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Supplementary material

Assessing the Economic and Environmental Impacts of Alternative Renewable Portfolio Standards: Winners and Losers

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Abstract: State-mandated renewable portfolio standards affect substantial portions of the total U.S. electricity supply. Renewable portfolio standards are environmentally motivated policies, yet they have the potential to greatly impact economy. There is not an agreement in the literature on the impact of renewable portfolio standards policies on regional economies, especially on job creation. By integrating various methodologies including econometrics, geographic information system, and input–output analysis into a unique system dynamics model, this paper estimates the economic and environmental impacts of various renewable portfolio standards scenarios in the state of New Mexico, located in Southwestern U.S. The state is endowed with traditional fossil fuel resources and substantial renewable energy potential. In this work we estimated and compared the economic and environmental tradeoffs at the county level under three renewable portfolio standards: New Mexico's original standard of 20% renewables, the recently adopted 100% renewables standard, and a reduced renewable standard of 10%. The final one would be a return to a more traditional generation profile. We found that while the 20% standard has the highest market-based economic impact on the state as a whole, it is not significantly different from other scenarios. However, when environmental impacts are included, the 100% standard yields the highest value. In addition, while the state level economic impacts across the three scenarios are not significantly different, the county-level impacts are substantial. This is especially important for a state like New Mexico, which has a high reliance on energy for economic development. A higher renewable portfolio standard appears to be an economic tool to stimulate targeted areas' economic growth. These results have policy implications.

Keywords: renewable portfolio standards; employment; economic output; water use; greenhouse gases; emissions; social benefits

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Section A

Abbreviation	Definition
AEO	Annual Energy Outlook
EASIUR	Estimating Air Pollution Social Impact Using Regression
eGRID	Emissions and Generation Resource Integrated Database
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FF	Fossil Fuel
FTE	Full-Time Equivalent
GHG	Greenhouse-gas
IMPLAN	Impact Analysis for Planning
JEDI	Jobs and Economic Development Impact
MWh	Megawatt-hour
NG	Natural Gas
NM	New Mexico
NREL	National Renewable Energy Laboratory
O&M	Operating and Maintenance
PV	Utility-Scale Photovoltaic Solar
RE	Renewable Energy
RPS	Renewable Portfolio Standards
RPV	Residential Photovoltaic Solar
SD	System Dynamics

Table S1: US EIA Annual Energy Report Price Scenarios [1].

No.	AEO2018 Scenarios	No.	
1	Reference case	18	Nuclear costs 20% higher low resources
2	High economic growth	19	Nuclear costs 20% lower high resources
3	Low economic growth	20	Nuclear costs 20% higher high resources
4	High oil price	21	$15 carbon allowance fee
5	Low oil price	22	$25 carbon allowance fee
6	High oil and gas resource and technology	23	ANWR mean resources
7	Low oil and gas resource and technology	24	ANWR low resources
8	Reference case with Clean Power Plan	25	ANWR high resources
9	High economic growth with Clean Power Plan	26	New efficiency requirements
10	Low economic growth with Clean Power Plan	27	No new efficiency requirements
11	High oil price with Clean Power Plan	28	PTC/ITC extension
12	Low oil price with Clean Power Plan	29	Early PTC/ITC sunset
13	High resource with Clean Power Plan	30	Solar PV tariff
14	Low resource with Clean Power Plan	31	Autonomous battery electric vehicle
15	Nuclear costs 20% lower Reference case	32	Autonomous hybrid electric vehicle
16	Nuclear costs 20% higher Reference case	33	AEO2017 without Clean Power Plan
17	Nuclear costs 20% lower low resources	34	AEO2017 with Clean Power Plan

Table S2: Sources of data for key variables.

Data for	Source
Electricity demand	EIA
Population	United States Census Bureau
Gross state product	Bureau of Economic Analysis
Generation data	EIA-860, EIA-861, EIA-923
Existing RPV capacity	New Mexico Public Regulation Commission
RPV potential	Solar for all – NREL
Wind Potential	Wind Data – NREL

PV Potential	Solar Data – NREL
NG Potential	Layer Information for Interactive State Maps – EIA
Levelized Cost of Energy	[2] – NREL
Job multiplier	IMPLAN and JEDI (NREL)
Output multiplier	IMPLAN
GHG social benefit multipliers	[3]
Air pollution social benefit multipliers	[4,5]
Human mortality and morbidity multipliers	[6–9]
Avian mortality multipliers	[10–13]

Table S3: Summery statistics and mean and distribution tests (Kolmogorov-Smirnov and t-test*) across different scenarios at the state level and selective counties.

		RPS – 20%		RPS – 100%		RPS – 10%		100% vs 20%[d]		10% vs 20%[d]		100% vs 10%[d]	
	Characteristics	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**K-S**	**t-test**	**K-S**	**t-test**	**K-S**	**t-test**
State - level	Jobs[a]	4,466	2,700	4,450	2,230	4,574	2,705	0.86	0.98	0.86	0.87	0.47	0.84
	Water Consumption[b]	8,520	4,250	7,570	5,180	8,720	4,160	**0.03**	0.41	0.67	0.84	**0.03**	0.32
	CO2 Emission[c]	26,200	5,723	22,500	10,000	20,000	12,800	**0.03**	**0.07**	**0.03**	**0.07**	**0.01**	**0.02**
Curry County	Jobs[a]	217	120	271	136	182	86	0.31	**0.07**	0.37	**0.06**	**0.01**	**0**
	Water Consumption[b]	-	-	-	-	-	-	-	-	-	-	-	-
	CO2 Emission[c]	-	-	-	-	-	-	-	-	-	-	-	-
Eddy County	Jobs[a]	278	302	124	127	297	316	**0.01**	**0.01**	0.35	0.36	**0**	**0**
	Water Consumption[b]	7.14	10.20	0.14	0.01	9.15	11.40	**0**	**0**	0.42	0.21	**0**	**0**
	CO2 Emission[c]	24	33	1	0	28	34	**0**	**0**	0.61	0.32	**0**	**0**
Lea County	Jobs[a]	528	316	449	124	506	313	**0.13**[f]	**0.11**[f]	0.56	0.56	**0.05**	**0.09**
	Water Consumption[b]	56.20	9.80	49.30	0.34	58.20	11.00	**0**	**0**	0.41	0.21	**0**	**0**
	CO2 Emission[c]	176	31	176	31	180	32	**0**	**0**	0.42	0.32	**0**	**0**
San Juan County	Jobs[a]	769	269	558	369	756	269	**0.02**	**0.01**	0.95	0.5	**0.03**	**0.01**
	Water Consumption[b]	545	389	502	381	511	371	**0.04**	**0.3**	0.9	0.67	**0.06**	**0.35**
	CO2 Emission[c]	897	646	867	649	894	621	**0.04**	**0.4**	0.92	0.54	**0.06**	**0.38**

* Kolmogorov-Smirnov (K-S) tests are to compare distributions, while t-tests are for comparing means. Values under test results are p-values. a: Jobs are annual average; b: Water consumption is per million gallons. "-" indicates no change in water consumption; c. CO2 emission is per thousand tons; d: P-values in bold are statistically significant at p-value<10; f. Statistically significant at p<0.15.

Section B: System Dynamics Modeling Description

B.1. Demand

The population module coupled with electricity demand module create the Demand sub-model. The former estimates population projection by county and the latter uses that information to forecast electricity demand. Below, we first describe the electricity demand module and then the population.

Recall that RPS policy regulates all the large electric utilities to source 20% of their electricity sold in-state from RE in NM by 2020. In order to extrapolate in-state electricity consumption beyond historical values, we estimate NM's monthly electricity demand and use the derived coefficients in the SD model. Following the literature (e.g., [13]), we apply a linear form using electricity price, Henry hub NG price, temperature, gross state product, population, and recession period as independent variables in the empirical analysis. Thus, in the empirical study the following specification (S1) for state electricity demand is employed:

$$\mathrm{ED_t} = \beta_0 + \beta_1 \mathrm{P_t} + \beta_2 \mathrm{HHNG_t} + \beta_3 \mathrm{HDD_t} + \beta_4 \mathrm{CDD_t} + \beta_5 \mathrm{GSP_t} + \beta_6 \mathrm{Pop_t} + \beta_7 \mathrm{Recession_t} + \sum_{i=2}^{12} \gamma_i \mathrm{month_i} + \varepsilon_t \quad \text{(S1)}$$

where ED_t is the state consumption for electricity at time t, P is real electricity price, HHNG is real Henry Hub NG price, HDD and CDD are heating and cooling degree days respectively, GSP is real gross state product, Pop is population, Recession is a dummy variable for experienced recession months of the year, $month_i$ captures seasonality of consumption, and ε_t is the error term. Recession occurred from March to November 2001 and December 2007 to June 2009. Thus, dummy variable month equals "1" for those months and "0" for the remaining period. This analysis is executed utilizing monthly data for NM for the period of 1/2001 – 12/2015. Table S4 presents the descriptive statistics of the data, while Table S5 summarizes the estimated coefficients for electricity demand. Estimated variables form the main body of the electricity demand module variables.

Table S4: Descriptive statistics of state electricity demand from January 2001 to December 2015.*

Variables	Mean	SD	Min	Max
Total state MWh consumption	1,794,770	209,656.9	1,361,108	2,305,957
Real total price $/MWh	93.6	6.2	81.7	111.1
Real Henry Hub NG price	7.1	3.6	2	20.3
Heating degree days	373.7	335.6	0	1,024
Cooling degree days	84.5	118.7	0	401
Real Gross State Product	92,215.6	6,367.2	77,801.6	97,572.9
Population	2,082,706	167,597.5	1,831,690	2,356,236

*Number of observations=180.

Table S5: Regression results on state's electricity demand.

Variables	State
Real total price $/MWh	-2769***
	(875.2)
Real Henry Hub NG price	1288
	(1397)
HDD	147.3**
	(63.05)
CDD	971.2***
	(157.9)
Real GSP	6.956***
	(1.309)
Population	0.551***
	(0.0578)
AIC	4342.5
Obs.	180
R-Squared	0.967

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Moreover, future electricity demand is partially driven by population (see equation S1). Thus, to be able to forecast future electricity demand beyond 2015, we develop the population module that takes into account the following drivers: fertility; mortality; and aging. Figure S1 and Figure S2 summarize the stock/flow and causal loop diagrams of population module. As population rises, the number of births increase with a delay, and population will grow as the number of births increase, leading to a reinforcing loop. Additionally, as population grows, the number of deaths also increase (with a delay) and population will shrink as the number of deaths increase, leading to a balancing loop. Similarly, as population increases, so does the number of individuals who age, thereby decreasing overall population and results in another balancing loop.

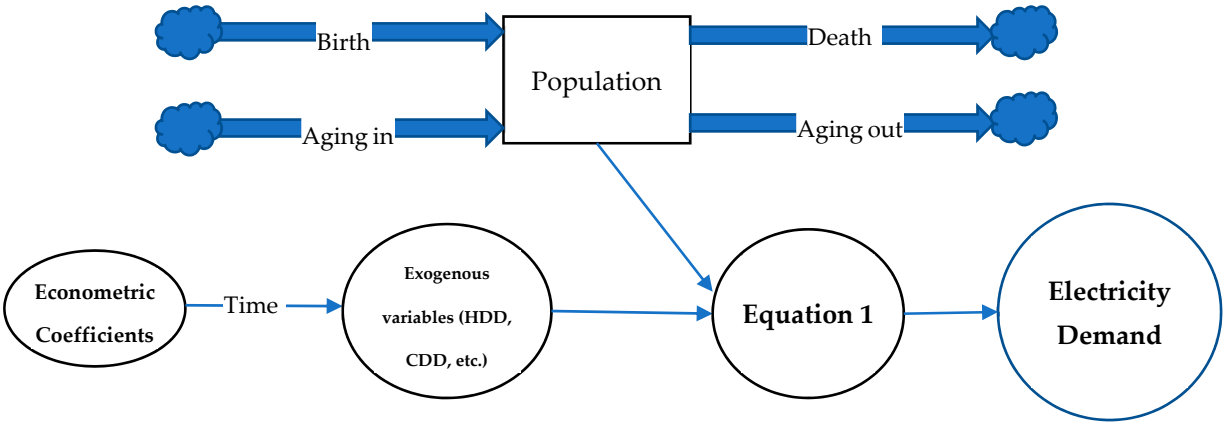


Figure S1: Population and Electricity Demand Stock/Flow Diagram.

