mexico from the CA-GREET 3.0 model[37]. Both Arizona and New Mexico have set goals for increasing the use of renewables in electrical generation. Arizona Public Service has a goal of 65% renewable power by 2030[38] and New Mexico recently passed the Energy Transition Act which has a standard of 50% use of renewables by 2030. Based on the data in the

[31] Title 17, CCR, section 95488.9(b)(4), Table 8.

[32] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

[33] Ibid.

[34] https://electrek.co/2021/08/24/current-ev-registrations-in-the-us-how-does-your-state-stack-up/

[35] https://www.env.nm.gov/wp-content/uploads/2021/11/2021-10-25-PR-Draft-Rule-Release-and-CleanCarsNM-PublicMtg-3-FINAL.pdf

[36] Grid electricity refers to electricity generated off-site and may be from a mixture of fossil fuel and renewable sources.

[37] https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation

[38] https://www.aps.com/en/About/Our-Company/Clean-Energy

U.S. Environmental Protection Agency's (EPA's) 2019 eGRID data[39], Arizona currently has approximately 39% renewables (including nuclear) and New Mexico has approximately 24% renewables. Therefore, both states have targets of achieving an approximate 26% increase in renewables by 2030. For the model evaluation, the current regional grid average CI (128.01 gCO2e/MJ) was reduced by 26% over the period 2022 to 2030. The model assumed 75% of the electricity used for BEV recharging in 2024 was electricity having the grid average CI, with the remainder being zero-CI electricity (e.g., wind or solar). The percentage of grid CI electricity was reduced to 70% in 2025, 65% in 2026, 60% in 2027, 55% in 2028, 50% in 2029, and 25% in 2030.

The BEV scenario assumed in the model would require 179,000,000 kwh of zero-CI electricity dedicated for BEV recharging in 2030. Based on EPA's 2019 eGRID data, New Mexico generated at total of 8,266,000,000 kwh of electricity from solar and wind in 2019[40].

2.1.3 Hydrogen Fuel Cell Electric Vehicles (HFCEVs)

There is currently no use of HFCEVs in New Mexico although this is expected to change due to New Mexico's proposed clean cars rule. The model assumed 0.5% of the yearly new automobile sales in New Mexico in 2022 and 2023 will be HFCVs, resulting in a fleet size of 269 by 2024. The model then assumes the yearly sales percentages would remain at 0.5% in 2025 and 2026 and increase to 1% in 2027 and 2028 and 2% in 2029 and 2030. This rate of sales increase would result in an HFCEV fleet size of 4010 by 2030. This modest rate of increase would allow time for development of a hydrogen production and distribution infrastructure as well as development of increased availability of commercially-available HFCEVs. The hydrogen initially used for transportation was very conservatively assumed to consist of 75% "grey" hydrogen (i.e., produced by steam reforming of fossil methane with no CCS) with the balance being low-CI hydrogen. The percentage of grey hydrogen decreases over time to 50% in 2025, 40% in 2026, 30% in 2027, 15% in 2029, and 0% in 2029 and 2030. The CI used for low-CI hydrogen was 10.51 gCO2e/MJ, which is the LCFS lookup value for hydrogen produced by electrolysis using zero-CI electricity[41] (i.e., green hydrogen). Although there are currently no approved LCFS pathways for blue hydrogen (i.e., steam reforming of fossil methane with CCS), CIs similar to green hydrogen are expected, particularly if captured fugitive methane is used as the methane source.

The HFCEV scenario assumed in the model would require 14,100 kg of low-CI hydrogen in 2024, increasing to 850,000 kg in 2030. There is currently no production of commercially-available low-CI hydrogen in New Mexico.

[39] https://www.epa.gov/egrid/egrid-2019-summary-tables

[40] Ibid.

[41] Title 17, CCR, section 95488.5(e), Table 7-1.

2.2 Medium- and Heavy-Duty Vehicles

2.2.1 Unblended Diesel

The model assumed unblended diesel use would provide the balance of medium- and heavy-duty fuel not provided by biodiesel blends, renewable diesel, CNG, or RNG. The CI used for unblended diesel was the LCFS lookup table value for diesel[42] (100.45 gCO2e/MJ). Based on the assumed usages of biodiesel blends, renewable diesel, CNG, RNG, and HFCEVs, the model showed unblended diesel initially comprising 44% of the medium- and heavy-duty fuel use in 2024, decreasing to 0% in 2029 and 2030. This use rate is equivalent to 346 MGY in 2024, decreasing to 0 MGY in 2029.

2.2.2 Biodiesel Blends

A baseline blend rate of 5% biodiesel by volume was assumed, based on the current New Mexico mandate. The total blend rate was increased to 10% in 2025, and maintained at that level. The model assumed that blended biodiesel would account for 50% of the medium- and heavy-duty fuel use in 2024. This rate would increase to 60% in 2025 and remain at that rate until 2030, where it would decrease slightly to 57% based on increased use of renewable diesel. The model assumed a CI for diesel blendstock of 100.45 gCO2e/MJ, which is equal to the LCFS lookup table value for diesel[43]. The evaluation assumed a CI for biodiesel of 45.0 gCO2e/MJ, which is equal to the LCFS regulation temporary pathway CI for biomass-based diesel produced from fats, oils, and grease residues[44].

The fuel use assumed by the model would require a baseline of 27 MGY of biodiesel for blending in 2024, increasing to 66.6 MGY from 2025 to 2029 and decreasing slightly to 63.3 MGY in 2030. There is currently no production of biodiesel in New Mexico. Neighboring Texas has 8 biodiesel producers having a production capacity of 380 MGY in 2020[45].

