Relative Cost-Effectiveness of Electricity and Transportation Policies as a Means to Reduce CO_2 Emissions in the United States: A Multi-Model Assessment

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Supplemental Material

S1. Additional Figures

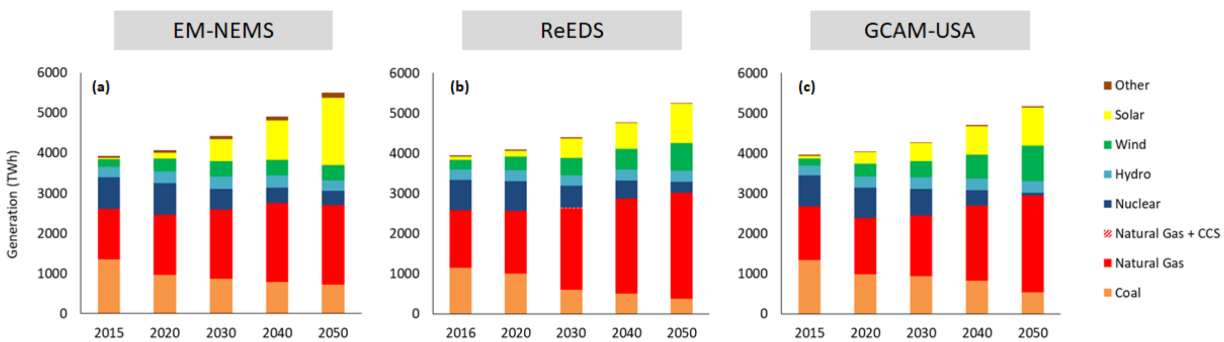

Figure S1: Electricity generation in the Reference Case for EM-NEMS (panel a), ReEDS (panel b), and GCAM-USA (panel c). The "other" category includes geothermal, biomass and storage losses. The first year shown is 2016 in ReEDS because the model solves in two-year time steps.

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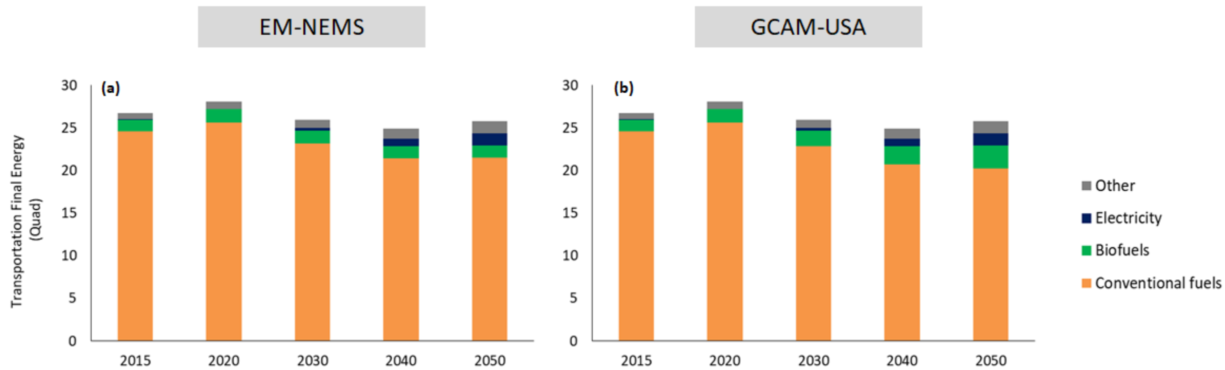

Figure S2: Transportation final energy in the Reference Case for EM-NEMS (panel a) and GCAM-USA (panel b). The “other” category includes natural gas and hydrogen.