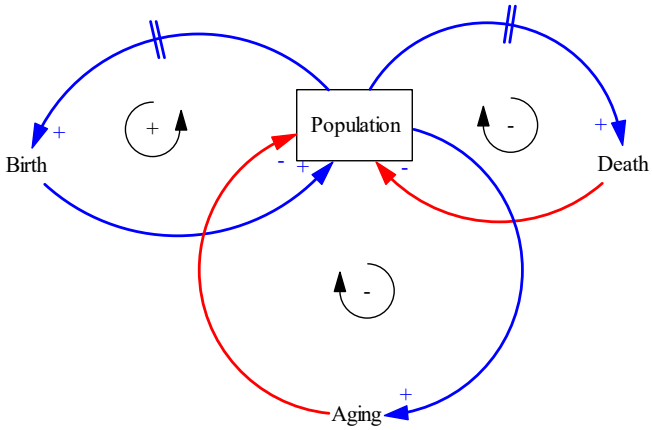


Figure S2: Population causal loop diagram.

Assumptions made in the Demand sub-model include: (1) EIA's forecasts beyond 2015 for electricity and Henry Hub NG prices (all 34 scenarios) are used; (2) heating and cooling degree days (HDD and CDD) will either be the same as, 5%, or 10% higher than those of January 1916 to December 1950; (3) We use $GSP = 5887.8ln(t) + 14{,}738$ function (t for time) derived from Stata based on historical data to forecast real gross state product beyond historical data; and 4) population module is used beyond historical data. Figure S3 depicts electricity demand calibration.

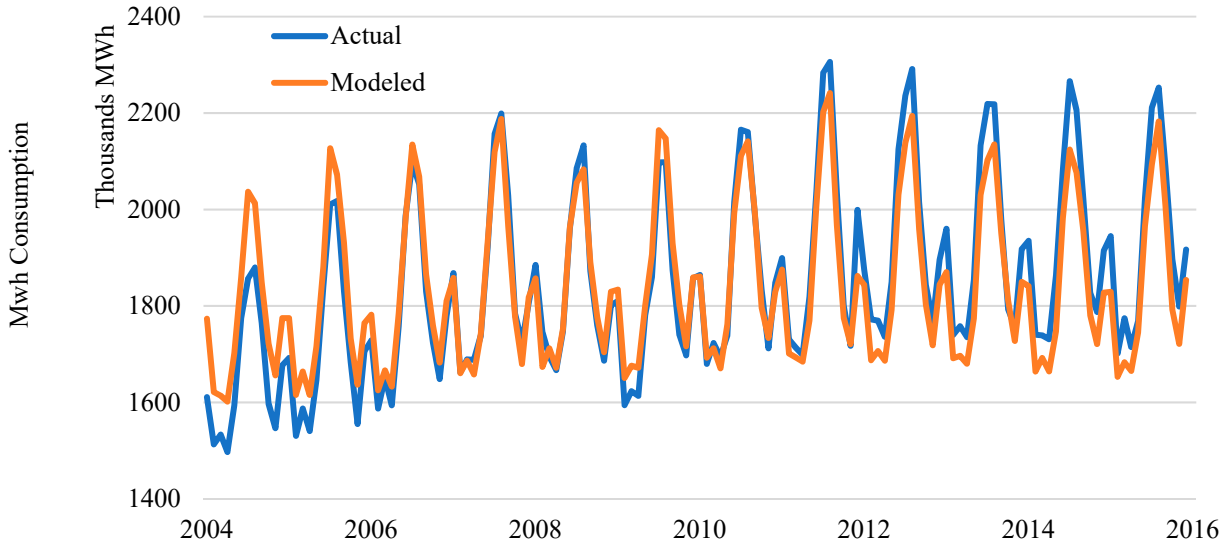


Figure S3: State Monthly Electricity Demand Historical versus Modeled.

B.2. Supply

As mentioned earlier, the Supply sub-model consist of six modules. Each module estimates monthly electricity generation by one of our six main energy sources, namely: baseload coal, peaker NG, baseload NG, wind, PV, and RPV. Baseload is the amount of electricity that is constantly required (over a period of 24 hours), while peak-load is the daily fluctuation of electricity usage. Baseload is usually supplied by coal-fired, nuclear, and/or combined-cycle NG power stations (also known as baseload plants), whereas peak-load is normally delivered by open-cycle NG (also known as peaker NG). Additional peaker NG capacity is tied to RE development: the higher level RE capacity is installed, the higher peaker NG is needed to address the additional RE intermittency issue. On the other hand, baseload NG capacity is installed when it is the cheapest energy source (more on this below). Existing power plants are assumed to maintain similar power production to capacity ratios (i.e., capacity factors) as were measured and recorded in the eGRID database for 2014 and EIA-861. To allow for technology improvement and thus more efficient power plants, capacity factors are defined in a way that can be changed over time in the SD model. Figure S4 shows the capacity factors for wind for each 5-year period.

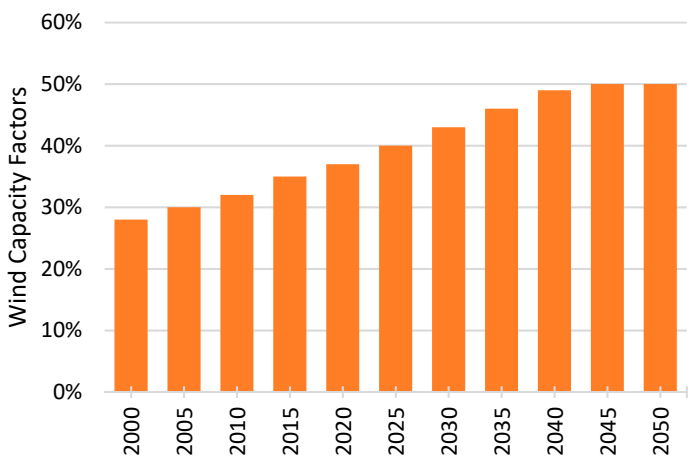


Figure S4: Adjustable capacity factor for wind energy.

In each of the six generation modules, we first convert plant-level data to county-level, that is, we aggregate existing megawatt nameplate capacities of all the power plants that are fueled the same in each county. This process is called "historical capacity – convert plant to county" in the SD model. Second, we model the construction of new power plants, which is driven by increased demand for electricity, exogenous RPS policy, or both. Specifically, new power plants are ordered when the demand exceeds the existing electrical power generation, RPS is not met, or both happen simultaneously (more detail in the next subsection). We show this process in the "Permitting, Construction, to Delivery Plants". Next, we model the additional nameplate capacity by source and county. Finally, utilizing equation (S2), we estimate electricity generation:

$$\begin{aligned} \text{MWh} = {} & \text{nameplate capacity (MW)} \times \text{capacity factor (\%)} \\ & \times (1 - \text{Not Accounted}) \times \text{timestep} \end{aligned} \tag{S2}$$

where, not accounted is 5.15% which is the fraction of the electricity generated at the source place (power plant location) that is not accounted for due to *direct use*, *losses*, and *unaccounted* (3.52% losses, 0.55% direct use, and 1.08% Unaccounted; overall, 5.15%. These values are from EIA "Table 10. Supply and disposition of electricity, 1990 through 2015"). Further, timestep in our model is 1 month. Figure S5 depicts a snapshot of the wind module and Figure S6 illustrates the supply sub-model calibration. Figure S7 presents RE generation versus required generation to meet RPS constraints by the three modeled scenarios.

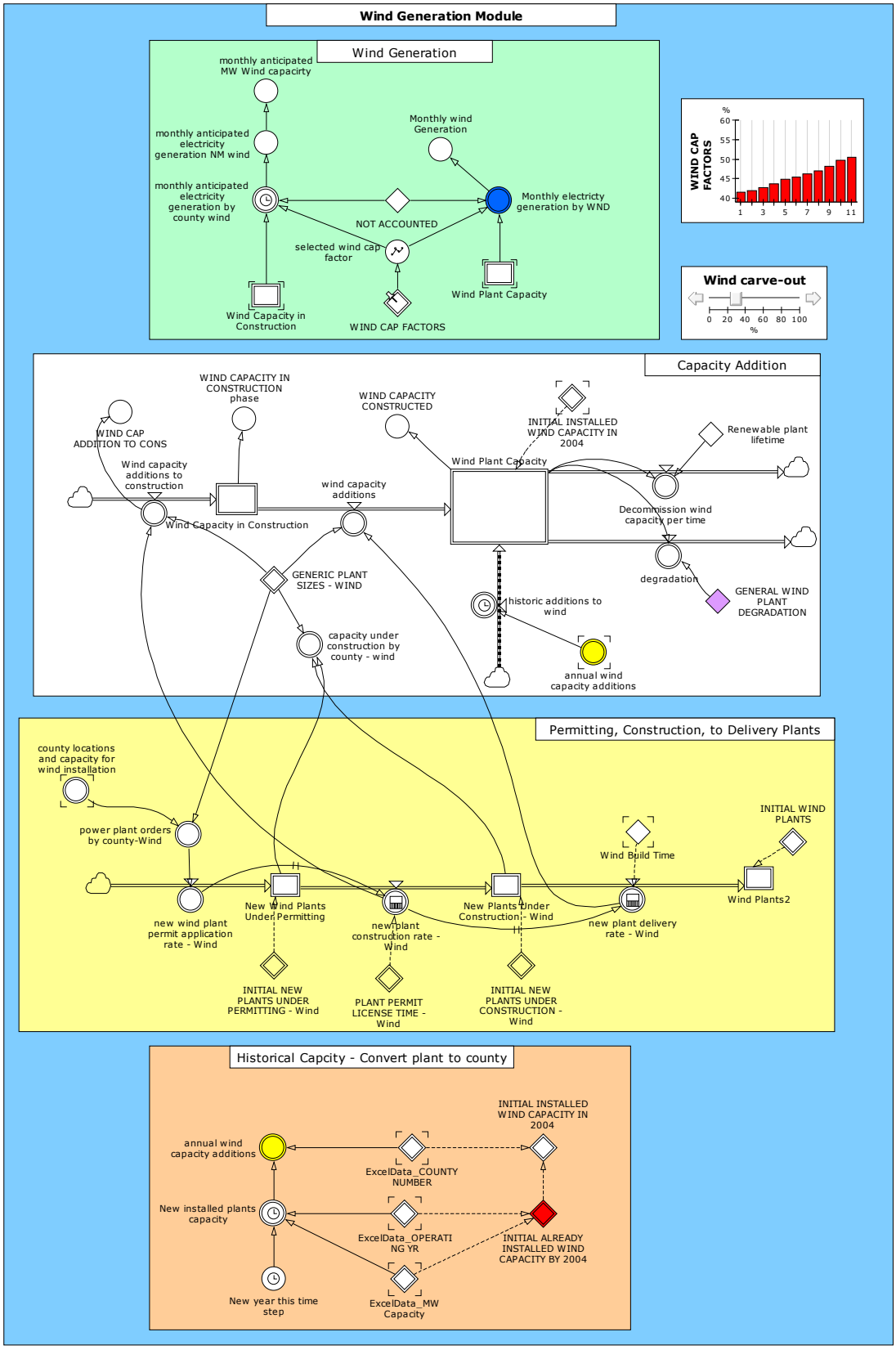


Figure S5: Wind generation module snapshot.

