A Roadmap to Climate-Friendly Cars

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Highlights

America's high-carbon electricity grid is short-circuiting efforts to give consumers climate-friendly, electric-vehicle options. Depending on where you live, generating the electricity to charge an electric car can produce more greenhouse gas pollution than driving a fuel-efficient gasoline powered car.

The good news is that Americans have lots of choices to reduce the carbon footprint from their daily driving. Anywhere in the country, an electric car is much better for the climate than the average-mileage vehicle. But in many states, popular high-mileage hybrid and conventional gas-powered cars are climate-friendlier alternatives to electric cars today, and new fuel economy standards should lead to even more climate-friendly options in the coming few years.

This report provides a state-by-state roadmap to the most climate friendly cars on the market today. The analysis is benchmarked to emissions associated with the Nissan Leaf and Chevy Volt because these are the top-selling all-electric and plug–in electric vehicles on the road today.

In 36 states, the hybrid electric Toyota Prius produces less greenhouse gas pollution than the all-electric Nissan Leaf, because when you plug in a Leaf to recharge, you are tapping into electricity generated largely by burning coal and natural gas in those states. (The Prius, which is the most efficient gasoline car sold in the U.S. today, is called a hybrid electric vehicle, but it can be thought of simply as a high-efficiency gasoline car because it derives all of its power from gasoline: its batteries are recharged by running its engine and recovering braking energy.)

Coal is the largest contributor to the high-carbon footprint of our electrical grid today. In states like Wyoming or Indiana, where 90 percent or more of the electricity comes from coal, driving a Leaf is responsible for much more greenhouse gas emissions per mile (about 0.9 pounds) than a Prius (about 0.5 pounds). The Leaf fares better in states that get a significant share of their electricity from natural gas, like Rhode Island or Nevada (about 0.6 pounds per mile), but typically still produces more emissions than a Prius. The Leaf does best in states that rely heavily on nuclear, like Connecticut

In Many States High-Mileage Gas-Powered Cars are Better for the Climate than Electric Cars

The 10 most fuel-efficient gasoline cars ranked by the EPA.

EPA Rank	Car	EPA mpg	Number of States Where This Car Emits Less CO_2 Than a Leaf	Number of States Where This Car Emits Less CO_2 Than a Volt
1	Toyota Prius	50	36 states	45 states
2	Honda Civic Hybrid	44	24 states	38 states
3	Lexus CT 200h	42	22 states	37 states
4	Toyota Prius V	42	22 states	37 states
5	Ford Fusion Hybrid	39	18 states	23 states
6	Lincoln MKZ Hybrid	39	18 states	23 states
7	Scion IQ	37	16 states	18 states
8	Chevy Volt	--	13 states*	--
9	Hyundai Accent (manual)	34	12 states	11 states
10	Kia Rio (manual)	34	12 states	11 states

**For a Volt driving half its miles using battery electricity and half using gasoline. (The Volt's EPA rating is 37 mpg when using gasoline only.)*

(0.3 pounds), or on hydropower, like Idaho or Washington (0.1 pounds).

It isn't only the Prius that outperforms the Leaf. In the 10 states with the most carbon-polluting electricity generation, there are 20 cars that are better for the climate than the Leaf; 13 of them are gas-powered vehicles with conventional engines. The rest are gas-powered hybrids.

The partially electric Chevy Volt has a similar profile, depending on how often a driver engages its gasoline engine. A Volt, like a Leaf, plugs in to charge its battery, but when the charge is depleted during driving it switches to its onboard gasoline engine to keep going. If a Volt drives half its miles using gasoline and half using electricity from plug-in charging of its battery, it is a bigger carbon polluter than the Prius in 45 states.

But this doesn't mean that electric cars are not an important option for fighting climate change. They can help address our oil addiction and save consumers thousands of dollars on gasoline over the life of a vehicle. And in the long term, once the grid becomes low-carbon, electric cars, unlike gas-powered automobiles, could be a cornerstone of personal mobility in a world where carbon emissions are next to zero, which will be required to stabilize the climate.

In the meantime, as we work to shift much more of our electricity generation to low-carbon alternatives, there are many high-mileage hybrids, diesels, and other gas-powered cars available today that can offer substantial reductions in climate impacts.