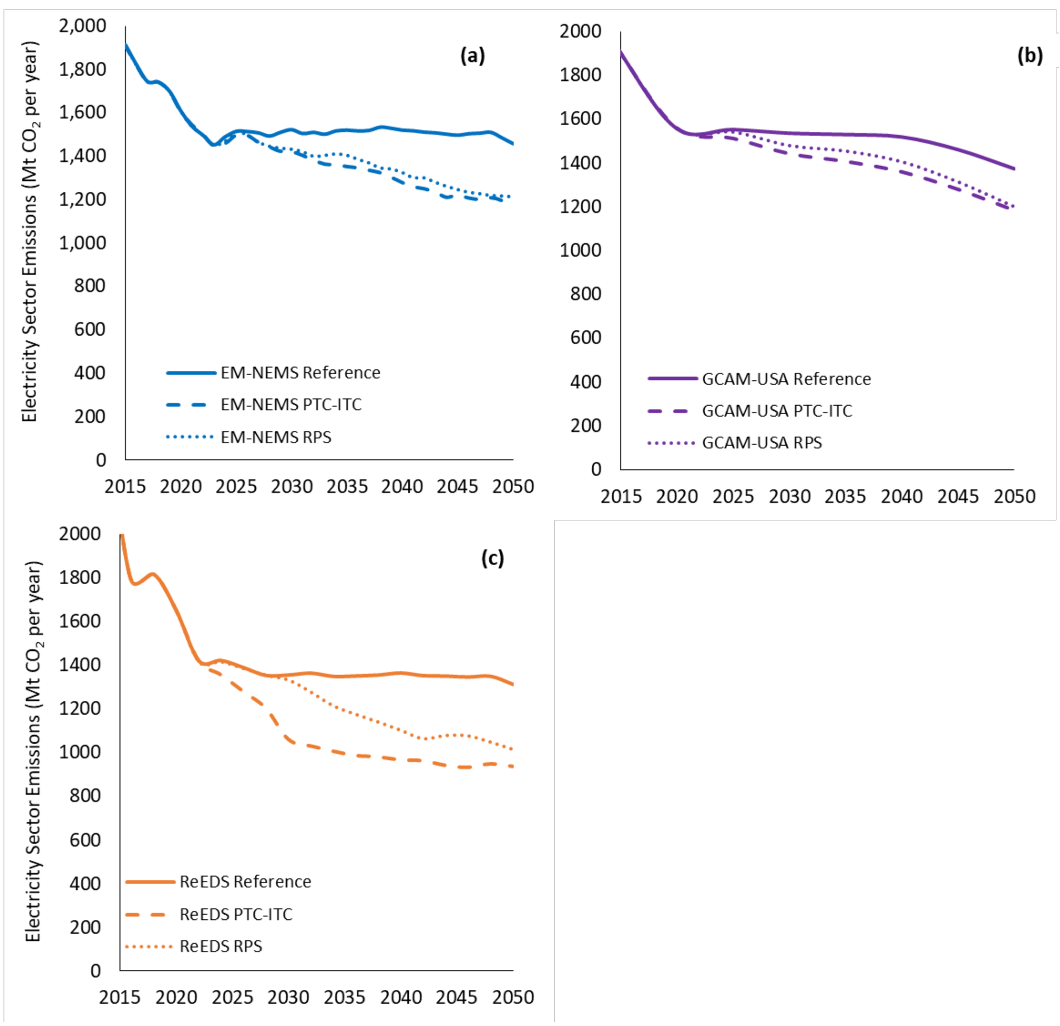

Figure S3: Electricity sector CO_2 emissions in the Reference Case and two electricity sector policy cases for EM-NEMS (panel a), GCAM-USA (panel b), and ReEDS (panel c).

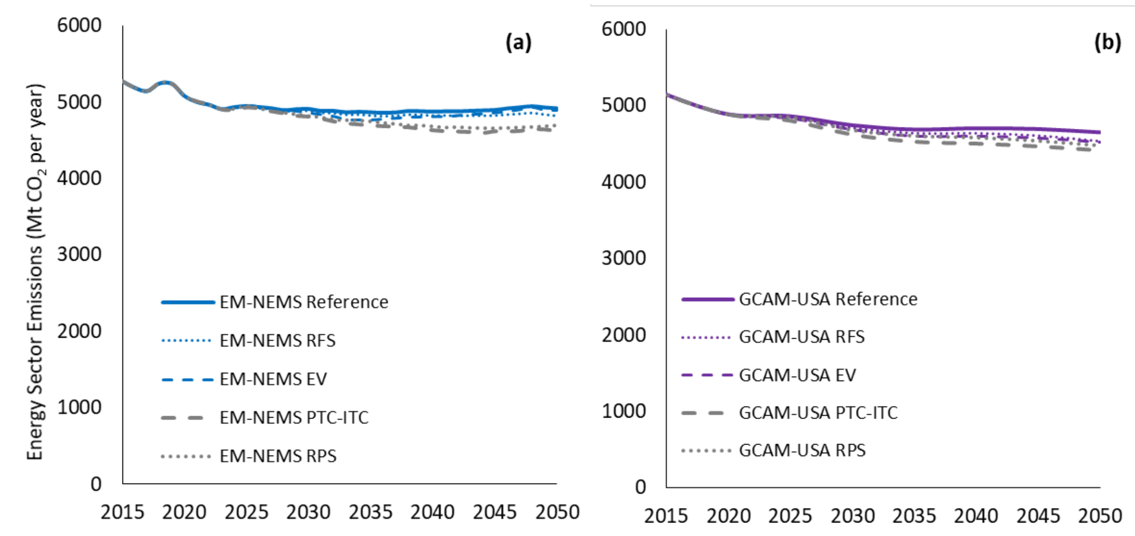

Figure S4: Energy sector CO_2 emissions in the Reference Case and four policy cases for EM-NEMS (panel a) and GCAM-USA (panel b).