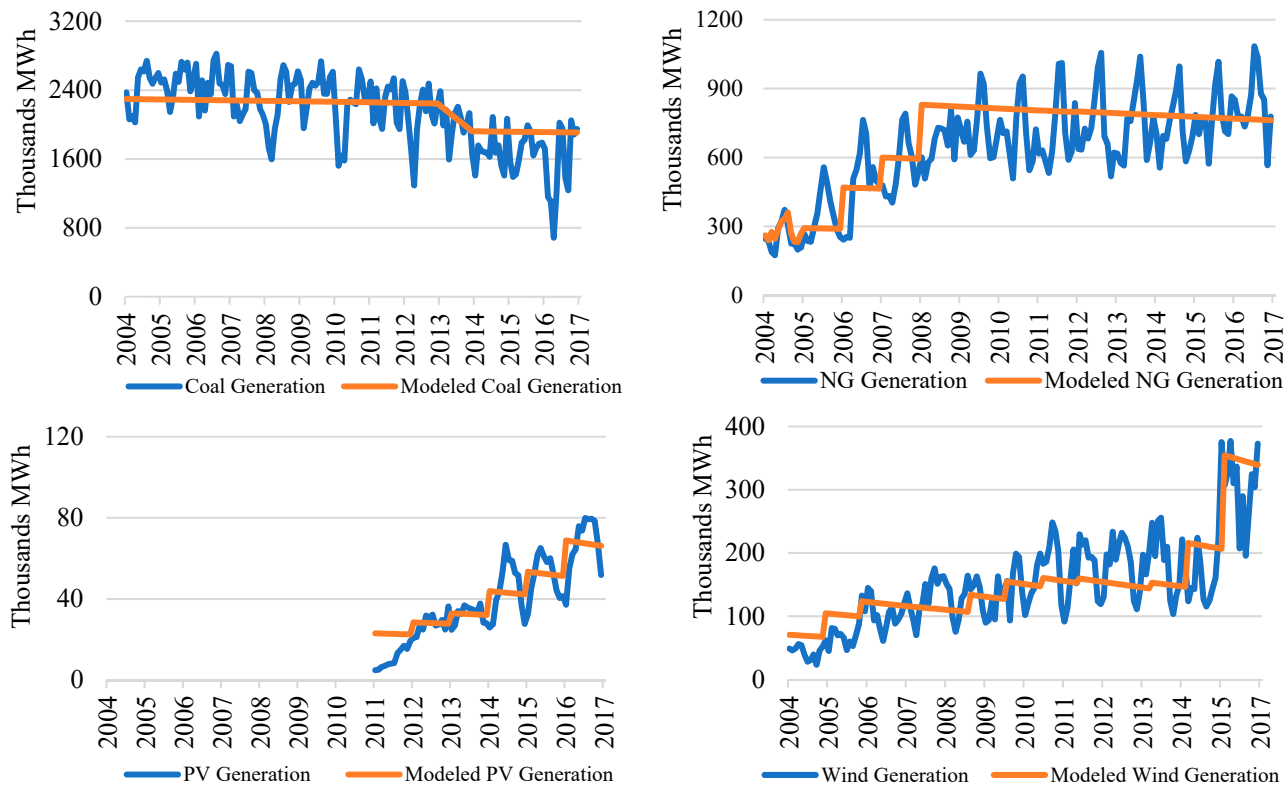


Figure S6: Generation calibration, modeled versus historical data for coal, NG, wind, and PV.

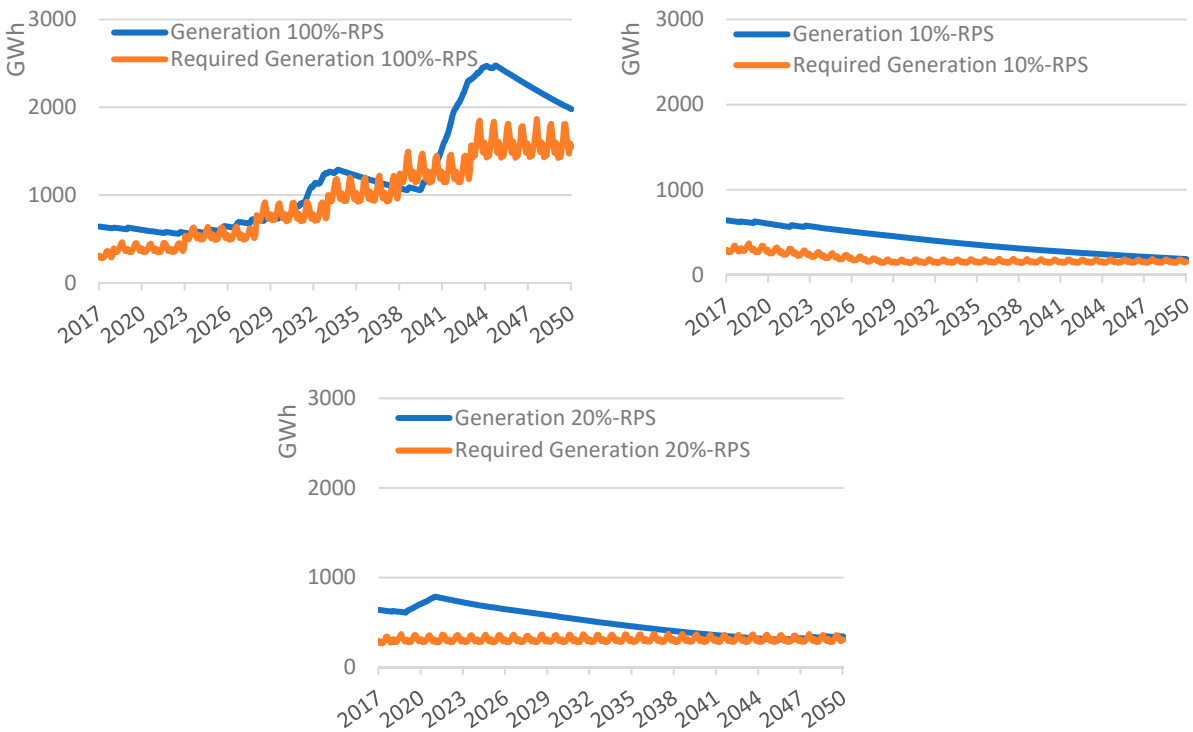


Figure S7: Renewable generation versus required generation to meet RPS constraints by the three modeled scenarios.

B.3. The Gap between Supply and Demand

In this subsection, we discuss the Gap sub-model and ways to address it. To better understand this sub-model, we start with explaining assumptions used in the calculation

of the gap between generation and electricity demand. We then describe each of the seven modules that together solve the Gap sub-model.

As mentioned in the Background section, NM has three main electricity providers: PNM, EPE, and SPS. These electric utility companies import 17.71% of their in-state electricity consumption from nuclear power from Arizona. Historically, approximately 35% of net NM electricity generation is exported to neighboring states. Total in-state electricity consumption, net electricity generation, total in-state electricity consumption, net in-state generation, and gap in electricity demand are summarized in equation (S3), (S4), (S5), and (S6) respectively.

$$\text{Total in_state electricity consumption} = \text{State electricity demand} - \text{Total imported electricity from AZ} \quad \text{(S3)}$$

$$\text{Net generation} = \text{Total generation} - (\text{direct use} + \text{unaccounted} + \text{losses} + \text{international export}) \quad \text{(S4)}$$

$$\text{Net in_state generation} = \text{Net generation} - \text{Net interstate exports} \quad \text{(S5)}$$

$$\text{Gap in electricity demand} = \text{Net instate generation} - \text{Total in_state consumption} \quad \text{(S6)}$$

As mentioned earlier, a gap occurs when RPS policy is not satisfied, the demand exceeds the existing electrical power generation, or both happen simultaneously. Recall that NM's RPS mandates electric utility companies generate their in-state sales from RE sources. Thus, we call a shortage in fulfilling the in-state sales requirement also a "gap" that needs to be addressed. To overcome a potential monthly gap between power generation and electricity demand, we need to know "when" the gap occurs, "how much" capacity of "what" energy source(s) we need to fulfill the gap, and *where* to add the new capacity. Hence, we develop the Gap sub-model, which consist of seven modules. The first module calculates the Gap (Equations (S3)–(S6)). The second module checks to see if RPS policy is satisfied and whether RE carve-outs are met. The third module finds the cheapest energy source in case RPS is satisfied and yet there is a gap to be fulfilled. The cheapest energy source is the source with the lowest LCOE at each point in time. More information on LCOE is provided in the Scenario Definitions section. The fourth module computes capacity needed to satisfy the carve-outs first and then RPS. The fifth module calculates the additional capacity needed to fill the gap by each energy source. The sixth module estimates counties' potential energy for each source. Finally, the last module allocates the capacity from the fifth module amongst desirable counties with potential. To address the additional RE intermittency issue, we add 5% (can be modified to add more, less, or nothing) peaker NG in "the best" counties. The intermittency issue of RE can be resolved by either storage, peaker NG, or both. Figure S8 summarizes this process.

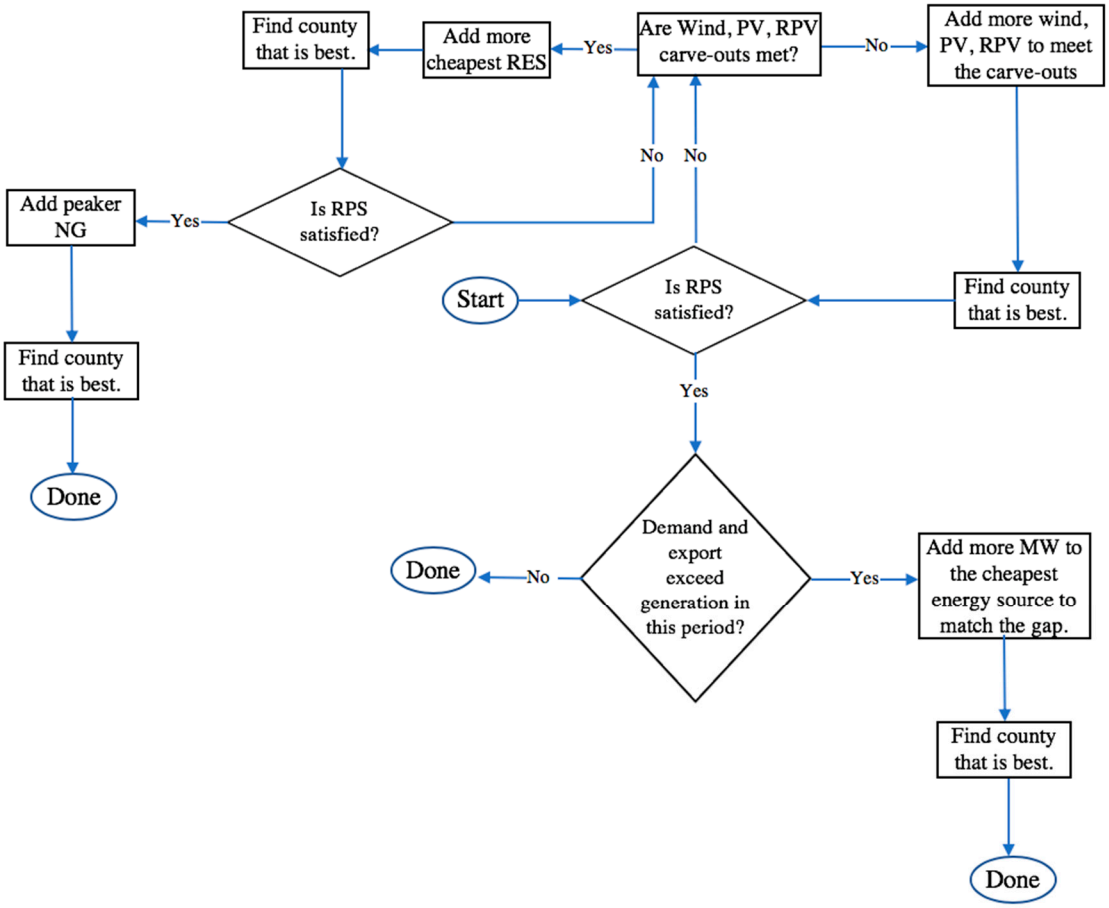


Figure S8: Flow diagram that depicts how to overcome the gap.