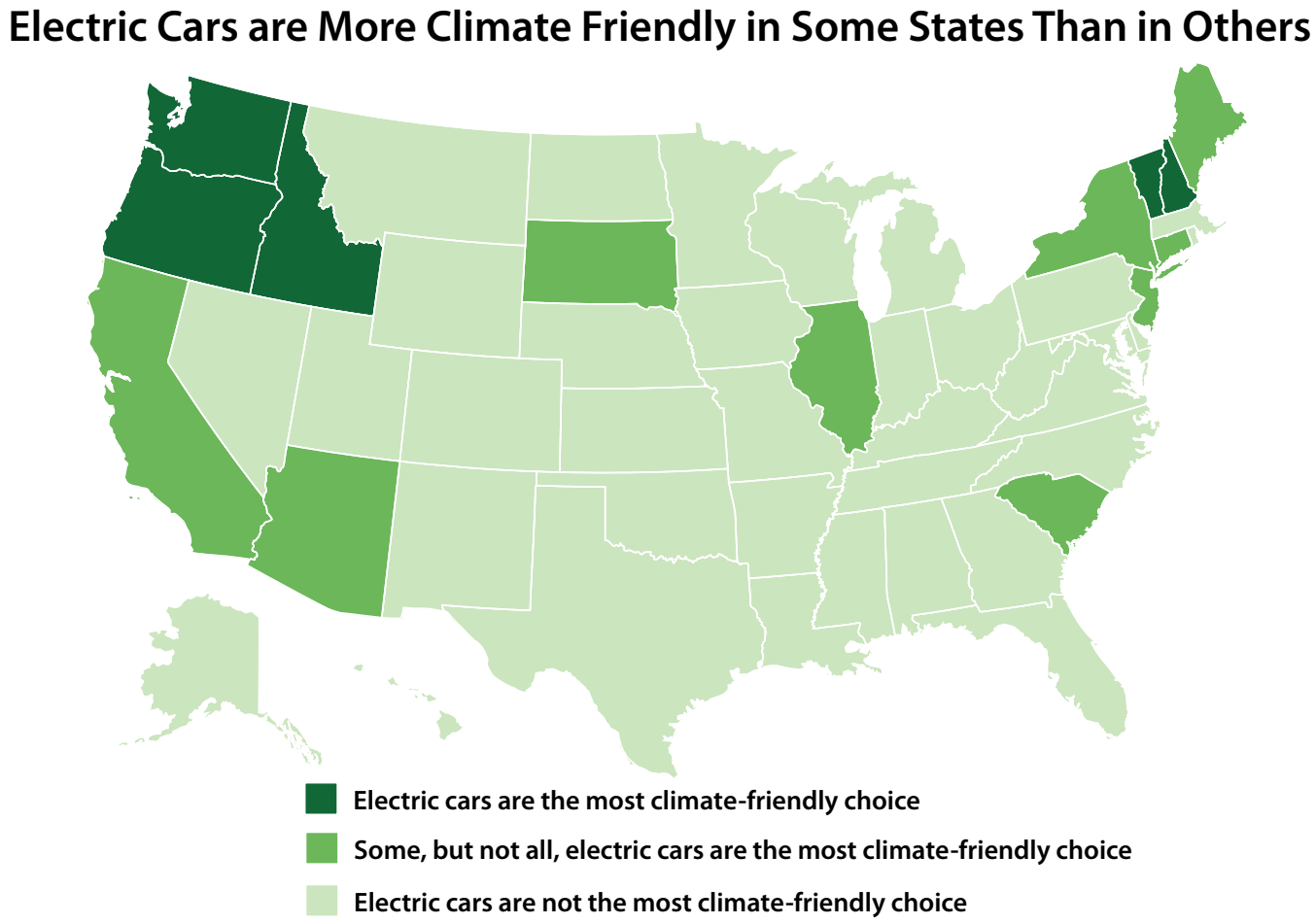


Figure 1. *Greenhouse gas emissions from electric cars differ by state. In some states, electric cars produce fewer emissions than gas-powered cars, making them more climate-friendly. In other states, however, electric cars can produce more emissions than gas-powered cars.*

Introduction

All-electric vehicles, like the Nissan Leaf, are attracting attention as vehicles that have zero "tailpipe" pollutant emissions. No fuel combustion takes place onboard the car, so tailpipe emissions of the important greenhouse gas (GHG), carbon dioxide (CO_2), are zero. However, the source of the electricity used to charge the onboard battery must be considered in assessing the carbon footprint of an electric vehicle to have a complete picture.