2.2.3 Renewable Diesel

The model assumes renewable diesel would provide 4% of the total medium- and heavy-duty fuel use in 2024, increasing to 8% in 2025, 15% in 2026, 20% in 2027, 25% in 2028, 33% in 2029, and 35% in 2030. The baseline CI for renewable diesel was assumed to be 65 gCO2e/MJ, which corresponds to the LCFS regulation temporary pathway CI for biomass-based diesel produced from feedstocks derived from plant oil, excluding palm oil[46]. Use of this value for the baseline assumes an initial low availability of lower-CI renewable diesel in New Mexico due to high demand in California. The model assumes a gradual reduction of renewable diesel CI by 5% per year to a value of 47.78 gCO2e/MJ

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42 Ibid.

43 Ibid.

44 Title 17, CCR, section 95488.9(b)(4), Table 8.

45 https://www.eia.gov/biofuels/biodiesel/production/

46 Title 17, CCR, section 95488.9(b)(4), Table 8.

in 2030. For comparison, the 38 renewable diesel pathways currently approved by CARB[47] have a mean value of 34.32 gCO2e/MJ and a median value of 32.47 gCO2e/MJ.

The fuel use assumed by the model would require a baseline of 32.6 MGY renewable diesel in 2024, increasing to 285 MGY in 2030. There is currently no renewable diesel production in New Mexico, but HollyFrontier has announced plans to construct a renewable diesel unit (RDU) at its Navajo Refinery in Artesia[48]. The RDU is expected to come online in early 2022 and have a capacity of approximately 125 MGY. Total production capacity in the United States was approximately 600 MGY at the end of 2020, and was expected to increase to approximately 5100 MGY by the end of 2024[49].

2.2.4 Natural Gas

The estimated use of natural gas as a transportation fuel was based on the total use of natural gas in New Mexico (305 trillion BTU in 2019)[50] and the estimated percentage (0.2%) used as transportation fuel[51]. This amount is equivalent to approximately 0.6% of the total medium- and heavy-duty fuel use. The model assumed NGVs accounted for 1% of medium- and heavy-duty fuel use in 2024, and that this percentage remained constant through 2030, with any increase in natural gas transportation fuel use being supplied by RNG. The evaluation assumed a CI for compressed natural gas (CNG) of 79.21 gCO2e/MJ, which is the LCFS lookup table value[52].

The fuel use assumed by the model would require 1 trillion BTU per year of CNG from 2024 through 2030. As noted above, total natural gas use in New Mexico in 2019 was 305 trillion BTU.

2.2.5 Renewable Natural Gas (RNG)

The model assumed the baseline usage of RNG would be 1% of the total medium- and heavy-duty fuel use in 2024 (i.e., the same as CNG), and would increase by 1% per year to 7% in 2030. The model assumed a CI for RNG of 57.5 gCO2e/MJ, which is equal to the average of the LCFS regulation temporary pathway CIs for biomethane from landfill gas (70 gCO2e/MJ) and biomethane from municipal wastewater sludge, food scraps, urban landscaping waste, and other organic wastes (45 gCO2e/MJ)l[53]. This CI is conservative and higher than many RNG CIs that have been approved under the California LCFS program, and the potential exists to develop RNG projects having lower CIs.

The fuel use assumed by the model would require 1 trillion BTU per year of RNG in 2024, increasing to 7 trillion BTU per year in 2030. RNG production in New Mexico is currently

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[47] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

[48] https://s25.q4cdn.com/488560379/files/doc_news/archive/6dd6a463-3718-46cb-9b5a-b02c7c4e0e22.pdf

[49] https://www.eia.gov/todayinenergy/detail.php?id=48916

[50] https://www.eia.gov/state/print.php?sid=NM

[51] https://afdc.energy.gov/fuels/natural_gas_basics.html

[52] Title 17, CCR, section 95488.5(e), Table 7-1.

[53] Title 17, CCR, section 95488.9(b)(4), Table 8.

at a scale where it is more efficient to use the gas for on-site electricity generation, though there is some on-site and fleet use as CNG in vehicles[54].

2.2.6 Hydrogen

Hydrogen also has applications for medium- and heavy-duty vehicles. As with light-duty applications, there is currently no HFCEV use in New Mexico for medium- and heavy-duty applications, nor refueling infrastructure to support such use. The fuel use evaluation assumes the first major use of HFCEVs in New Mexico will for refueling long-haul trucks. HFCEVs have a greater range than BEVs or NGVs for long-haul applications and the concentration of long-haul trucking along certain corridors (e.g., interstate highways) provides an opportunity for an efficient buildout of refueling infrastructure. Daimler, the world's largest manufacturer of semi-trucks, recently announced that by 2027 it will sell HFCEV semi-trucks that cost less to buy and to operate than ICE trucks, and by 2036 all of its long-haul trucks will be zero-emission vehicles[55]. Based on this announcement, the fuel use model assumes use of HFCEVs for long-haul trucking will begin in 2027. Initially, the model assumed that 1% of the long-haul fleet traveling through New Mexico would be replaced by HFCEVs in 2027 and that this annual replacement rate would increase by 1% per year through 2030, resulting in 10% of the fleet being HFCEVs in 2030.

Use of hydrogen for long-haul trucking was estimated from the number of interstate crossings through New Mexico. Based on New Mexico Department of Transportation (NMDOT) data on interstate crossings and percentage of truck traffic, an average of 4680 truck crossings was assumed for I-10, 1416 for I-25, and 6000 for I-40[56]. The model assumed that the number of HFCEV crossings would be 1% of the total crossings in 2027, 3% in 2028, 6% in 2029, and 10% in 2030. Given an expected range of 600 mi[57], not every crossing would require refueling in New Mexico. Therefore, the model assumed an average 33 kg of hydrogen purchased in New Mexico associated with each crossing. This amount of hydrogen represents approximately 60% of the hydrogen estimated to be needed for a 600 mi range.