Regarding energy potential spatial analysis, we utilize GIS to estimate NM's potential for wind, PV, and NG. The analysis included only private land for the preliminary buffers. As none of the existing RE power plants are on federal, public, or BLM lands, we excluded those types of lands. For renewables (wind & PV), transmission lines were buffered at 5- and 10-mile increments and intersected with private land. PV estimates are total potential (kilowatt-hour) by county using area weighted buffers and solar radiation data from NREL, while wind estimates are total land available for different heights (80 m, 100 m, and 140 m) and efficiency levels (capacity factors of 30%, 35%, and 40%). For NG, both transmission lines and NG pipelines were buffered at 5- and 10-mile distances. Only the areas that also intersected private land were included. NG potential is total land area available for NG plants based on the buffers. Moreover, we assume San Juan county is the only county with potential for more coal-fired power plant installation or recommission. Lastly, we use the NREL's "solar for all" map, which estimates the RPV potential for each county [14].

In regard to "the best" county selection process, wind and PV are assumed to be installed in the least populous (most rural) counties, while RPV in the more populous counties first. Following [15], we assume that additional utility-scale RE capacity will be located primarily in rural areas of NM. Further, the more populous the county, the higher the number of buildings, thus the larger the RPV potential. For additional NG capacities, we assume the counties with existing infrastructure have priorities over those without. Lastly, new coal-fired power plants, if any, are assumed to be built only in San Juan county, where most of the state's coal reserves are located. Similar to PNM's latest integrated resource plan, we assume every 200 MW (can be varied from 100 to 500 MW in the SD model) additional RE capacity is accompanied with a 40-MW, four-hour battery

storage. The SD model overcomes the intermittency issue of RE or the need for additional quick-start generation capacity by either storage, peaker NG, or both.

B.4. Employment

Sub-model Jobs includes six modules to calculate number of jobs for each energy source (i.e., coal, NG peaker, NG baseload, wind, PV, and RPV).

To measure the change in economic activity, the JEDI model of NREL is used to determine the impact of constructing and operating a renewable generator based on size of generation, renewable source (number of turbines or photovoltaic cells), location, and year of construction for twelve planned wind and solar power plants [16]. JEDI model is a spreadsheet tool that applies the IMPLAN (Impact Analysis for Planning) Input-output economic impact system to calculate consumption and spending patterns and project costs (i.e., specific expenditures) as well as economic activity that will accrue to the state being analyzed. From this, we estimate the job multipliers by energy type at a county level during construction and operations using IMPLAN. IMPLAN is an economic impact modeling tool for forecasting the effect on a local, regional, or national economy of a given economic change or event in the economy's activity. IMPLAN is a derivative of the work developed by [17], in which he utilized a matrix mathematical approach to predict/project standard input-output modeling, conjunct with social accounting matrices and multipliers. Utilizing job multipliers derived from IMPLAN and NREL's technology cost scenarios (see Scenario Definitions Section) along with Transmission Cost Calculator developed by Western Electricity Coordinating Council, each module estimates the number of full-time equivalent (FTE) jobs associated with different RPS policy requirements and any combination of carve-outs during construction and operating and maintenance (O&M) phases. Note that not all the counties have energy related multipliers, especially rural counties. To overcome this issue, we modified IMPLAN multipliers and instead used counties with similar characteristics (potential for energy, population, etc.) multipliers. Construction phase is a temporary time-period (1-2 years, depending on size of projects) that installation of a power plant occurs, while O&M phase is permanent (20-50 years, depending on type of power plant) and starts when a facility starts generating electricity. Figure S9 summarizes the model structure.

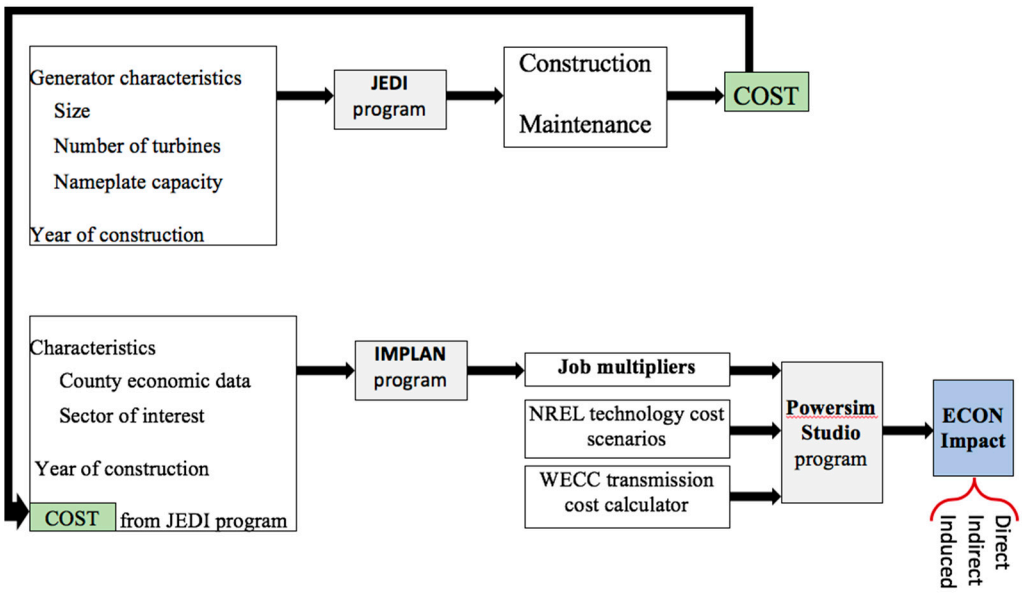


Figure S9: Economic impact modeling schematic.

Different studies assume different percentage of construction employment is from local crew. For example, Lantz et al. [18] assume 70% of construction employment are

local residents in their default scenario (90% in the Medium scenario), while Godby et al. [19] assume 80% of construction employment are nonresident. We assume all construction and O&M workers are local labor. The 100%-local-worker assumption is attainable when NM policymakers implement workforce training programs across counties, especially rural counties, to ensure that local workers are skillful and competitive. Such programs are already in place for example in San Juan County. Moving forward in the timeline, this assumption can be more realistic.

B.5. Environmental Impacts

Environmental Impact sub-model consists of one module, which calculates primary GHG emissions (CO_2), air pollution (SO_2, NO_x, and PM), and water usage (withdrawal and consumption) under different scenarios. This module follows Equations (S7) and (S8) to capture existing and potential future environmental impacts of different scenarios.

$$\text{Gallon water} = \text{MWh generation} \times \text{conversion factor(gallon/MWh)} \quad \text{(S7)}$$

$$\text{Ton GHG emission \& air pollution} = \text{MWh generation} \times \text{conversion factor(ton/MWh)} \quad \text{(S8)}$$

where MWh is megawatt-hour electricity generation and different energy sources have different conversion factors. These factors are calculated from actual data when exist (historical EIA, EPA data, and utility companies integrated resource planning), or else from the energy literature. Table S6 summarizes the conversion factors utilized in the environmental impact estimation and their corresponding sources. Note that all of the conversion factors for coal-fired power plants are higher than those of NG.

Table S6.: Conversion factors used in estimating water usage, GHG emission, and air pollution.

Outcome	NG (peaker)	NG (baseload)	Coal	Source
Mercury (lbs/GWh)	0	0	0.0172	[20]; EIA; EPA
PM (lbs/MWh)	0.0975	0.0628	0.094	[20]; EIA; EPA
CO2 (lbs/MWh)	1,569.27	961.84	2,150.7	[20]; EIA; EPA
NOx (lbs/MWh)	2.8879	0.1293	6.77	[20]; EIA; EPA
SO2 (lbs/MWh)	0.008	0.005	1.691	[20]; EIA; EPA
Water Withdrawal (gallon/MWh)	250	250	10,180	[21]; EIA; EW3 [22]
Water Consumption (gallon/MWh)	160	160	630	[21]; EIA; EW3 [22]

Once potential environmental impacts are estimated, we calculate the potential GHG and air pollution reduction relative to the *20%-RPS* scenario. From these values, we quantify economic benefits/costs based on GHG and air pollution's social cost. In so doing, we utilize USD/ton multipliers used in the U.S. regulatory agencies such as Environmental Protection Agency [3,6] and academic literature [4,5,23–25] and multiply them by the estimated ton emissions (CO_2, SO_2, NO_x, and PM) to calculate dollar values.

To estimate social benefit of air pollution and GHG emission, we use multipliers from the Estimating Air pollution Social Impact Using Regression (EASIUR) model, developed by [4,5], and [3] respectively. The EASIUR predicts marginal benefits of "primary" and "secondary" PM2.5, where secondary PM2.5 includes SO_2 and NO_x. Similarly, the EPA model predicts social benefits of avoiding CO_2 emissions. As acknowledged by [26], these models are common practice and are based on the state-of-the-art air-quality models, which best serves our purpose.

The EASIUR model estimates marginal social cost of "primary" and "secondary" PM2.5 in USD per ton. As avoiding air pollution (SO_2, NO_x, and PM) reduces corresponding risk of premature mortality, the derived EASIUR multipliers can be viewed as marginal social benefit as well. We use three sets of marginal social benefit estimates for NO_x, SO2 and PM2.5 at ground-level and by county. Although EPA takes a similar approach in estimating social benefit of CO2, it is rather less finely determined spatial resolution. EPA

values (USD/ton) are developed for the entire U.S. We follow [27] but only use the central set of estimates, which are calculated based on a 3-percent discount rate. We use US$45 per tCO2 in 2017, US$57 per tCO2 in 2030, and US$79 per tCO2 in 2050. These multipliers are national estimates and are not specific to New Mexico. The social benefit of reducing carbon is intended to capture (but is not limited to) changes in net agricultural productivity, human health, avoiding property damages from increased flood risk, and the value of ecosystem services due to climate change [3].

Reference [6] estimates premature mortality, morbidity, and non-fatal heart attack incidence per ton of NO_x and SO_2 for three US regions: East, West, and California. We use EPA's West incidence-per-ton estimates to assess human premature mortality and morbidity reduction relative to baseline scenario. Lastly, we utilize estimated multipliers by [10], [11], and [12] to estimate avian mortality reduction caused by coal, NG, wind turbines, and PV panels. Following [11], we assume NG kills half as many birds as coal-fired power plants. Coal, NG, wind and PV avian mortality multipliers are: 5.18, 5.18/2, 0.4, and 0.23 birds per gigawatt-hour electricity generation respectively. A simplified schematic of the environmental impact modeling frame is provided in the figure below (Figure S10).

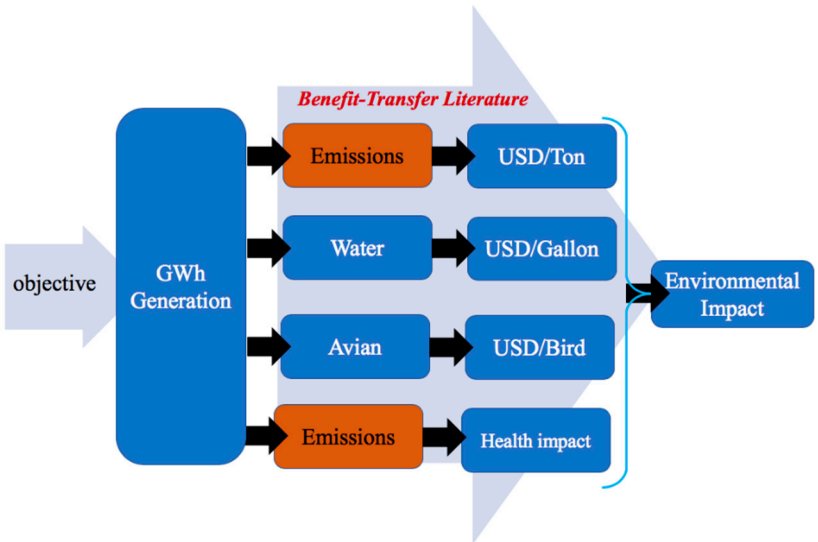
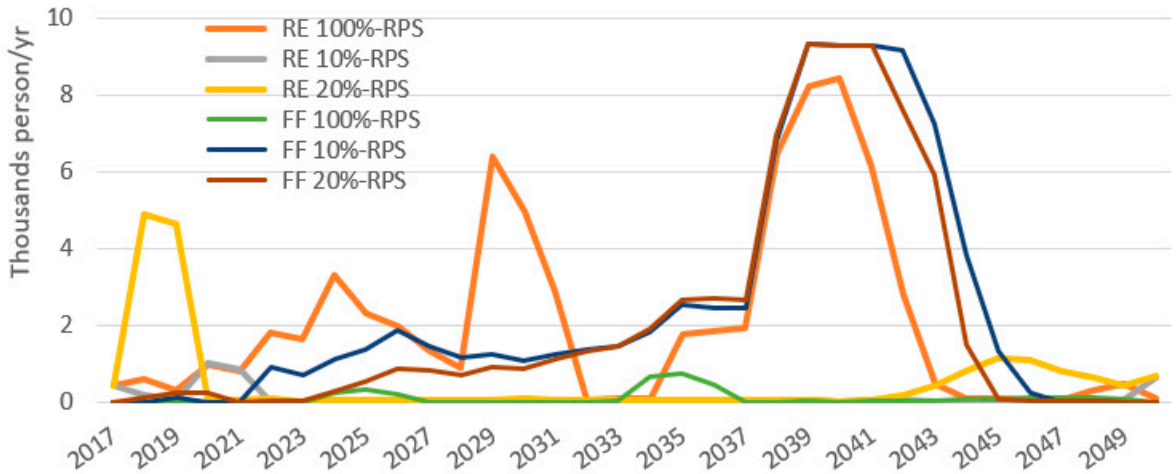


Figure S10: Environmental impact modeling schematic.