The same is true for a partially electric (sometimes called a plug-in hybrid electric) vehicle, which uses externally supplied electricity to charge its battery and then also burns some gasoline to run the car when the battery charge runs low.

Conventional hybrid-electric vehicles like the Toyota Prius derive all of their power, as well as their GHG emissions, from gasoline. (They're called hybrid electric because they house a big battery that is recharged by running the gasoline engine and by recovering braking energy.)

What are GHG emissions of these different kinds of cars compared with old-fashioned gasoline vehicles if we consider tailpipe emissions and "upstream" emissions? The latter are the emissions that occur when oil is extracted from the ground, refined into gasoline, and delivered to a car's fuel tank, or when coal or natural gas are extracted from the ground, transported to a power plant, and burned to make electricity. For the analysis here, we have considered this complete accounting of GHG emissions for driving—often called lifecycle GHG emissions.

This report provides a roadmap for understanding where driving an electric vehicle is likely to be friendlier for the climate than a gasoline car on a lifecycle basis.

From fuel economies (miles per gallon for gasoline cars or kilowatt-hours per mile for electric cars) it is possible to estimate GHG emissions per mile driven. The combined highway/city driving fuel economy of cars reported by the Environmental Protection Agency (EPA) are used here. Our methodology and data sources used for calculating lifecycle GHG emissions and expressing these in terms of CO_2-equivalent (CO_2e) emissions are described in the last section of this report.

Figure 1 shows that all-electric vehicles like the Nissan Leaf or partially electric vehicles like the Chevy Volt may or may not be "climate friendly" (i.e., less CO_2 emitting). It depends on what state they are operating in (and what vehicles they are being compared against).

The Leaf

Several all-electric vehicles are available to consumers today. For illustrating GHG emissions, we have selected the best selling of these, the Nissan Leaf. It is categorized by the EPA as a mid-size car, which puts it on par functionally with the Toyota Prius and many other gasoline cars. Other all-electric cars are less comparable. For example, Mitsubishi's MiEV is a sub-compact and the Tesla S is in the luxury class.

The "greenness" of a Leaf depends on what state it is operating in and what vehicle it is compared against. As discussed in the final section of this report, the average GHG emissions per kilowatt-hour of electricity used in the Leaf in a given state are assumed to correspond to the average GHG emissions associated with electricity generation and delivery in that state.

On this basis, Table 1 lists the calculated emissions for the Leaf in each of the 50 states. In 36 states, driving a Prius leads to lower lifecycle carbon emissions than driving a "zero emissions" Leaf.

At the same time, in every state, even those with the most carbon-intensive electricity systems, the Leaf is always better for the climate than the average car on the road today *(Figure 2)*.

In 36 States the Gas-Powered Hybrid Prius is Better for the Climate Than the All-Electric Leaf

Table 1. Calculated lifecycle GHG emissions per mile by state for an all-electric Nissan Leaf. For comparison, emissions for a Toyota Prius are about 0.52 lbsCO_2e/mile. For the average U.S. car today, emissions are about 1.3 lbsCO_2e/mile.

Rank	State	lbsCO_2e/mile Leaf	
1	Wyoming	0.88	Prius Produces Fewer Emissions
2	Kentucky	0.87	
3	Indiana	0.86	
4	West Virginia	0.84	
5	North Dakota	0.83	
6	Utah	0.80	
7	Missouri	0.79	
8	New Mexico	0.79	
9	Delaware	0.79	
10	Ohio	0.79	
11	Colorado	0.78	
12	Iowa	0.77	
13	Hawaii	0.75	
14	Oklahoma	0.73	
15	Alaska	0.73	
16	Kansas	0.71	
17	Wisconsin	0.70	
18	Texas	0.66	
19	Louisiana	0.65	
20	Michigan	0.64	
21	Montana	0.63	
22	Nebraska	0.62	
23	Florida	0.61	
24	Minnesota	0.59	
25	Georgia	0.59	
26	Rhode Island	0.58	Prius Produces Fewer Emissions
27	Nevada	0.58	
28	Maryland	0.58	
29	Mississippi	0.56	
30	Virginia	0.56	
31	Massachusetts	0.56	
32	Arkansas	0.55	
33	Tennessee	0.55	
34	North Carolina	0.54	
35	Alabama	0.53	
36	Pennsylvania	0.52	
37	Arizona	0.51	Leaf Produces Fewer Emissions
38	Illinois	0.48	
39	Maine	0.42	
40	South Carolina	0.39	
41	California	0.38	
42	New York	0.37	
43	New Jersey	0.36	
44	Connecticut	0.34	
45	South Dakota	0.34	
46	New Hampshire	0.29	
47	Oregon	0.22	
48	Washington	0.15	
49	Idaho	0.14	
50	Vermont	0.01	