S2. Scenario Assumptions

Table S1: Electricity sector capital costs for selected technologies in 2018 $ per kW used in all three models. Costs are based on NREL's 2018 Annual Technology Baseline (ATB) Mid Case.[††] Values for 2020 reflect costs in 2020 or first on-line year if later. Natural gas CC + CCS is assumed to have a capture fraction of ~90% in all models. Capital costs for natural gas CC, natural gas CC + CCS, and nuclear in EM-NEMS decline at a faster rate than shown here due to the application of a materials price index, which declines over time. The heat rate starts at ~6200 Btu/kWh for Natural Gas CC and above 7,000 Btu/kWh for Natural Gas + CCS, with a decline rate that varies by model. Capacity factors for wind and solar PV vary by region and resource class, so realized average national capacity factors vary by scenario and model. In general, for solar PV, realized national average capacity factors vary between 20% and 30% over the projection period in all three models. For wind, in EM-NEMS and ReEDS, national average capacity factors vary between 30% and 50% over the projection period, with the highest values (over 40%) observed in ReEDS in later years. In GCAM-USA, differences in wind resource quality are incorporated into the LCOE via the integration cost discussed in the methods section, so GCAM-USA capacity factors for wind are not directly comparable to realized values from EM-NEMS and ReEDS.

Technology	**2020**	**2030**	**2040**	**2050**
Natural Gas CC	$1,072	$1,024	$988	$948
Natural Gas CC + CCS	$2,217	$2,036	$1,889	$1,736
Nuclear	$5,906	$5,660	$5,354	$5,009
Wind (onshore)	$1,484	$1,334	$1,255	$1,248
Solar PV	$1,293	$1,101	$1,006	$897

Table S2: Biofuel non-energy costs (production costs excluding feedstock costs) in 2018 $ per MMBtu used in GCAM-USA and EM-NEMS. Non-energy costs are based on Muratori et al (Carbon capture and storage across fuels and sectors in energy system transformation pathways 2017). Biomass feedstock costs vary by model and scenario, but range between $3 and $8 per MMBtu (per unit input) for second-generation ethanol and FT biofuels and between $16 and $34 per MMBtu (per unit input) for biodiesel, depending on the model, scenario and year. Biomass conversion efficiencies are approximately 50% for ethanol and FT biofuels (note that for corn ethanol and biodiesel other fuel inputs may be significant).

Technology	**2020**	**2030**	**2040**	**2050**
Corn Ethanol	$9.26	$9.26	$9.26	$9.26
Cellulosic Ethanol	$16.98	$15.91	$15.12	$14.54
FT Biofuel	$27.95	$26.18	$24.89	$23.93
Biodiesel	$7.31	$7.31	$7.31	$7.31

[††] See https://atb.nrel.gov/.

Table S3: Midsize passenger vehicle costs for selected technologies in 2018 $ per vehicle used in GCAM-USA and EM-NEMS. For each size class, GCAM represents EVs using a single average range corresponding to the EV-200 assumptions shown below. Electric vehicle costs are based on the NREL Electrification Futures Study (EFS) Moderate Advancement Case.[‡‡] Vehicle fuel economy is assumed to increase over time for both conventional and electric vehicles.

Technology	2020	2030	2040	2050
Conventional Gasoline	$28.7k	$30.3k	$30.8k	$31.0k
EV-100	$38.8k	$33.8k	$32.9k	$32.4k
EV-200	$45.4k	$38.4k	$36.8k	$35.8k
EV-300	$54.5k	$44.8k	$42.2k	$40.5k
HEV	$33.4k	$33.5k	$33.6k	$33.8k

S3. Time-dependence of Abatement Costs

Table S4: Abatement costs (in 2018 $ per ton) reported for the period 2020-2035, 2035-2050, and 2020-2050. Abatement costs for the entire projection period (2020-2050) are consistent with those reported in the main text (Figure 3). The measure of abatement cost used in this study is defined in Section 2.3.

Model	Period	Electricity Tax Credit	RPS	EV Tax Credit	RFS
EM-NEMS	2020-2035	$63	$34	$752	$236
	2036-2050	$31	$45	$452	$160
	2020-2050	$39	$43	$568	$175
GCAM-USA	2020-2035	$60	$46	$756	$194
	2036-2050	$50	$26	$340	$184
	2020-2050	$53	$31	$497	$187
ReEDS	2020-2035	$29	$18	-	-
	2036-2050	$35	$33	-	-
	2020-2050	$33	$31	-	-

[‡‡] See https://www.nrel.gov/analysis/electrification-futures.html.

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