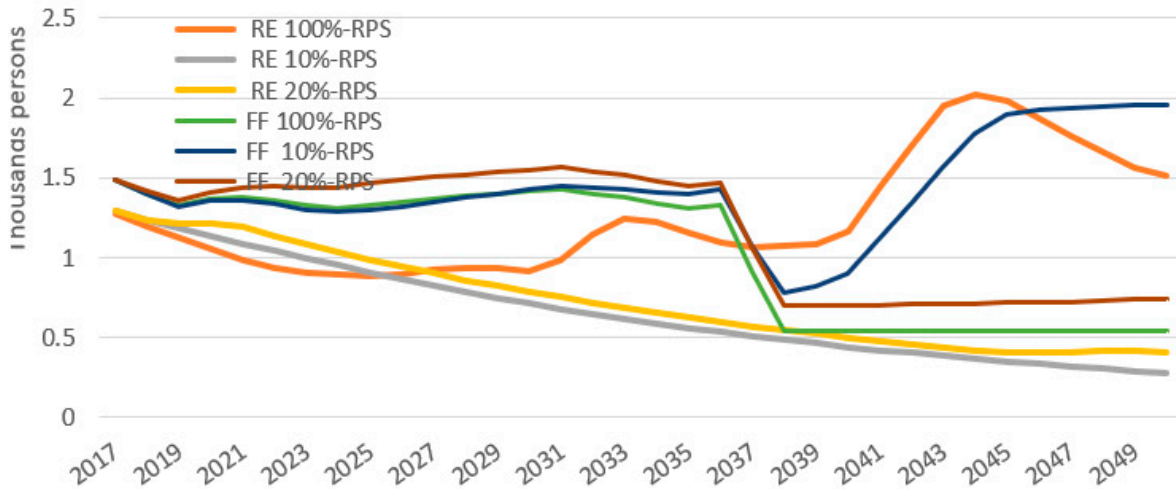
Section C: Supplemental Granular Results

C.1. Employment

We find higher levels of O&M employment in both energy industries (RE and FF) early on and lower levels as we move forward (see Figure S11-b). This is primarily due to changes from new, retired and avoided capacity, along with changes in capacity factor and physical capital degradation rate of power plants over time [28]. Overall, it takes less jobs to construct and more jobs to operate FF power plants. The opposite holds true for RE power plants: it takes more jobs to construct and less jobs to operate RE power plants.



(**a**)



(**b**)

Figure S11. B: Total construction and O&M jobs under three modeled scenarios. (**a**) Construction job-years – (**b**) O&M jobs

Figure S12 summarizes annual average of total employment impact by different energy source and scenario during construction and O&M from 2017 to 2049. On an annum account, the 20%-RPS is expected to support on average 750 RE and 1645 FF O&M FTE jobs. Relative to the *20%-RPS*, we find that the *100%-RPS* scenario has the potential to support 494 more RE and 589 less FF O&M FTE jobs on average than the 20%-RPS. Lastly, we estimate that 10%-RPS on average supports 82 less RE and 180 less FF O&M FTE jobs than the 20%-RPS. Table S7 summarizes these (annual average employment) impacts by energy type for construction and O&M impacts. Overall, 20%-RPS predicts higher annual average of total employment impacts in O&M period than the other two modeled scenarios. It estimates 5% and 14% higher number of annual averages of total employment than 100%-RPS and 10%-RPS respectively during O&M period.

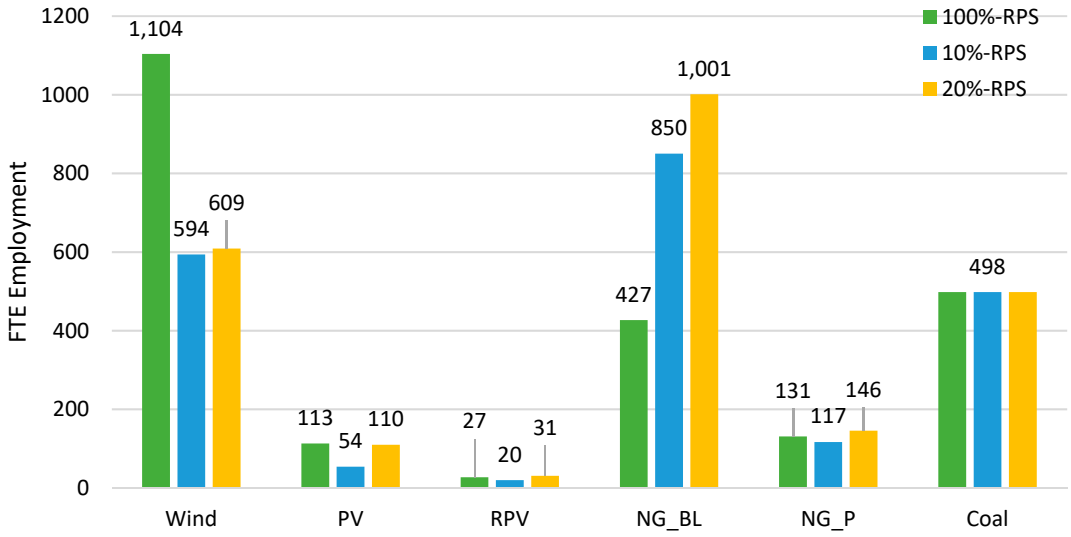


Figure S12: Annual average O&M job distribution by modeled scenarios and energy sources from 2017-2049.

Table S7: Annual average employment by energy type and scenario from 2017 to 2050.

	Construction (job-years)		
Energy source	**100%-RPS**	10%-RPS	Reference Case
Wind	1234	0	57
PV	765	56	378
RPV	119	32	71
Baseload NG	0	2445	2094
Peaker NG	127	0	10
		O&M (jobs)	
Wind	1,104	594	609
PV	113	54	110
RPV	27	20	31
Baseload NG	427	850	1,001
Peaker NG	131	117	146
Coal	498	498	498

Unlike O&M jobs that are permanent, construction jobs are temporal. Hence, presenting construction employment impact on an annual basis ignores its temporal nature. Herein, we summarize employment impact during construction period only for the impacted years. Under 20%-RPS, additional wind capacity will be constructed from 2042 to 2049 (3024 job-years on average), PV from 2018-2019 (4642 job-years on average) as well as 2042 to 2049 (399 job-years on average), RPV almost annually (88 job-years on average), NG peaker from 2018-2019 (121 job-years on average) as well as 2044 to 2048 (17 job-years on average), NG baseload roughly annually from 2019-2045 (2560 job-years on average), and there will be no new construction of coal-fired power plants and all the existing ones will retire by 2037 (on average, 780 jobs from 2017 to 2037 and no jobs afterwards). Compared to the 20%-RPS, the 100%-RPS scenario will result in higher levels of wind (almost annually (1234 job-years on average)), PV (almost annually (765 job-years on average)), RPV (119 annual job-years), and NG peaker (almost annually (127 job-years on average)) and lower baseload NG (no construction) construction employment. 10%-RPS yields lower number of construction employment in all energy sources, beside NG baseload. Under 10%-RPS, wind and NG peaker never are installed, lower number of individuals will be hired for installation of additional PV (from 2020 to 2021 (920 person-years on average)) and RPV (from 2017 to 2019 (218 job-years on average), from 2037 to 2042 (12 job-years on average), and from 2046 to 2050 (160 job-years on average)), and higher construction jobs for baseload NG (almost annually from 2019-2049 (2689 job-years on

average)) than the 20%-RPS. Overall, RE installation occurs more often in the RE intensive scenarios than the 20%-RPS, while higher level of FF installation takes place in 10%-RPS relative to the reference case.

Now we turn our attention to county level results. Table S8 and Table S9 summarize construction and O&M cumulative total job-years and jobs respectively. Population in 2017 and 2050, along with unemployment rate in 2017 by county is summarized in Table S10. Almost every county will have some sort of RE and FF jobs during the O&M phase, with majority in FF jobs, under the 20%-RPS. RE intensive scenario yield higher number of RE jobs than the 20%-RPS, while FF intensive scenario produces higher number of FF jobs. Majority of RE construction job-years in the 100%-RPS scenario will be in the wind sector. NG jobs are the main jobs under the 10%-RPS scenario.

Table S8: Construction cumulative total job-years by energy source and county from 2017 to 2050.*.

County	100%-RPS					10%-RPS					20%-RPS				
	Wind	**PV**	**RPV**	**NGp**	**NGb**	**Wind**	**PV**	**RPV**	**NGp**	**NGb**	**Wind**	PV	RPV	NGp	NGb
Bernalillo	0	0	587	415	0	0	0	146	0	7995	0	0	304	31	6743
Catron	1532	742	0	0	0	0	78	0	0	0	66	548	0	0	0
Chaves	1312	1032	241	415	0	0	0	73	0	0	71	137	169	31	0
Cibola	1927	977	0	0	0	0	78	0	0	0	83	548	0	0	0
Colfax	1927	1271	0	0	0	0	83	0	0	0	83	584	0	0	0
Curry	1652	1271	220	0	0	0	83	72	0	0	71	584	158	0	0
De Baca	1652	622	0	0	0	0	83	0	0	0	71	584	0	0	0
Dona Ana	0	0	420	415	0	0	0	104	0	8005	0	0	231	31	6834
Eddy	1652	1122	193	44	0	0	83	73	0	8009	71	584	169	22	6869
Grant	1532	1191	0	0	0	0	78	0	0	8009	66	548	0	0	6871
Guadalupe	1652	1271	0	0	0	0	83	0	0	0	71	584	0	0	0
Harding	1652	1271	0	0	0	0	83	0	0	0	71	584	0	0	0
Hidalgo	1532	755	0	0	0	0	78	0	0	8010	66	548	0	0	6878
Lea	23	700	189	415	0	0	0	73	0	8008	71	137	169	31	6863
Lincoln	871	100	0	0	0	0	83	0	0	0	66	129	0	0	0
Los Alamos	333	29	0	0	0	0	19	0	0	600	83	35	0	0	620
Luna	1532	1020	0	0	0	0	78	0	0	8009	66	548	0	0	6872
McKinley	0	0	203	415	0	0	0	69	0	8008	0	0	158	31	6860
Mora	1927	1232	0	0	0	0	83	0	0	0	83	584	0	0	0
Otero	1503	721	224	415	0	0	38	73	0	0	66	137	169	31	0
Quay	1652	1271	0	0	0	0	83	0	0	0	71	584	0	0	0
Rio Arriba	1927	780	0	0	0	0	78	0	0	0	83	548	0	0	0
Roosevelt	1652	1271	0	0	0	0	83	0	0	0	71	584	0	0	0
Sandoval	0	0	288	415	0	0	0	92	0	0	0	0	202	31	0
San Juan	0	0	575	415	0	0	0	94	0	8007	0	0	212	31	6844
San Miguel	1532	1271	0	0	0	0	83	0	0	0	66	584	0	0	0
Santa Fe	0	0	575	415	0	0	0	94	0	0	0	0	216	31	0
Sierra	1532	1191	0	0	0	0	78	0	0	0	66	548	0	0	0
Socorro	1532	1191	0	0	0	0	78	0	0	0	66	548	0	0	0
Taos	1927	359	0	0	0	0	78	0	0	0	83	548	0	0	0
Torrance	1927	1191	0	0	0	0	78	0	0	0	83	548	0	0	0
Union	1652	1271	0	0	0	0	83	0	0	0	71	584	0	0	0
Valencia	0	0	223	415	0	0	0	77	0	8008	0	0	173	31	6857

*Divide values by 33 (2050 – 2017) to calculate annual average job-years, though not recommended as it ignores the temporal nature of construction phase.