The Leaf and Volt are Always Better for the Climate Than the Average Car

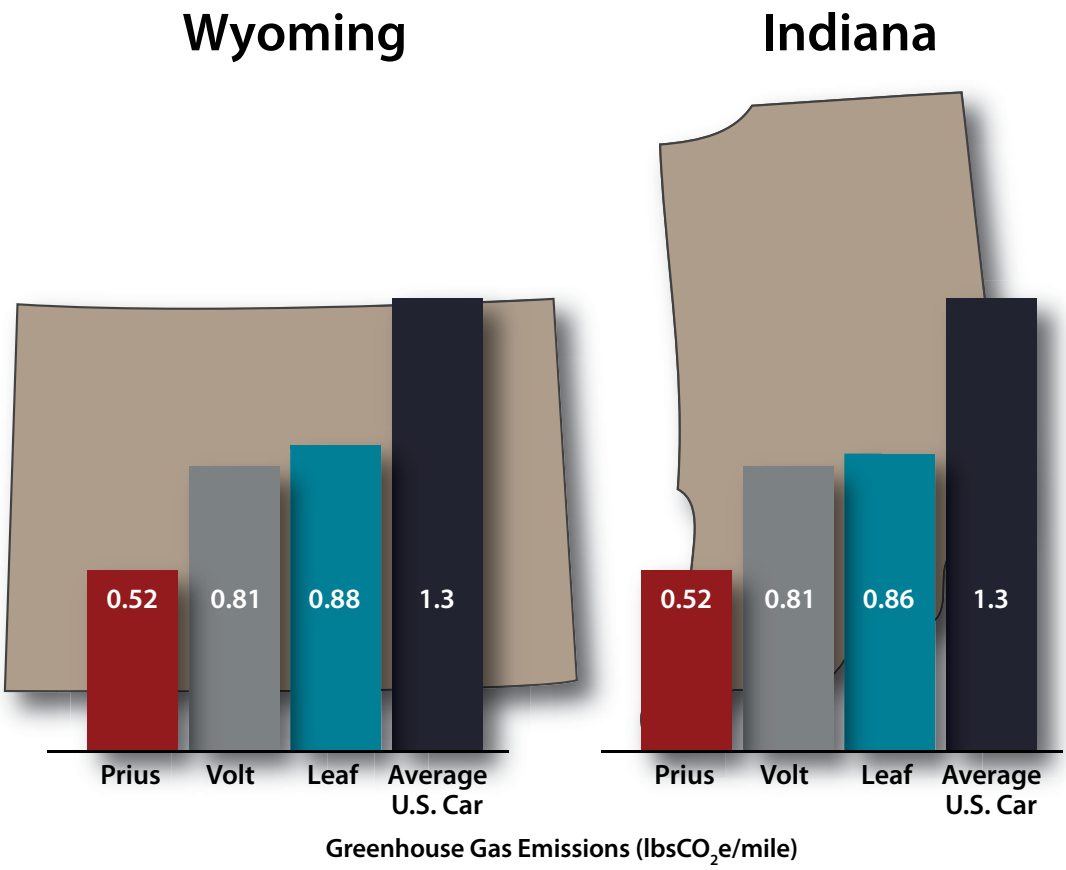


Figure 2. *Wyoming and Indiana are two of the top three states for GHG emissions per kWh of electricity generated due to heavy reliance on coal. In these states, the Leaf and the Volt are more climate-friendly than the average car on the road today. But the Prius (and other gasoline cars) are even more climate-friendly.*

The Volt

The Chevy Volt is one of the few plug-in vehicles available to U.S. consumers today. It is classified by the EPA as a compact car (not a mid-size like the Leaf or Prius). We have chosen it for the analysis here because it is the only model-year 2012 plug-in hybrid electric vehicle that has been assigned a fuel economy rating by the EPA.