The same blend of grey hydrogen and low-CI hydrogen described in section 2.1.3 for light duty HFCEVs was assumed (i.e., 30% grey hydrogen in 2027, 15% in 2029, and 0% in 2029 and 2030), as were the same hydrogen CIs.

The HFCEV scenario assumed in the model would require 1,010,000 kg per year of low-CI hydrogen for long-haul trucking in 2027, increasing to 14,400,000 kg per year in 2030. As described in section 2.1.3, there is currently no production of commercially-available low-CI hydrogen in New Mexico.

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[54] http://www.resourcerecoverydata.org/biogasdata.php

[55] https://www.nytimes.com/2021/05/23/business/hydrogen-trucks-semis.html

[56] https://www.nmlegis.gov/handouts/TIRS%20101017%20Item%201%20B%20-%20Interstate%20Traffic%20data-map.pdf

[57] https://www.nytimes.com/2021/05/23/business/hydrogen-trucks-semis.html

3.0 Implementation Strategies and Opportunities

As previously noted, the exact fuel use blend that would result from implementation of a CFS in New Mexico depends on a number of factors, and the scenarios presented in Section 2.0 are just one possibility. The following sections discuss changes that are expected to result to each of the major transportation fuel types, issues related to implementing these changes, and opportunities for economic growth that might result.

3.1 Gasoline

Gasoline is the major transportation fuel used in New Mexico and has the greatest impact on transportation CI. Because gasoline comes from numerous sources which all get blended in pipelines or bulk terminals, other CFS programs (e.g., California and Oregon) have opted to treat all petroleum-derived gasoline as having the same CI. Thus, the primary strategy for lowering the CI of blended gasoline requires using low-CI ethanol and/or increasing the ethanol content of the blended gasoline.

It is possible to produce low-CI gasoline, but a producer of low-CI gasoline would need to separately manage its product from the point of production through vehicle fueling to avoid blending with higher-CI gasoline. The CFS would provide an incentive for producers of low-CI gasoline to distribute and sell their products in New Mexico since they would be able to generate credits in addition to providing a “green premium”. Because they would not be able to utilize the existing petroleum product distribution network, this approach would likely be limited to urban areas, such as Albuquerque in order to maximize the density of retail sales. Due to the time needed to plan, construct, and permit a new facility, production and sale of low-CI gasoline is unlikely to provide the opportunity for significant CI reduction in the 2030 time frame.

Another possibility would be to encourage producers who will not offer retail sales but choose to distribute their gasoline through pipelines and bulk terminals to take credit for lowering their CI. Although this has not been used by other programs, the New Mexico CFS could consider a book-and-claim approach whereby credits could be generated for low-CI gasoline that is blended with other gasoline delivered for sale in New Mexico. This approach is currently used in California for RNG injected into pipelines and low-CI electricity used for production of hydrogen through electrolysis.

3.2 Ethanol

Increased use of low-CI for ethanol is needed to substantially lower the CI of blended gasoline used for transportation. Due to the cost and carbon intensity of feedstock transportation, fuel ethanol is generally produced within 75 mi of the feedstock source, which could limit New Mexico’s opportunities for local production to areas with sufficient feedstock. The production of cellulosic, or “second generation” ethanol is the optimal choice for significant in-state ethanol production with local feedstocks since it does not compete for feedstock with food production. Potential cellulosic feedstock sources include agricultural and forest residues.

Another option of lowering the CI of blended gasoline is to increase the ethanol blend rate. The blend rate is currently capped by EPA at 10% (E10) under Clean Air Act regulations, with a waiver for E15 for 2001 and newer light-duty vehicles during non-summer months. Thus, ethanol blending above 15% would require a regulatory change by EPA. There have been concerns in the past about engine damage resulting from E15 use, but a recent evaluation by the Renewable Fuels Association shows that nearly 95 percent of new model year 2022 vehicles sold will carry the manufacturer's unequivocal approval to use E15[58]. Ethanol producers are advocating for increasing the blend to 30%, which should be technically feasible for most newer vehicles without causing engine damage. Flex fuel vehicles are already approved for use of up to 85% ethanol. Use of E85 in New Mexico is limited, however, with only 12 public and 6 private E85 fueling stations currently located in the state.

3.3 Biodiesel/Renewable Diesel

Biodiesel (BD) and renewable diesel (RD) provide the best opportunity to quickly lower the CI associated with medium- and heavy-duty vehicle use. BD and RD diesel use can be readily increased with using the existing fuel distribution infrastructure. BD (at blends of up to 5% for nearly all diesel applications and up to 20% for many engines) can readily be blended with petroleum diesel at existing distribution terminals. Additionally, RD can be used neat or at any blend level (with or without BD) with petroleum diesel. Accordingly, increased blending of BD and RD in the diesel pool can be utilized with the current diesel fleet to generate substantial volumes of CFS credits in the near-term with the existing distribution infrastructure.

There will likely be high demand for low-CI RD from all states having LCFS/CFS programs and New Mexico will have to compete for lower-CI fuels. Therefore, even though RD will be produced in New Mexico at HollyFrontier's Artesia facility, the New Mexico CFS credit price would need to be high enough to compete with the high California credit value.

3.4 Renewable Natural Gas

California's LCFS program has generated great demand for low-CI RNG. Currently, 98% of the NGV fuel use in California is being met with very-low-CI RNG. California's use of NGVs in the heavy-duty transportation sector was facilitated by incentives and regulations aimed at driving diesel fleets to convert to NGVs. New Mexico does not have similar incentives and has not developed NGV fleets and CNG/LNG infrastructure. The ability to use RNG in state would be limited until vehicles could be converted and a refueling infrastructure established. CNG/LNG use in New Mexico is currently equal to only 0.6% of the total diesel transportation fuel use. There are currently only 8 public and 3 private CNG fueling stations and 1 public LNG fueling station in New Mexico[59]. Expanding the LNG infrastructure would be desirable since LNG has sufficient energy density to be used for longer distance applications.