Table S9: O&M cumulative total jobs by energy source and county from 2017 to 2050.*.

	100%-RPS	10%-RPS	20%-RPS

County	Wind	PV	RPV	NGp	NGb	Wind	PV	RPV	NGp	NGb	Wind	PV	RPV	NGp	NGb
Bernalillo	0	44	198	778	133	0	72	226	736	1407	0	72	261	902	1602
Catron	751	103	0	0	0	0	18	0	0	0	4	106	0	0	0
Chaves	738	104	42	42	0	143	8	20	0	0	148	12	44	6	0
Cibola	917	138	0	0	0	0	40	0	0	0	5	128	0	0	0
Colfax	917	179	0	13	0	0	90	0	13	0	5	174	0	16	0
Curry	5826	134	39	0	0	6010	17	20	0	0	6015	101	43	0	0
De Baca	813	83	0	0	0	0	17	0	0	0	5	101	0	0	0
Dona Ana	0	86	118	656	2732	0	140	100	614	4009	0	140	130	754	4960
Eddy	813	140	34	35	0	0	41	20	27	1279	5	125	44	38	1484
Grant	751	142	5	215	0	0	21	10	215	1279	4	109	10	262	1485
Guadalupe	1295	206	0	0	0	578	134	0	0	0	583	217	0	0	0
Harding	813	134	0	0	0	0	17	0	0	0	5	101	0	0	0
Hidalgo	751	104	0	509	0	0	18	0	509	1,279	4	106	0	620	1488
Lea	553	115	33	638	6126	236	96	20	596	7,405	241	100	44	731	9308
Lincoln	512	15	0	0	0	0	17	1	0	0	4	27	1	0	0
Los Alamos	181	8	0	0	251	0	10	0	0	473	5	14	0	0	592
Luna	1070	291	3	0	3790	383	282	5	0	5,069	387	370	5	0	6328
McKinley	0	0	40	52	0	0	0	21	10	1,279	0	0	46	18	1480
Mora	917	132	0	0	0	0	17	0	0	0	5	101	0	0	0
Otero	736	119	43	42	0	0	54	28	0	0	4	51	52	6	0
Quay	2205	231	0	0	0	1669	178	0	0	0	1674	262	0	0	0
Rio Arriba	917	106	0	0	0	0	18	0	0	0	5	106	0	0	0
Roosevelt	3954	134	0	0	0	3766	17	0	0	0	3771	101	0	0	0
Sandoval	754	32	83	42	0	904	52	76	0	0	904	52	104	6	0
San Juan	0	121	90	42	1060	0	212	24	0	2,338	0	212	53	6	2828
San Miguel	751	144	0	0	0	0	33	1	0	0	4	117	1	0	0
Santa Fe	0	17	126	42	0	0	27	92	0	0	0	27	121	6	0
Sierra	751	146	0	0	0	0	27	0	0	0	4	114	0	0	0
Socorro	751	140	0	0	0	0	18	0	0	0	4	106	0	0	0
Taos	917	62	0	0	0	0	27	0	0	0	5	115	0	0	0
Torrance	4568	140	0	0	0	4378	18	0	0	0	4383	106	0	0	0
Union	2394	134	0	0	0	1896	17	0	0	0	1900	101	0	0	0
Valencia	0	41	43	1214	0	0	66	22	1172	1279	0	66	48	1432	1479

Note: Only two counties have coal-fired power plants. San Juan = 15020 jobs and McKinley=1398 jobs. *Divide values by 33 (2050 – 2017) to calculate annual average jobs for each county.

Table S10: Population in 2017 and 2050, along with unemployment rate in 2017.

County	Population in 2017	Population in 2050*	Unemployment Rate 2017**
Bernalillo	669,296	783,957	5.5%
Catron	3532	3286	6.9%
Chaves	65,640	74,917	6.4%
Cibola	27,442	31,628	7.9%
Colfax	13,409	14,076	6.0%
Curry	49,192	58,709	4.8%
De Baca	1943	1967	4.5%
Dona Ana	212,457	252,482	6.9%
Eddy	53,731	60,712	5.3%
Grant	28,722	30,138	6.2%
Guadalupe	4679	5279	6.4%
Harding	643	589	6.6%
Hidalgo	4833	5270	5.2%
Lea	65,744	77,646	6.6%
Lincoln	19,888	20,130	5.5%
Los Alamos	17,585	18,401	3.8%
Luna	24,709	26,865	14.1%
McKinley	72,873	86,244	8.7%

Mora	4773	4984	7.9%
Otero	64,044	73,421	6.1%
Quay	8809	9184	6.2%
Rio Arriba	40,218	44,983	6.4%
Roosevelt	20,270	24,778	5.3%
Sandoval	141,542	207,314	6.2%
San Juan	142,718	221,595	7.2%
San Miguel	31,724	47,440	7.4%
Santa Fe	152,987	216,704	5.1%
Sierra	11,863	14,243	7.9%
Socorro	19,497	30,078	6.5%
Taos	34,522	47,312	7.9%
Torrance	17,462	24,896	8.6%
Union	4858	7206	3.8%
Valencia	82,728	122,762	6.7%
Total	**2,114,333**	**2,649,196**	**5.90%**

Note: Population in 2050 changes by scenario. *Population in 2050 under the *20%-RPS*. **Unemployment data are from Bureau of Labor Statistics.

Since construction jobs, unlike O&M jobs, are temporal, we report cumulative employment impacts for impacted counties. Under the 20%-RPS, there will be additional job-years by all the energy sources, with PV and NG holding the majority of jobs for RE and FF sources respectively.

Under 100%-RPS, wind energy is capable of creating more than 1532 cumulative job-years in the impacted counties. PV industry will produce roughly more than 1,000 cumulative job-years on average in the impacted counties. 10%-RPS, on the other hand, hardly supports any RE jobs. Majority of the jobs will be in constructing additional NG power plants in the counties with existing infrastructure. Each of these counties will have more than 8,000 new construction job-years cumulatively. Overall, relative to the 20%-RPS, rural counties will experience more employment under the RE intensive scenarios, while urban counties (more populous counties) with existing NG infrastructure will see higher level employments under the FF intensive scenario (10%-RPS).

O&M county-level employment impacts are more consistent than construction impacts (see Table S8). Under all three modeled scenarios and the 20%-RPS, Curry, Torrance, and Roosevelt counties will have more than 100 O&M jobs per year in the wind sector, while Colfax, Luna, and Guadalupe counties will enjoy the greatest employment impact from PV installation. Bernalillo, Dona Ana, and Santa Fe are the counties with the highest potential for RPV diffusion and thus employment impact. Lea, Luna, Dona Ana, Valencia, Bernalillo, and Hidalgo counties will also contain the highest number of NG jobs across all three scenarios. Lastly, as the main coal-fired power plants of the state are located in San Juan county, it will experience the greatest employment impact from coal generation. Once again, RE and FF intensive scenarios are proven to yield higher level of O&M employment in the counties with potential for the corresponding energy source.

Figure S13 and Figure S14 depict cumulative employment impact by RE and FF during construction and O&M respectively. The darker the color of the county, the higher its population.

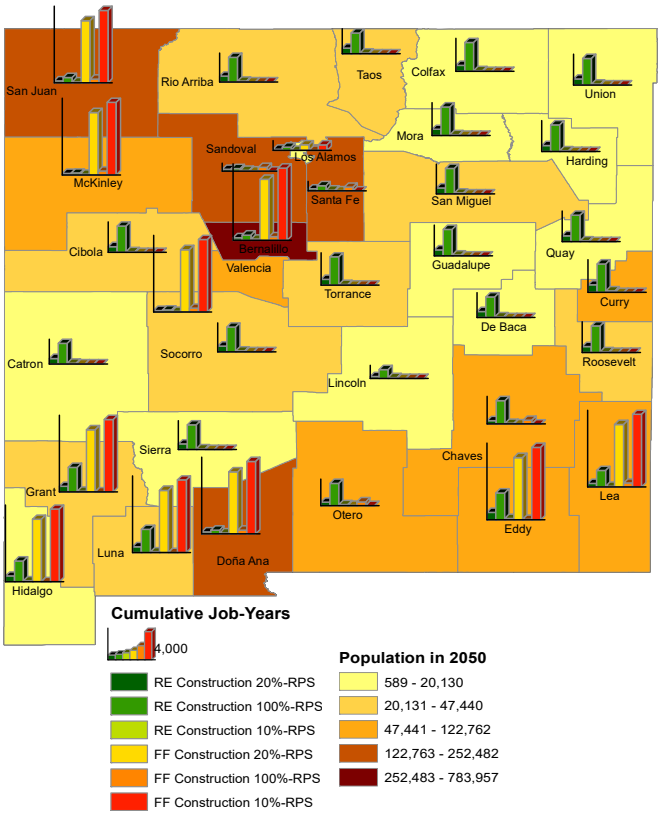


Figure S13: Cumulative total construction employment impact by modeled scenarios and energy sources from 2017 to 2050 against 2050 population density.

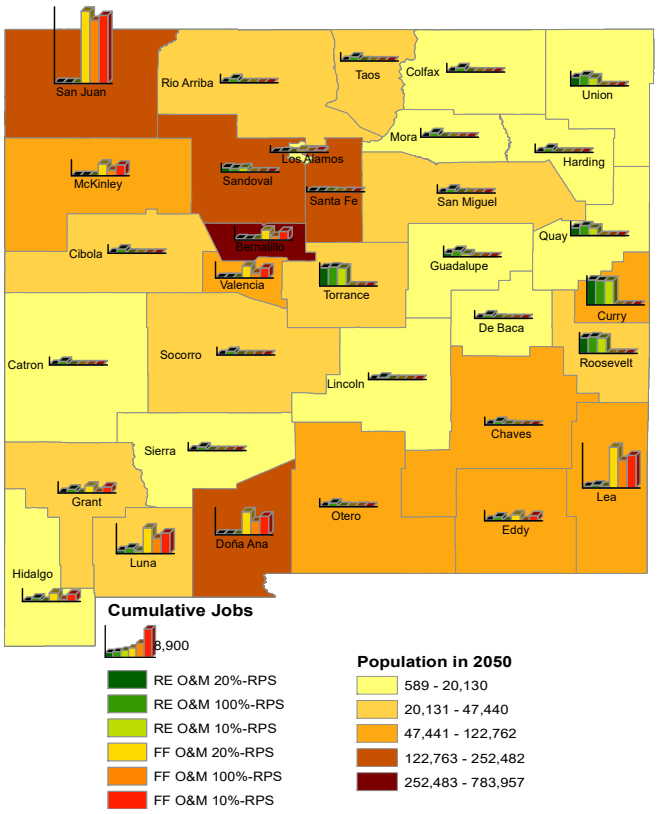


Figure S14: Cumulative O&M total employment impact by modeled scenarios and energy sources from 2017 to 2050 against 2050 population density.