A Volt, because it runs partially on gasoline and partially on electricity, has GHG emissions that depend on the mix of miles driven using electricity vs. those driven using gasoline. As a default for the analysis, we assume that a Volt is driven half its miles using electricity and half using gasoline. Table 2 shows the state-by-state emissions for a Volt, which are lower than for a Prius in only five states. As shown in Figure 3, if a Volt drives all of its miles using electricity instead of half its miles with gasoline, its GHG emissions would be lower in some states, like Kentucky, and higher in other states, like California. This comparison is shown for all states in the Appendix (*Table A5*).

In 45 States the Gas-Powered Hybrid Prius is Better for the Climate Than the Partially Electric Volt

Table 2. Calculated lifecycle GHG emissions per mile by state for a partially electric Chevy Volt (driving half its miles using electricity and half using gas). For comparison, emissions for a Toyota Prius are about 0.52 lbsCO_2e/mile. For the average U.S. car today, emissions are about 1.3 lbsCO_2e/mile.

Rank	State	lbsCO_2e/mile Volt	
1	Wyoming	0.81	Prius Produces Fewer Emissions
2	Kentucky	0.81	
3	Indiana	0.81	
4	West Virginia	0.80	
5	North Dakota	0.79	
6	Utah	0.77	
7	Missouri	0.77	
8	New Mexico	0.77	
9	Delaware	0.77	
10	Ohio	0.77	
11	Colorado	0.76	
12	Iowa	0.76	
13	Hawaii	0.75	
14	Oklahoma	0.74	
15	Alaska	0.74	
16	Kansas	0.73	
17	Wisconsin	0.72	
18	Texas	0.70	
19	Louisiana	0.70	
20	Michigan	0.69	
21	Montana	0.68	
22	Nebraska	0.68	
23	Florida	0.67	
24	Minnesota	0.66	
25	Georgia	0.66	
26	Rhode Island	0.66	
27	Nevada	0.66	
28	Maryland	0.66	
29	Mississippi	0.65	
30	Virginia	0.65	
31	Massachusetts	0.65	
32	Arkansas	0.64	
33	Tennessee	0.64	
34	North Carolina	0.64	
35	Alabama	0.63	
36	Pennsylvania	0.63	
37	Arizona	0.62	
38	Illinois	0.61	
39	Maine	0.57	
40	South Carolina	0.56	
41	California	0.55	
42	New York	0.55	
43	New Jersey	0.54	
44	Connecticut	0.53	
45	South Dakota	0.53	
46	New Hampshire	0.50	Volt Produces Fewer Emissions
47	Oregon	0.47	
48	Washington	0.43	
49	Idaho	0.42	
50	Vermont	0.35	

A Volt is More Climate Friendly in Some States when Driven Using Just Electricity but the Opposite is True in Other States