California's use of book-and-claim accounting for RNG under the LCFS program has facilitated out-of-state production of RNG used as transportation fuel in California. Use

[58] http://ethanolproducer.com/articles/18849/rfa-more-my-2022-vehicles-approved-for-e15-fewer-ffvs

[59] https://afdc.energy.gov/stations/states

of book-and-claim accounting by New Mexico's CFS would promote RNG production in New Mexico since potential RNG sources such as dairies are not located near major population centers, but are located near natural gas pipelines.

Although the amount of RNG used in California should not increase substantially, California's higher credit value should continue to attract the very-low-CI RNG, and the RNG available in New Mexico would be expected to have higher CIs unless New Mexico credit prices were similar to California's.

3.5 Battery Electric Vehicles

New Mexico currently has relatively low use of BEVs compared to other states, with 2,620 vehicles registered in the state as of December 2020[60]. There are currently 170 public charging locations in New Mexico, with 404 charging stations (2 Level 1, 279 Level 2, and 123 DC Fast)[61]. There are an additional 16 private charging locations with 51 charging stations (8 Level 1, 38 Level 2, and 5 DC Fast)[62]. Because of higher voltage and current requirements compared to Level 1 or Level 2 stations, increasing the number DC Fast charging stations could require upgrades in local substations or local distribution lines. The cost of these required electric infrastructure upgrades can be significant and difficult for owners to recover if charger utilization is low, such as with remote locations. Both California and Oregon require electrical utilities to invest some of the revenue from LCFS/CFP credits for BEV charging in incentives for BEV purchase and installation of EV supply equipment (EVSE) infrastructure. New Mexico will likely require both grid upgrades and a reduction in the CI of the New Mexico grid mix to facilitate growth in the BEV fleet and this may limit the rate at which the fleet can grow. Reduction of the grid CI, however, is already mandated by New Mexico's Energy Transition Act, which requires 50% renewable electric power by 2030.

3.6 Hydrogen Fuel Cell Electric Vehicles

Although New Mexico has tremendous potential for production of hydrogen, there is currently no use of hydrogen as transportation fuel, only limited hydrogen production and no distribution infrastructure beyond using natural gas pipelines to carry a blendstock of 80% natural gas and 20% hydrogen. Most of the hydrogen use for transportation fuel in the U.S. is currently in California. In addition to the lack of production and distribution infrastructure, there is also limited commercial availability of hydrogen fuel cell vehicles, although this will change when New Mexico's proposed clean cars rule becomes effective in 2026[63].

The current New Mexico administration is advocating for New Mexico to become a hydrogen hub and has proposed legislation for this. If successful, the legislation should expedite the production of low-CI hydrogen and development of a hydrogen distribution

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[60] https://afdc.energy.gov/data/10962

[61] https://afdc.energy.gov/stations/states

[62] Ibid.

[63] https://www.env.nm.gov/wp-content/uploads/2021/11/2021-10-25-PR-Draft-Rule-Release-and-CleanCarsNM-PublicMtg-3-FINAL.pdf.

infrastructure. The California LCFS allows book-and-claim accounting for low-CI electricity supplied from off site to be used for production of hydrogen by electrolysis. A similar approach could be used in New Mexico to facilitate use of electricity from solar and wind for production of green hydrogen.

3.7 Discussion

The ability for New Mexico to meet a target of 20% CI reduction by 2030 will be challenged by the existing vehicle fleet and alternative fuels infrastructure. The ability to generate CFS credits will provide an incentive to expedite development of alternative fuels production and infrastructure. The ability to secure low-CI fuels, however, will depend on credit prices and the ability to compete with other states such as California and Oregon. New Mexico's ambitious CI-reduction target should, however, bolster credit prices.

Given the current vehicle fleet and fueling infrastructure, the greatest opportunity for CI reduction appears to be through increased use of ethanol in light-duty vehicles and increased use of biodiesel and renewable diesel in medium- and heavy-duty vehicles. Use of these fuels can be increased using existing infrastructure, allowing time for development of alternative fuel infrastructure.

It appears blended gasoline (with a 15% ethanol content) will be able to meet the CI target through 2027, assuming an ethanol CI of 67 gCO2e/MJ in 2024, decreasing to 20 gCO2e/MJ in 2027. CIs in that range would likely only be available from cellulosic ethanol. After 2027, it would likely be necessary to increase the blend rate above 15% in order to continue meeting the CI target or achieve further reductions in ethanol CI. Such reductions could potentially be achieved through carbon capture and storage (CCS). If New Mexico develops either a CCS capability, or a bolt-on bio-based chemical production line that uses waste CO2 as feedstock for producing blue hydrogen, these capabilities could also be used to store or process the carbon dioxide produced during ethanol fermentation and further reduce the CI of ethanol produced in New Mexico. Increasing the fleet of flex-fuel (E85) vehicles would also increase overall use of ethanol and effectively increase blend rate. Currently, however, the availability of flex-fuel vehicles is declining, and only Ford and General Motors will offer flex-fuel models in model year 2022[64], although this status could change with the Clean Cars rule.

A similar issue applies to the ability of biodiesel blends to meet the CI targets for diesel. Assuming a 10% blend of biodiesel, the biodiesel CI would need to be 12 gCO2e/MJ to achieve the 2026 diesel CI target. After that, it would be necessary to gradually increase the blend percentage to 22% by 2030 to continue to meet the CI target. Fortunately, the CIs for all renewable diesel fuels are less than the 2030 CI target, so renewable diesel can be used to generate credits and meet the diesel CI target.