As mentioned above, direct, indirect, and induced impacts are a fixed fraction of total impact. On average, 78%, 8%, and 14% (65%, 20%, and 15%) of total employment impact of wind power plant during construction (O&M) is direct, indirect, and induced impacts respectively. Similarly, 72%, 9%, and 19% (61%, 18%, and 22%) of total employment impact of solar energy installation is direct, indirect, and induced impacts respectively. Lastly, on average, 67%, 10%, and 22% (53%, 24%, and 23%) of total employment impact of fossil fuel power plant during construction (O&M) is direct, indirect, and induced impacts respectively. One can apply these percentages to arrive at employment results by category. Overall, the majority of employment impact occurs onsite. Lastly, Figure S15 and Figure S16 depict employment impacts of 100% and 10% RPS scenarios against the 20% RPS scenario, respectively. These figures and tables demonstrate an important result of the current study; some counties will be winners and others will be losers.

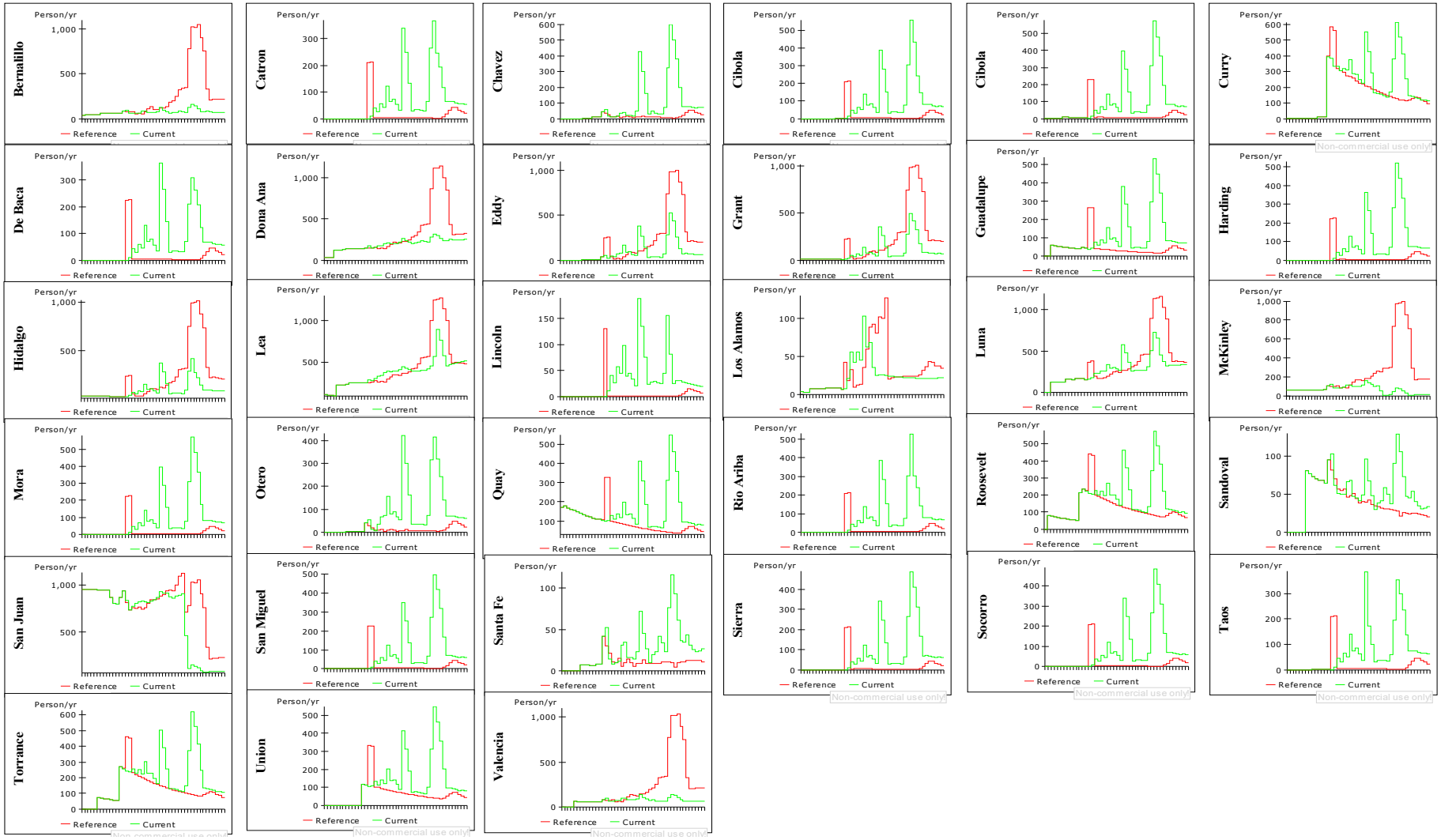


Figure S15. 100% RPS versus Reference Case (20%-RPS) employment from 2004 - 2050. Note: The "Current" graph is the 100% RPS Scenario.

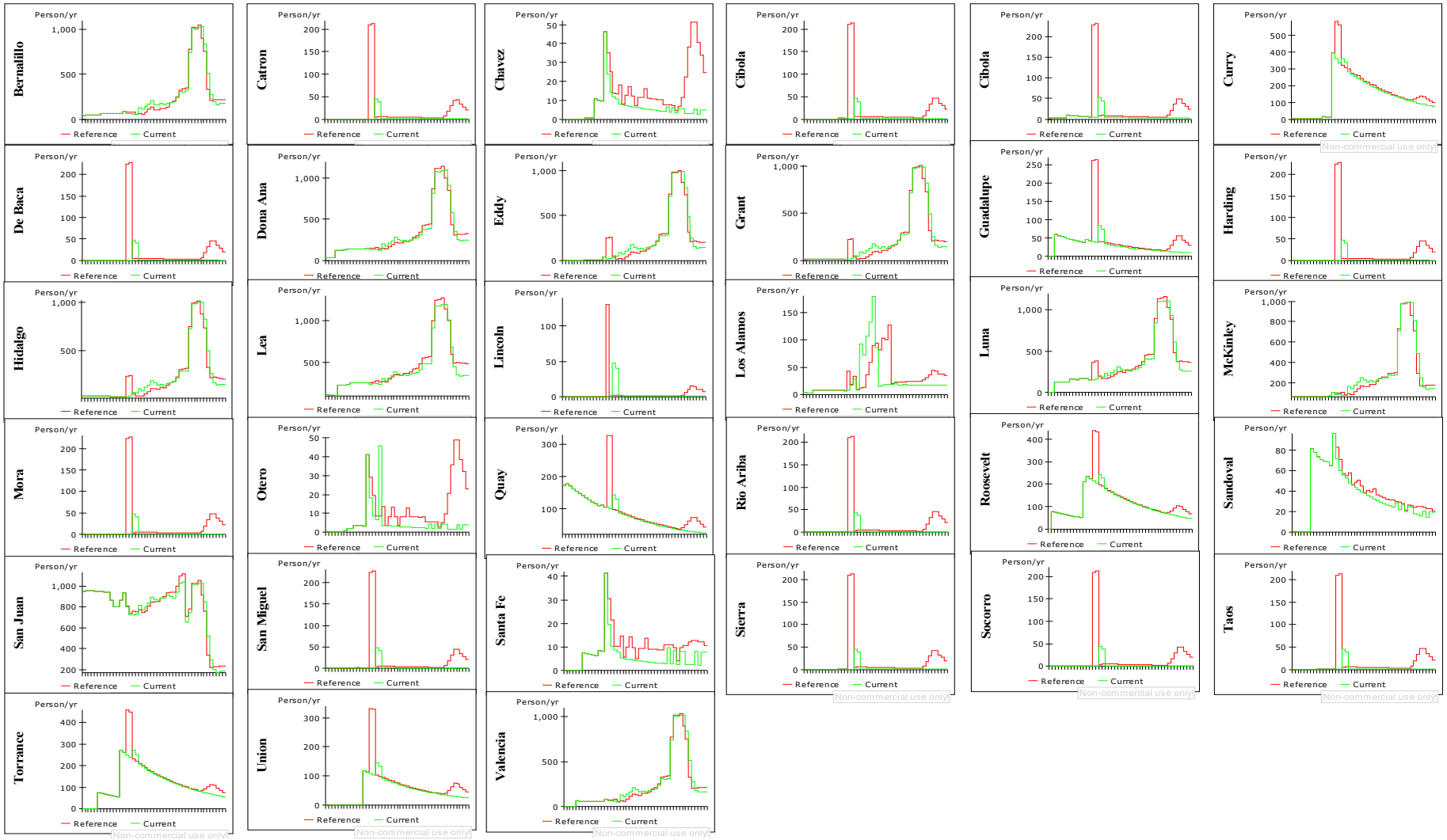


Figure S16. 10% RPS versus Reference Case (20%-RPS) employment from 2004 - 2050. Note: The "Current" graph is the 10% RPS Scenario.

C.2. Economic output

Figure S17 imparts the total annual economic output by energy source and modeled scenarios from 2017 through January 2050. Wind construction yield its highest economic output impact in 100%-RPS, while NG baseload in 10%-RPS. During O&M, beside NG baseload that has its highest economic output under the 20%-RPS, all the other energy sources yield their highest impact in the corresponding scenario with the highest impact during construction. Lastly, on an annum account, the 20%-RPS yields $355 million ($2017) per year during O&M period, while scenarios 100%-RPS and 10%-RPS yield $32 and $53 million ($2017) per year less than the 20%-RPS respectively.

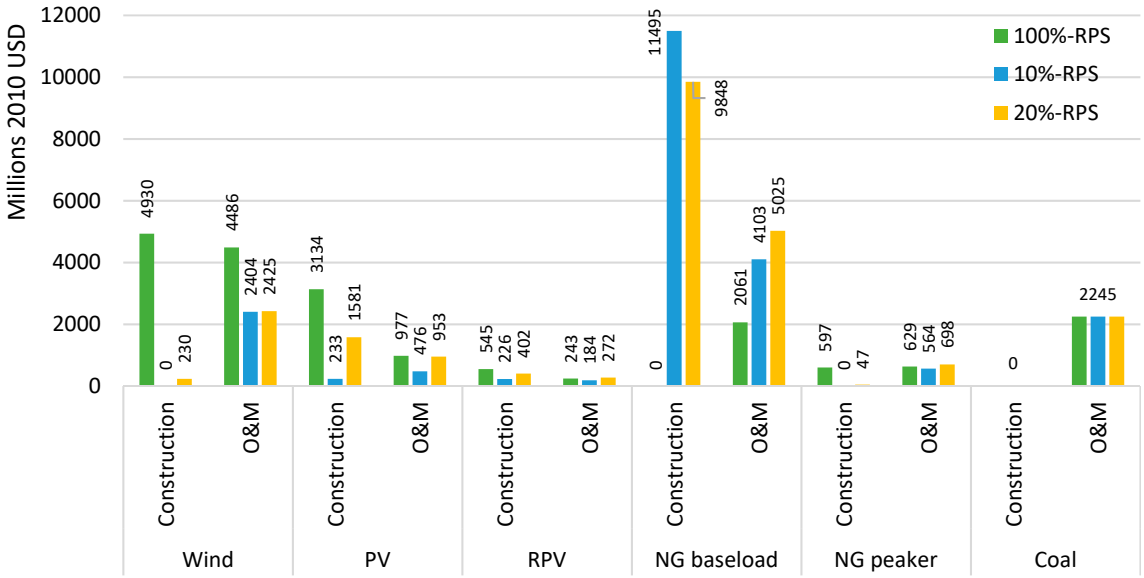


Figure S17: Cumulative gross economic output by energy source and modeled scenarios from January 2017 to January 2050. Note: Divide O&M figures by 33 to calculate annual average values.