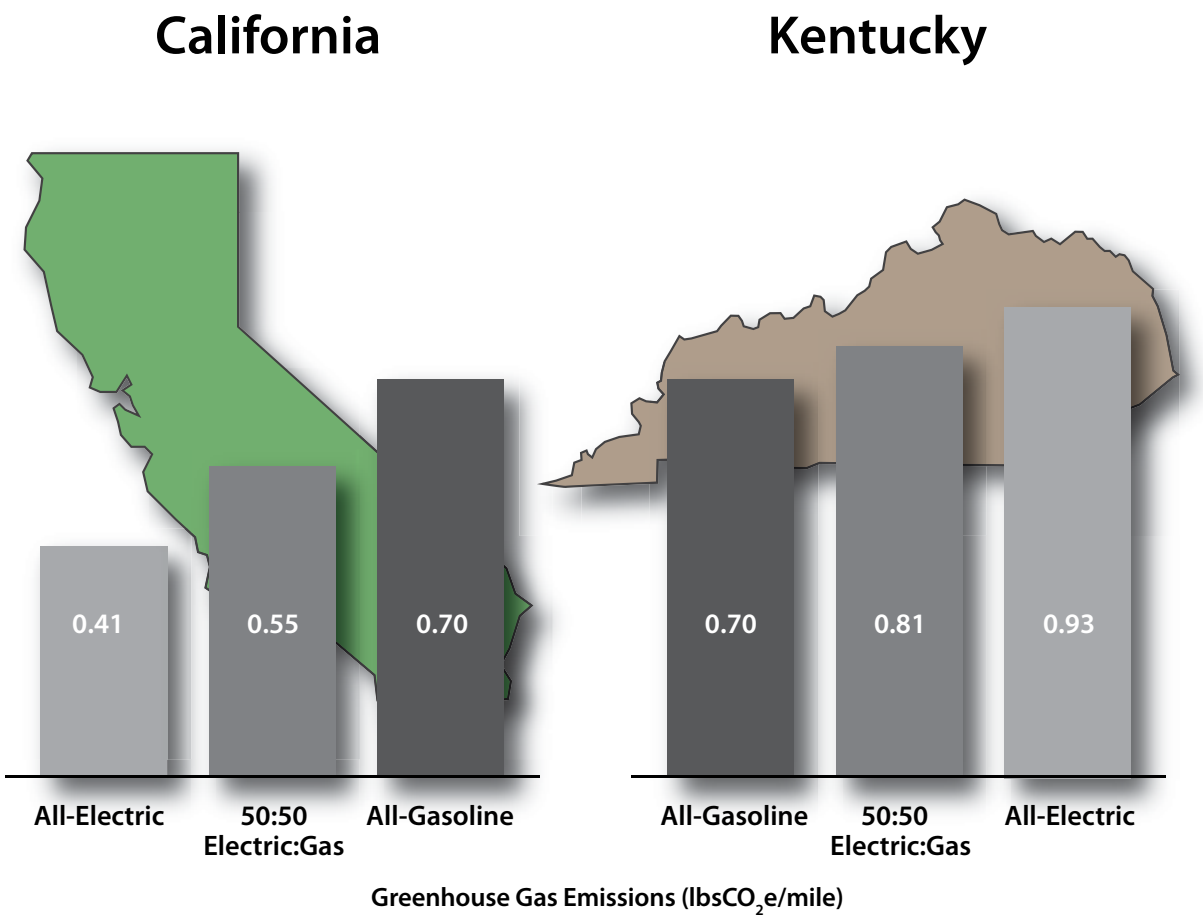
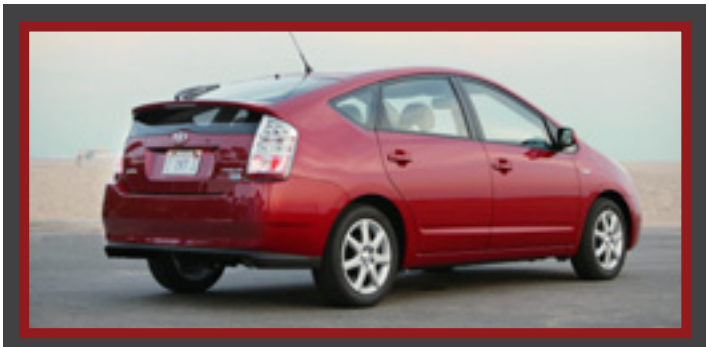


Figure 3. *For a Chevy Volt, as the fraction of miles driven on electricity increases, emissions decrease in states with lower-carbon electricity systems, like California, but emissions increase in states with higher-carbon electricity systems, like Kentucky. When a Volt drives all of its miles using gasoline, the emissions are the same in any state.*

Chevy Volt

Efficient gasoline cars

The state-to-state variations in GHG emissions for a Leaf or a Volt mean that in some states these cars will be bigger GHG emitters than many gasoline-powered cars including the Prius. Table 3 shows the number of states in which a Leaf or a Volt would emit more greenhouse gases than each of the top 34 most fuel efficient model-year 2012 gasoline vehicles sold in the U.S. (as ranked by the EPA). For each gasoline car, Table A6 in the Appendix lists all the states in which it is more climate-friendly than the Leaf, and Table A8 does the same for the Volt. Tables A7 and A9 reorganize this information to show which gas-powered cars are more climate-friendly than the Leaf and Volt in each state. In the 10 states with the most carbon-polluting electricity generation (Appendix, *Figure A1*), there are 20 cars that are better for the climate than the Leaf; 13 of them are conventional gas-powered vehicles and the others are hybrids. Two Ford and two Volkswagen diesel models on the market in Europe (but not in the U.S.), have fuel economies so high that they would have lower GHG emissions than the Leaf in as many as 38 states and lower emissions than the Volt in as many as 47 states *(Table 3)*.



Toyota Prius

How green is your grid?