In the immediate term, BEVs are expected to have minimal impact on meeting CI targets. To increase the impact of BEVs, it will be necessary to substantially increase the BEV fleet, which will also require expanding the EVSE recharging network. The effectiveness

[64] http://ethanolproducer.com/articles/18849/rfa-more-my-2022-vehicles-approved-for-e15-fewer-ffvs

of BEVs in meeting CI targets can also be increased through use of low- or zero-CI electricity for recharging. The CI of grid electricity in New Mexico is expected to decrease substantially in the future as its renewables portfolio increases from 27 percent in 2021 to 50 percent by 2030. BEVs offer a significant advantage for credit generation because they have a high energy efficiency ratio (EER). On a specific energy basis, therefore, BEVs would generate 3.4 times as many credits as ICEVs.

As with BEVs, the impact of NGVs will be limited by the size of the vehicle fleet and the fueling infrastructure. The CI of fossil natural gas is less than the CI targets through 2030, so any use of natural gas as a vehicle fuel would aid in meeting CI targets. The CIs for RNG can be substantially less than the CI for fossil natural gas so RNG use has the potential for generating significant credits.

HFCEVs could be expected to have minimal impact on meeting the 2030 CI reduction goal based on the current dearth of vehicles and the absence of a refueling network. This forecast could change significantly if long-haul trucking accelerates its transition from ICEVs to HFCEVs, given that I-40, I-10 and I-25 all traverse New Mexico, with I-40 and I-10 handling particularly heavy long-distance trucking traffic. HFCEVs offer great potential for further reductions in CI past 2030 as the supply of low-CI hydrogen increases.

4.0 Economic Impacts

This section looks at economic impacts associated with reducing the CI of transportation fuels in New Mexico, focusing on the timeframe from the present through 2030, which is the period by which to achieve a 20% CI reduction. This evaluation builds on information presented in Section 2.0, which looked at the changes in fuel use that could achieve a 20% CI reduction and Section 3.0, which discussed strategies for implementing those fuel use changes. This section now looks at the potential economic impacts, including creation of jobs, associated with the implementation strategies. Section 4.1 discusses the results of a study performed in California to evaluate options for achieving carbon-neutral transportation by 2045 and how those results might apply to New Mexico. Section 4.2 then discusses potential opportunities associated with each of the fuel types associated with fuel CI reduction, providing specific examples when possible.

4.1 California Carbon-Neutral Transportation Study and Its Implications for New Mexico

The University of California institute of Transportation Studies recently published a report describing an analysis of options for achieving carbon-neutral transportation in California by 2045[65]. The report included an evaluation of socioeconomic impacts, including impacts to the workforce associated with transportation. The analysis considered three main categories of workforce impact—contractions in industries related to ICVEs and fossil fuels, expansion of industries related to BEVs, and expansion of industries related to HFCEVs.

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[65] Brown, Sperling, Austin, et al., 2021.

Because the California LCFS program has been in place for over 10 years, it is at a much greater state of maturity than a program that would just be starting. Therefore, the approaches being considered by California to further reduce carbon intensity after 10 years would be different than those that would be implemented by New Mexico at the start of their program. Thus, the results of the California study would not be directly applicable to New Mexico. Nevertheless, the results present useful insight into potential economic impacts associated with a New Mexico CFS.

The fuel use scenario considered in the impact analysis included reducing gasoline usage from a maximum of approximately 14 billion gallons in 2020 to 0 in 2045. Similarly, fossil diesel usage would be reduced from a maximum of approximately 3 billion gallons gasoline equivalent (GGE) in 2020 to 0 in 2045. The reduction in fossil fuel use is accompanied by increased use of bio-based gasoline (approximately 2.6 billion GGE in 2045), bio-based diesel (approximately 0.5 billion GGE in 2045), electricity (approximately 2.3 billion GGE in 2045), and hydrogen (approximately 1.3 billion GGE in 2045). Bio-based gasoline includes ethanol blends and drop-in gasoline replacements and bio-based diesel includes biodiesel and renewable diesel. For comparison, New Mexico's current use of gasoline is approximately 1 billion gallons and current use of diesel is approximately 0.88 billion GGE.

4.1.1 Internal Combustion Engine Vehicles and Fossil Fuel

The study predicted a reduction of jobs related to ICVEs and fossil fuels of approximately 730,000 full-time equivalent (FTE) job-years over the period 2020 to 2045[66], with most of these related to lower demand for ICVE maintenance and repair (333,000 FTE job-years), followed by jobs related to reduced sales of ICVEs (270,000 FTE job-years) and jobs related to reduced consumption of fossil fuels (127,000 FTE job-years)[67]. Over the 25-year period, this number of FTE job-years would be equivalent to 29,000 full-time jobs. Jobs related to new ICEV sales were reduced to virtually zero by 2045, but jobs related to ICEV maintenance and repair remained at approximately 80,000 FTE in 2045 and those related to fossil fuel consumption remained at approximately 25,000 FTE.

The magnitude of ICEV and fossil fuel impacts described in the California study reflect a program at a stage of maturity where alternative fuels and vehicles have been sufficiently developed to affect a significant reduction in ICEV fleet size and fossil fuel use. Similar reductions would not be expected in New Mexico as a result of the CFS. The BEV and HFCEV fleet sizes are currently very small, and are not expected to grow at a rate sufficient to result in a substantial reduction in ICEV fleet size in the near term. To the extent that BEVs and HFCEVs are used to replace ICEVs, loss of jobs associated with ICEV sales and maintenance could be offset by new jobs for BEV and HFCEV sales and maintenance. Reduced fossil fuel use in ICEVs is not expected to result in significant job

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[66] Ibid at 331.