County-level cumulative economic output during construction and O&M from 2017 to January 2050 are summarized in Table S11 and Table S12 respectively. For the same reason discussed above, annual average output of construction does not convey useful information as construction, unlike O&M, does not occur annually. Thus, we only discuss cumulative economic output values during construction phase. Under the 20%-RPS, counties with appropriate infrastructure for NG baseload installation will experience 81 million dollars cumulatively over the time period of the study. 10%-RPS generates 14 million dollars more than the 20%-RPS in counties with appropriate infrastructure for NG baseload (see Table S11). Compared to the 20%-RPS, the 100%-RPS scenario produces no economic output from NG baseload as there will be no installation, however, it results in higher economic output from wind and PV installation. Under the 100%-RPS scenario, the majority of counties will experience more than 16 million dollars in cumulative total economic impact from wind plant installation.

Similar to employment impact we observe an emerging pattern during the O&M phase (see Table S12). Regardless of scenario, Curry, Torrance, and Roosevelt counties will have the highest economic output (with different magnitudes) from developing wind energy, while Colfax, Luna, and Guadalupe counties are better off with PV installation. This is because these counties meet our siting criteria: not only are they rural, but they also have higher potential for solar or wind energy. Bernalillo, Dona Ana, and Santa Fe are the counties most suitable for RPV diffusion with the highest economic impact. Developing NG peaker in Valencia, Bernalillo, Dona Ana, Lea, and Hidalgo counties, and NG baseload diffusion in Lea, Luna, and Dona Ana counties will lead to the highest economic

output regardless of scenario. Lastly, San Juan county will experience the greatest economic output from its coal-fired generation power plants. Figure S18 and Figure S19 visualize county-level gross economic output results by RE and FF during construction and O&M respectively against reference case population in 2050.

Table S11: Cumulative construction economic output by energy source and county from 2017 to 2050.*.

	100%-RPS (*$100,000)					**10%-RPS (*$100,000)**					**20%-RPS (*$100,000)**				
County	**Wind**	**PV**	**RPV**	**NGp**	**NGb**	**Wind**	**PV**	**RPV**	**NGp**	**NGb**	**Wind**	PV	RPV	NGp	NGb
Bernalillo	0	0	70	49	0	0	0	17	0	949	0	0	36	4	801
Catron	162	88	0	0	0	0	9	0	0	0	7	65	0	0	0
Chaves	132	98	23	49	0	0	0	7	0	0	7	13	16	4	0
Cibola	190	116	0	0	0	0	9	0	0	0	8	65	0	0	0
Colfax	190	121	0	0	0	0	8	0	0	0	8	55	0	0	0
Curry	166	121	21	0	0	0	8	7	0	0	7	55	15	0	0
De Baca	166	59	0	0	0	0	8	0	0	0	7	55	0	0	0
Dona Ana	0	0	50	49	0	0	0	12	0	951	0	0	28	4	812
Eddy	166	106	18	5	0	0	8	7	0	951	7	55	16	3	816
Grant	162	142	0	0	0	0	9	0	0	951	7	65	0	0	816
Guadalupe	166	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Harding	166	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Hidalgo	162	90	0	0	0	0	9	0	0	951	7	65	0	0	817
Lea	93	66	18	49	0	0	0	7	0	951	7	13	16	4	815
Lincoln	92	10	0	0	0	0	8	0	0	0	7	12	0	0	0
Los Alamos	33	3	0	0	0	0	2	0	0	71	8	4	0	0	74
Luna	162	122	0	0	0	0	9	0	0	951	7	65	0	0	816
McKinley	0	0	24	49	0	0	0	8	0	951	0	0	19	4	815
Mora	190	117	0	0	0	0	8	0	0	0	8	55	0	0	0
Otero	159	68	21	49	0	0	4	7	0	0	7	13	16	4	0
Quay	166	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Rio Arriba	190	93	0	0	0	0	9	0	0	0	8	65	0	0	0
Roosevelt	166	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Sandoval	0	0	34	49	0	0	0	11	0	0	0	0	24	4	0
San Juan	0	0	69	49	0	0	0	11	0	951	0	0	25	4	813
San Miguel	162	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Santa Fe	0	0	69	49	0	0	0	11	0	0	0	0	26	4	0
Sierra	162	142	0	0	0	0	9	0	0	0	7	65	0	0	0
Socorro	162	142	0	0	0	0	9	0	0	0	7	65	0	0	0
Taos	190	43	0	0	0	0	9	0	0	0	8	65	0	0	0
Torrance	190	142	0	0	0	0	9	0	0	0	8	65	0	0	0
Union	166	121	0	0	0	0	8	0	0	0	7	55	0	0	0
Valencia	0	0	29	49	0	0	0	101	0	951	0	0	135	4	814

*Values are in hundred thousand 2017 USD. Divide values by 33 (2050 – 2017) to calculate annual average economic output for each county though not recommended as it ignores the temporal nature of construction phase.

Table S12: Cumulative O&M economic output by energy source and county from 2017 to 2050.*.

	100%-RPS (million $)					**10%-RPS (million $)**					**20%-RPS (million$)**				
County	Wind	PV	RPV	NGp	NGb	Wind	PV	RPV	NGp	NGb	Wind	PV	RPV	NGp	NGb
Bernalillo	5	13	53	110	19	0	19	61	105	200	0	20	70	128	227

Catron	95	29	0	0	0	0	5	0	0	0	1	29	0	0	0
Chaves	94	26	10	6	0	17	2	5	0	0	18	4	11	1	0
Cibola	116	39	0	0	0	0	11	0	0	0	1	36	0	0	0
Colfax	120	44	0	2	0	9	22	0	2	0	9	42	0	2	0
Curry	699	33	9	0	0	715	4	5	0	0	716	25	10	0	0
De Baca	97	20	1	2	12	0	5	1	2	31	1	25	1	3	42
Dona Ana	6	25	32	93	388	0	38	27	87	589	0	39	35	107	729
Eddy	102	35	8	6	0	0	10	5	4	201	1	31	11	6	235
Grant	96	40	1	31	0	1	6	3	31	182	2	30	3	37	211
Guadalupe	160	51	0	0	0	69	32	0	0	0	70	53	0	0	0
Harding	102	33	0	2	0	0	4	0	2	20	1	25	0	2	25
Hidalgo	94	29	0	75	26	0	5	0	74	227	1	29	0	90	274
Lea	68	28	8	91	870	28	23	5	85	1051	29	24	11	104	1321
Lincoln	62	4	0	0	1	0	4	0	0	2	1	7	0	0	4
Los Alamos	27	4	0	0	52	1	4	0	0	103	1	6	0	0	132
Luna	128	78	1	0	538	46	76	2	0	739	46	100	2	0	923
McKinley	7	2	11	7	0	0	0	6	1	181	0	1	12	3	210
Mora	114	32	0	0	0	0	4	0	0	0	1	25	0	0	0
Otero	96	30	10	6	0	2	14	7	0	0	3	13	12	1	0
Quay	269	56	0	0	0	199	43	0	0	0	199	63	0	0	0
Rio Arriba	118	30	0	0	0	5	5	0	0	0	6	29	0	0	0
Roosevelt	471	32	0	0	0	449	4	0	0	0	450	24	1	0	0
Sandoval	90	9	24	6	5	107	15	21	0	24	107	15	29	1	31
San Juan	5	34	24	6	150	0	57	6	0	332	0	58	14	1	401
San Miguel	90	34	2	0	0	0	8	1	0	0	1	28	1	0	0
Santa Fe	5	6	34	6	0	0	7	25	0	0	0	8	33	1	0
Sierra	95	41	0	0	0	0	7	0	0	0	1	32	0	0	0
Socorro	96	38	0	0	0	0	5	0	0	0	1	29	0	0	0
Taos	120	19	0	0	0	6	7	0	0	0	7	32	0	0	0
Torrance	551	39	0	0	0	523	5	0	0	0	524	29	0	0	0
Union	285	32	0	4	0	226	4	0	4	20	226	24	0	5	25
Valencia	0	13	12	172	0	0	19	6	167	182	0	20	13	204	210

Note: Only two counties have coal-fired power plants. San Juan 2053 and McKinley 192 million (2017 USD). * Values are in million 2017 USD. Divide values by 33 (2050 – 2017) to calculate annual average economic output for each county.

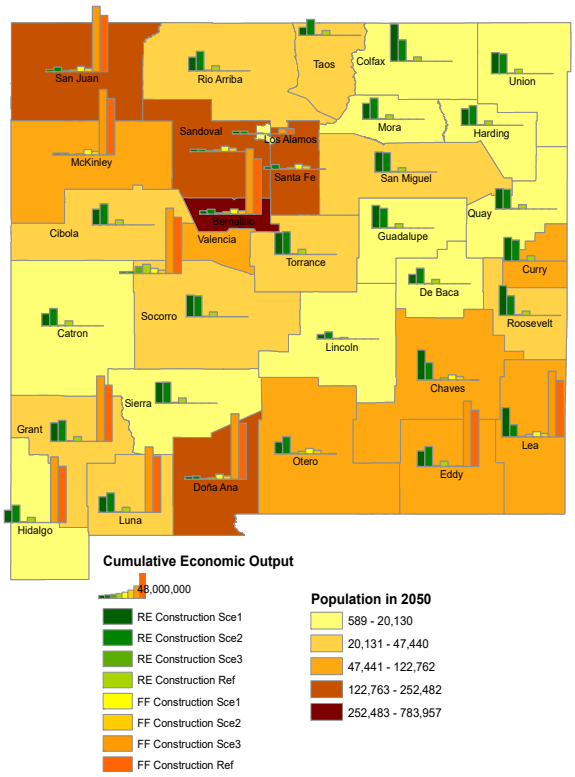


Figure S18: Cumulative economic output during construction from 2017 to January 2050 against 2050 population. *Note: Sce1 is 50%-RPS, Sce2 is 100%-RPS, Sce3 is 10%-RPS, and Ref is the reference case scenario.

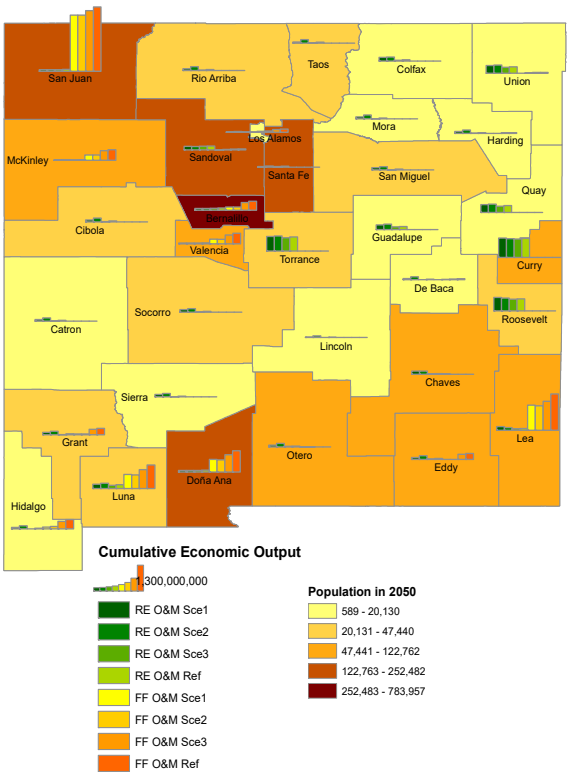


Figure S19: Cumulative economic output during O&M from 2017 to January 2050 against 2050 population. *Note: Sce1 is 50%-RPS, Sce2 is 100%-RPS, Sce3 is 10%-RPS, and Ref is the reference case scenario.

During construction (O&M) phase, on average, 77%, 9%, and 14% (63%, 21%, and 15%) of total gross economic output impact of wind power plant is direct, indirect, and induced impacts respectively. These figures for solar energy are 71%, 11%, and 19% (54%, 21%, and 24%) of total employment impact respectively. Lastly, on average, 67%, 13%, and 21% (46%, 33%, and 21%) of total gross economic output impact of fossil fuel power plant during construction (O&M) is direct, indirect, and induced impacts respectively. One can apply these percentages to arrive at gross economic output results by category. Overall, similar to employment impact, majority of the economic output impact is due to direct impacts (onsite). We break down the duration into three segments, 2017–2030, 2031–2040, and 2041–2050, to preserve some of the temporality.

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