The large state-to-state differences in emissions for electric vehicles *(Table 1* and *Table 2)* are due to the large differences in carbon-intensity of electricity production that arise from the different mix of electricity generation sources from state-to-state *(Figure 4)*. [Table A4 in the Appendix gives state-by-state average lifecycle carbon-intensities of electricity generation (lbs of CO_2e per kWh).]

Fossil fuels used for generating electricity, and especially coal, play a key role. If a Leaf refuels in a state like West Virginia (97 percent coal), its GHG emissions will be high. In states like Washington (only 8 percent coal and 10 percent natural gas), emissions are much lower. *(Figure 5)*.

Nissan Leaf

Not surprisingly, if all coal-generated electricity in the U.S. were somehow replaced overnight by electricity from natural gas, a lower-carbon fossil fuel, the carbon-intensity of electricity in coal-reliant states would fall significantly. However, the Leaf would still be a higher carbon emitter than a Prius in some states, as suggested by a comparison of emissions for the Leaf and the Prius in Nevada *(Table 1)*, which generates much of its electricity from natural gas *(Figure 4)*. Of course, the climate benefits would be even greater if completely non-carbon electricity were the fuel for the electric vehicles, as suggested by the estimate of emissions for the Leaf in Idaho (Table 1), which generated most of its electricity from hydropower in 2010 *(Figure 4)*.

In Many States There are Several Choices for Climate-Friendly Gas-Powered Cars

Table 3. Many high-efficiency gasoline cars emit less GHG emissions per mile than a Leaf or a Volt in many states.

EPA mpg Rank	Make and Model	mpg[a]	GHG Emissions lbsCO_2e/mile	Number of States Where This Car Emits Less GHGs Than a Leaf	Number of States Where This Car Emits Less GHGs Than a Volt
Cars Sold in Europe	Volkswagen Polo (diesel)	59	0.44	38 States	47 States
	Ford Fiesta (diesel)	57	0.45	38 States	47 States
	Volkswagen Golf (diesel)	54	0.48	38 States	46 States
	Ford Ka (diesel)	50	0.52	36 States	45 States
1	Toyota Prius	50	0.52	36 States	45 States
2	Honda Civic Hybrid	44	0.59	24 States	38 States
3	Lexus CT 200h	42	0.62	22 States	37 States
4	Toyota Prius V	42	0.62	22 States	37 States
5	Ford Fusion Hybrid	39	0.66	18 States	23 States
6	Lincoln MKZ Hybrid	39	0.66	18 States	23 States
7	Scion IQ	37	0.70	16 States	18 States
8	Chevy Volt	--	--	13 States[b]	--
9	Hyundai Accent (manual)	34	0.76	12 States	11 States
10	Kia Rio (manual)	34	0.76	12 States	11 States
11	Chrysler Fiat 500	33	0.79	10 States	5 States
12	Ford Fiesta	33	0.79	10 States	5 States
13	Ford Focus SFE	33	0.79	10 States	5 States
14	Honda Civic HF	33	0.79	10 States	5 States
15	Hyundai Accent (automatic)	33	0.79	10 States	5 States
16	Kia Rio (automatic)	33	0.79	10 States	5 States
17	Nissan Versa	33	0.79	10 States	5 States
18	Toyota Yaris (manual)	33	0.79	10 States	5 States
19	Chevy Cruze Eco (manual)	33	0.79	10 States	5 States
20	Hyundai Elantra	33	0.79	10 States	5 States
21	BMW Mini Cooper	32	0.81	5 States	2 States
22	Honda Civic	32	0.81	5 States	2 States
23	Hyundai Veloster	32	0.81	5 States	2 States
24	Mazda2	32	0.81	5 States	2 States
25	Toyota Yaris (automatic)	32	0.81	5 States	2 States
26	Kia Soul Eco	32	0.81	5 States	2 States
27	Ford Escape Hybrid	32	0.81	5 States	2 States
28	Ford Focus	31	0.84	4 States	0 States
29	Honda Civic (manual)	31	0.84	4 States	0 States
30	Chevy Cruze Eco (automatic)	31	0.84	4 States	0 States
31	Honda Fit	31	0.84	4 States	0 States
32	BMW Mini Cooper S	31	0.86	3 States	0 States
33	Volkswagen Passat (Diesel)	31	0.86	3 States	0 States
34	Volkswagen Jetta (Diesel)	30	0.87	2 States	0 States

[a] *EPA model-year 2012 combined highway and city fuel economy in miles per gallon of gasoline or, for diesel vehicles, miles per gallon of gasoline equivalent.*