[67] Based on the relative number of vehicles registered in California and New Mexico, New Mexico's sales, maintenance and repair sector is 4.3% of the size of California's. https://www.statista.com/statistics/196010/total-number-of-registered-automobiles-in-the-us-by-state/

loss since New Mexico is a net exporter of fossil fuels and reductions in in-state use would not affect exports.

4.1.2 Battery Electric Vehicles

The study predicted creation of over 4.8 million FTE job-years in California related to adoption of BEVs over the period 2020 to 2025[68]. These jobs would include labor related to the sales of new BEVs (over 3.5 million FTE job-years), consumption of electricity as a transportation fuel (over 370,000 FTE job-years), and maintenance for BEVs (over 883,000 FTE job-years).

The number of BEVs registered in California as of December 2020 was 425,300, as compared to 2620 in New Mexico[69]. Due to this large difference in fleet size, the impacts related to BEVs in New Mexico would be only a small fraction of those predicted for California. An increase in BEV fleet size in New Mexico resulting from a CFS is not expected to create job growth related to in-state BEV manufacture, but manufacturing in New Mexico could be used to support BEV growth in other states and take advantage of New Mexico's proximity to supply chains. An increase in BEV fleet size in New Mexico would result in jobs associated with retail sales and BEV maintenance. To the extent increased BEV use creates a demand for low-CI electricity for charging, this would likely result in in-state job creation.

The study predicted a significant portion of the jobs related to BEVs would be associated with construction of BEV charging infrastructure and installation of new EVSE. These activities are expected to create over 805,000 FTE job-years in California over the next 25 years, which is equivalent to slightly more than 32,000 full-time jobs spanning the 25-year period[70]. Occupations associated with EV charging infrastructure would include electricians, construction laborers, solar photovoltaic installers, and wind turbine service technicians. Similar job growth would be expected in New Mexico, although the magnitude would be much smaller. More importantly, the job growth would largely be local. Given the relatively small size of the charging infrastructure in New Mexico and the need for significant expansion, sustained job growth in this area would be expected.

4.1.3 Hydrogen Fuel Cell Electric Vehicles

The study predicted creation of over 1.5 million FTE job-years in California related to adoption of HFCEVs over the period 2020 to 2025[71]. These jobs would include labor related to the sales of new HFCVs (430,000 FTE job-years), production and distribution of hydrogen fuel (474,000 FTE job-years), and HFCEV maintenance (688,000 FTE job-years).

The magnitude of HFCEV job impacts in New Mexico would be expected to be similar to those for BEVs. That is, in-state HFCEV growth would not be sufficient to support manufacturing, but manufacturing capacity could be created to support HFCEV growth

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[68] Ibid at 341.

[69] https://afdc.energy.gov/data/10962

[70] Ibid at 350.

[71] Ibid at 348.

in other states. As with BEVs, local jobs should be created related to retail sales and vehicle maintenance. Hydrogen hub legislation in New Mexico could fuel job growth related to low-CI hydrogen production beyond that needed to service New Mexico's HFCEV fleet.

Similar to BEVs, the study predicted a significant portion of the jobs related to HFCEVs would be associated with construction of new hydrogen refueling infrastructure. These activities are expected to create over 92,000 FTE job-years in California over the next 25 years, which is equivalent to approximately 3,700 full-time jobs[72]. Occupations associated with HFCEV fueling infrastructure would include construction trades workers, engineers, engineering technicians, drafters, mappers. As with BEVs, similar job growth would be expected in New Mexico, although the magnitude would be much smaller, but job growth would largely be local. Since there is currently no hydrogen fueling infrastructure in New Mexico, sustained job growth in this area would be expected.

4.2 Opportunities for New Mexico

4.2.1 Ethanol

As described in section 3.2, there will be an immediate need for ethanol to increase blend rates. Over time, lower-CI ethanol will be needed to further reduce the CI of blended gasoline. Ethanol is available from out-of-state suppliers, but in-state production would have the benefit of job growth.

Use of existing production facilities in Portales and Tucumcari would be advantageous both in terms of lessening the time needed to begin production and lowering the initial capital investment. Production of "second generation" cellulosic ethanol would be advantageous due to the lower CI, although the existing facilities do not currently have the second-generation equipment needed to produce cellulosic sugars for fermentation. Such equipment can be added, however, without significant modification to the existing production infrastructure. Production of low-CI cellulosic ethanol has the potential for generating significant credits that could be used to offset investment costs. As noted in section 2.1.1, the 53 cellulosic ethanol pathways currently approved by CARB[73] have a mean value of 29.8 gCO2e/MJ and a median value of 28.3 gCO2e/MJ. Assuming a CFS credit price of $150/MTCO2e, cellulosic ethanol having a CI value of 30 gCO2e/MJ could generate credits worth approximately $0.80/gal in 2024. Additionally, dozens of bio-based chemicals can be produced as co-products of cellulosic ethanol (including eight such chemicals for which such production has already been commercialized[74]), further reducing the per-gallon production cost of cellulosic ethanol. Another potential high-value co-product is carbon fiber, which can be produced by electrospinning lignin, a waste that's generated from the production of cellulosic ethanol[75]. While not yet commercialized, this technology is currently being demonstrated.

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72 Ibid at 352.

73 Ibid.

74 https://biotechnologyforbiofuels.biomedcentral.com/articles/10.1186/s13068-019-1529-1

75 https://www.frontiersin.org/articles/10.3389/fenrg.2020.00208/full

Ethanol production through biological fermentation generates a substantial amount of carbon dioxide that is relatively easy to capture. Geologic storage of this carbon dioxide would result in a major reduction in the CI of the ethanol. As an alternative to sequestering carbon dioxide, it could be recycled as feedstock in a bio-based chemical production plant co-located with an ethanol plant. Creation of a hydrogen hub in New Mexico is likely to accelerate the development of both geologic sequestration projects and carbon dioxide waste-to-feedstock projects. Having this storage capacity and infrastructure available to ethanol producers, in addition to ample biomass feedstock, could provide an incentive for ethanol producers to locate in New Mexico.

Currently, there are 2 idled first-generation ethanol plants in New Mexico, located in Portales and Tucumcari within House Districts 66 and 67 and Senate Districts 27 and 8. Each one is located within a 75-mile radius of a 30-year supply of feedstock sufficient to produce at least 5 million gallons per year of low-CI ethanol. For forecasting purposes, we assume that both/all of these plants will be restarted as cellulosic ethanol plants. The facility in Portales, purchased by Natural Chem Group in 2016 is expected to create 35 jobs[76]. These direct jobs pay an annual national average salary of $62,000 to support operations[77]. The facility in Tucumcari, at about 10% of the size of the Portales plant, is expected to create three permanent jobs at an annual wage of $62,000 each.

4.2.2 Biodiesel and Renewable Diesel

As described in section 3.3, BD and RD provide the best opportunity to quickly lower the CI associated with medium- and heavy-duty vehicle use. BD and RD production are increasing in the U.S., so an adequate supply should be available to help meet CI reduction targets. In-state production, however, would help lower CI and would also offer the added benefit of economic development. The RDU at HollyFrontier's Navajo Refinery in Artesia is expected to come online in early 2022 and have a capacity of approximately 125 MGY, which would be sufficient to supply New Mexico's needs for several years. As with ethanol production, converting existing refining facilities to RD production could expedite the production process as well as reduce capital expenditures. As with cellulosic ethanol, RD production has the potential to quickly generate credits that could be used to offset investment costs. As noted in section 2.2.3, the 38 RD pathways currently approved by CARB[78] have a mean value of 34.32 gCO2e/MJ and a median value of 32.47 gCO2e/MJ. Assuming a CFS credit price of $150/MTCO2e, RD having a CI value of 34 CO2e/MJ could generate credits worth approximately $1.20/gal in 2024.

The Marathon refinery (aka Ciniza Refinery) with a capacity of 26,000 barrels/day of refining capacity was indefinitely idled in 2020, laying off 220 employees[79]. Located in

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[76] http://ethanolproducer.com/articles/13910/natural-chem-acquires-abengoa-plant-in-portales-new-mexico

[77] An annual average salary of $62,000 was used as being representative of the range of average salaries reported by various on-line recruiting services.

[78] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

[79] https://www.ogj.com/refining-processing/refining/article/14180915/marathon-permanently-idles-two-us-refineries

House District 9 and Senate District 3, this plant could be converted to produce RD similar to the Martinez Renewable Fuels Facility in California.

Additionally, it is expected that if a CFS passes, the partially-constructed15M gallon/year BD facility currently owned by REG near Clovis[80] could be completed and become operational. Completion of construction would require an assumed investment of $30M as the capacity would need to enlarged to 30M gallon/year to become sized at the industry standard. This project could result in 200-250 construction jobs, with an estimated 30 permanent jobs once it was operating again.

4.2.3 Renewable Natural Gas

California's LCFS program has created a huge demand for low-CI RNG. Agricultural wastes that currently release methane to the atmosphere have the potential to generate very low or negative CIs because of the CI credit given for methane abatement. Manure from dairies or confined livestock operations that is currently allowed to degrade and release methane and carbon dioxide to the atmosphere is a very attractive feedstock for this reason. New Mexico is the 6th largest dairy production state in the U.S. and it has the largest herd size, making it very attractive as a feedstock provider to RNG projects. (Note: while dry-lot herd management can indeed pose technical challenges to anaerobic digestion, these challenges have been overcome elsewhere.[81]) Dairy manure can be anaerobically digested to produce biogas. If the biogas is cleaned up to a pipeline quality RNG, the RNG can be injected into pipelines and can be used to generate CFS credits using book-and-claim accounting procedures. The 151 compressed RNG pathways currently approved by CARB[82] have a mean value of -29.51 gCO2e/MJ. Assuming a CFS credit price of $150/MTCO2e, RNG having a CI value of -30 gCO2e/MJ could generate credits worth approximately $2.00/therm in 2024.

New Mexico has large concentrations of dairies in the vicinity of Roswell-Dexter, Clovis-Portales, and south of Las Cruces, and some of these dairies are located near natural gas pipelines[83]. Currently, there are three project developers (one of which publicly announced in 2020: Dominion Energy and Vanguard Renewables[84]) exploring dairy biogas projects in different parts of the state, and so for forecasting purposes we assume that New Mexico will soon support at least three dairy manure-to-biogas projects, one each in Curry County (House District 63 and Senate District 7), Chaves County (House District 58 and Senate District 32), and Dona Ana County (House District 33 and Senate

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[80] http://www.biodieselmagazine.com/articles/8527/biodiesel-to-become-available-at-new-reg-clovis-terminal-in-nm

[81] Estimating Greenhouse Gas Reductions For a Regional Digester Treating Dairy Manure, Deborah Bartram, Eastern Research Group, Incorporated, 14555 Avion Parkway, Suite 200 , Chantilly, Virginia 20151, deborah.bartram@erg.com; Wiley Barbour , Environmental Resources Trust, Incorporated , 1612 K Street, NW Suite1400 , Washington, DC 20006 , wbarbour@ert.net

[82] Ibid.

[83] Adelante Consulting, Inc. December 2021.

[84] https://www.washingtonpost.com/climate-solutions/2020/06/16/climate-solutions-manure/

District 31). The average investment to support a manure-to-biogas project at a dairy or dairy cluster with 20,000 cows is approximately $15 million[85].

Increasing the use of RNG also creates the potential for job growth related to developing an RNG refueling infrastructure. As noted in section 3.4, there are currently very few fueling stations for NGVs in New Mexico. As with developing BEV recharging infrastructure and HFCEV fueling infrastructure, developing NGV refueling infrastructure will create local jobs associated with construction.

4.2.4 Low-CI Gasoline

With current limitations on ethanol blend rates, the CI of blended gasoline is strongly affected by the CI of gasoline blendstock. As described in section 3.1, because blendstock comes from many sources, a single composite CI is used and low-CI gasoline would need to be handled separately. Although this approach complicates handling and transportation, it does create benefits in terms of job creation from production, distribution, and retail sales.

4.2.5 Hydrogen

Several opportunities exist for producing low-CI hydrogen in New Mexico for transportation fuel. The CI for hydrogen produced from steam reforming of methane can be substantially lowered if the carbon dioxide produced is captured and geologically stored. Areas where natural gas is produced in New Mexico have favorable geology for storing carbon dioxide and, in 2020, $17.5 million in U.S. Department of Energy (DOE) funding and additional $4.5 million cost share was awarded to New Mexico Institute of Mining and Technology (NMT) to study a geological storage complex located in northwest New Mexico.[86]

The principal source of non-fossil hydrogen is electrolysis of water. While very energy intensive, the resulting hydrogen can have a very low CI if electricity produced from solar or wind is used for electrolysis. Although New Mexico has ample potential for solar and wind energy, the electrolysis process is also water intensive, which is a concern in the semi-arid West.

Non-fossil hydrogen can also be produced using biomass including heterogeneous blendstocks of wood waste and sludge from wastewater treatment plants, usually through gasification of biomass to produce hydrogen-containing syngas, which is then cleaned up to produce hydrogen. The CI can be further reduced if the carbon dioxide separated from the syngas can be stored.

There are currently multiple project developers and process equipment providers involved in developing hydrogen projects in New Mexico. New Mexico's own BayoTech has developed and patented a hydrogen production package plant that makes it economically feasible to take hydrogen production to the methane feedstock source. An unannounced firm is projecting to locate a pyrolytic wood waste-to-hydrogen production

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[85] https://www.washingtonpost.com/climate-solutions/2020/06/16/climate-solutions-manure/

[86] https://geoinfo.nmt.edu/news/home.cfml?id=420, June 9, 2020.

facility along the I-40 corridor in the vicinity of Grants, and is almost certain that it will prioritize a New Mexico plant if the State passes a CFS. For forecasting purposes, we are conservatively assuming that multiple production facilities will locate in New Mexico, on the I-40 and I-10 corridors initially and then on the I-25 corridor to supply long-haul trucking, to be followed by locations near state roads that have been designated as AFCs. On December 3, 2021, Bayotech announced its first hub in Albuquerque, New Mexico, which is anticipated to create eight to 12 full-time jobs plus 20 temporary jobs in manufacturing and construction[87]. This facility is targeted for completion mid-2022. We additionally forecast a minimum of four package plants similar to BayoTech's to situate along New Mexico's alternative fuel corridors on I-40 and I-10 by 2027 as a result of a CFS, and two larger-capacity package plants or 31 small-capacity plants to be added along all of New Mexico's AFCs.

Capital costs for package plants were obtained from an industry survey and indicated unit costs would initially be approximately $10,000,000 per plant for the first five plants, and would then drop to approximately $3,000,000 per plant. Operations were assumed to require 8 staff per plant.

As discussed in section 4.1.3, increasing the HFCEV fleet will also result in local job growth associated with developing a fueling infrastructure. A network of hub and spoke stations are being planned by an undisclosed organization which will bring a large production facility and 2 filling stations to the State by 2030.

4.2.6 Battery Electric Vehicles

As discussed in section 4.1.2, increasing the BEV fleet will result in local job growth associated with developing a recharging/EVSE infrastructure. The U.S. has 18.5 EVs per charging plug today, but international benchmarks suggest one charger is needed for every 10 to 15 EVs[88]. As noted in section 3.5, New Mexico currently has 2620 BEVs with 404 public charging locations. This equates to 1 public charging location per 6.5 BEV, which meets the above benchmark. The fuel use scenario described in section 2.1.2 suggests a fleet size of 51,000 BVs would be needed to meet the 2030 CI reduction goal. Such a fleet size would need approximately 3400 to 5100 charging stations to meet the above benchmark. "Ballpark" cost data for EVSE unit costs and installation costs prepared for the U.S. Department of Energy in 2015 indicate equipment costs of $400 to $6,500 for Level 2 charges and $10,000 to $40,000 for DC Fast chargers[89]. Installation costs ranged $600 to $12,700 for Level 2 chargers and $4,000 to $51,000 for DC Fast chargers[90]. These cost ranges suggest an investment on the order of $100,000,000 in EVSE infrastructure by 2030. Approximately half of this would be for EVSE equipment and half for installation. A large portion of the installation cost will be comprised of labor.

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[87] https://www.bizjournals.com/albuquerque/inno/stories/news/2021/12/03/bayotech-plans-hydrogen-production-facility-in-abq.html

[88] https://www.axios.com/electric-vehicle-charging-stations-equity-1b00f7a6-f87a-4125-9bc0-82399663b345.html

[89] New West Technologies (2015) at 11.

[90] Ibid at 17.

Zero-CI electricity from generated from solar and wind energy has the potential to generate valuable CFS credits if used as a transportation fuel. Assuming a CFS credit price of \$150/MTCO2e, electricity having a CI value of 0 gCO2e/MJ could generate credits worth approximately \$0.20/kwh in 2024.

5.0 References

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