[b] *Volt driving half its miles using electricity from plug-in charging of the battery and half using gasoline.*

There are Vast Differences in How Electricity is Generated in Each State

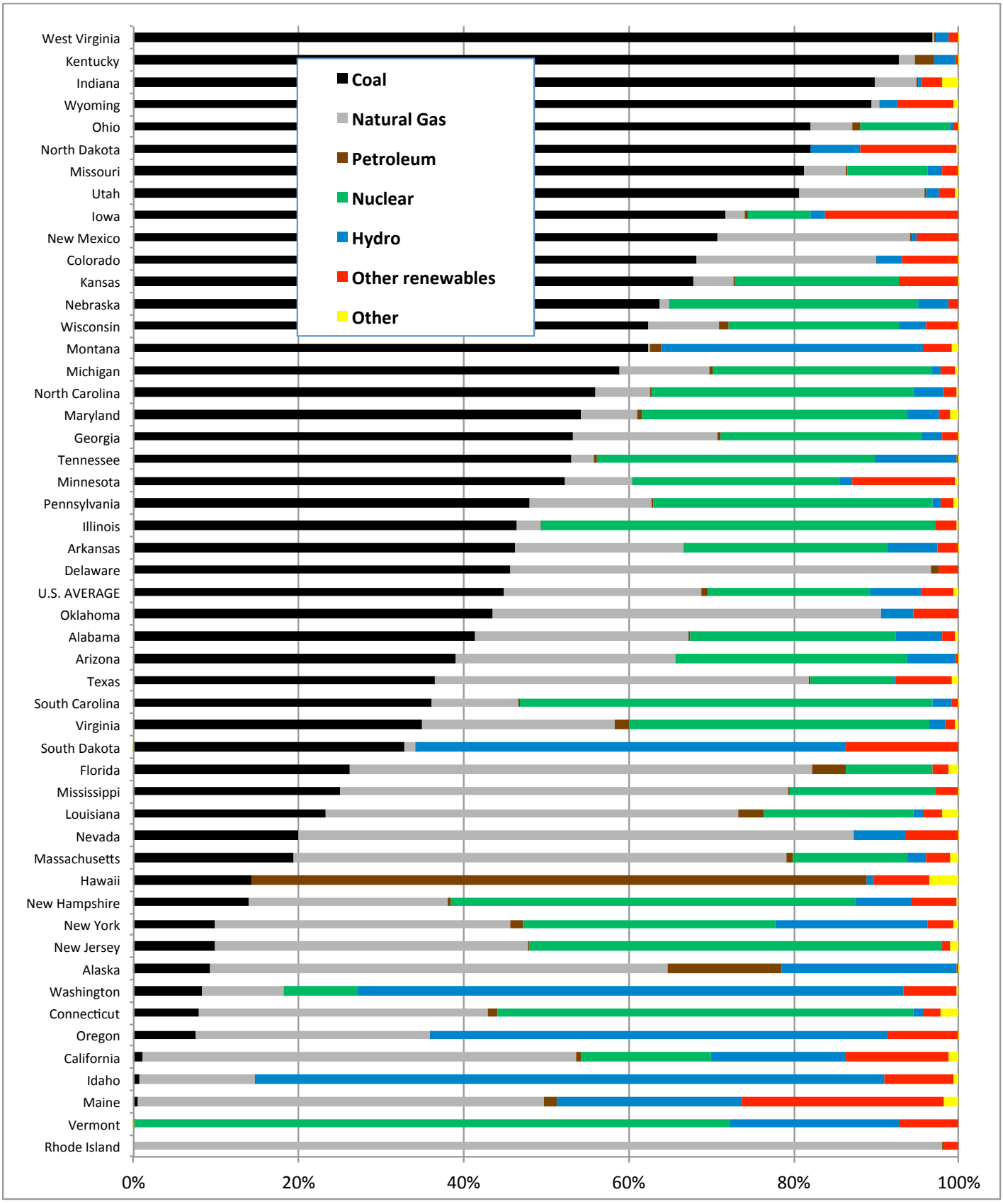


Figure 4. *Electricity generation in 2010 by fuel source. The states are ranked (top to bottom) according to the fraction of their electricity generated from coal.*

When More Electricity Comes from Fossil Fuel Electric Cars are Less Climate Friendly

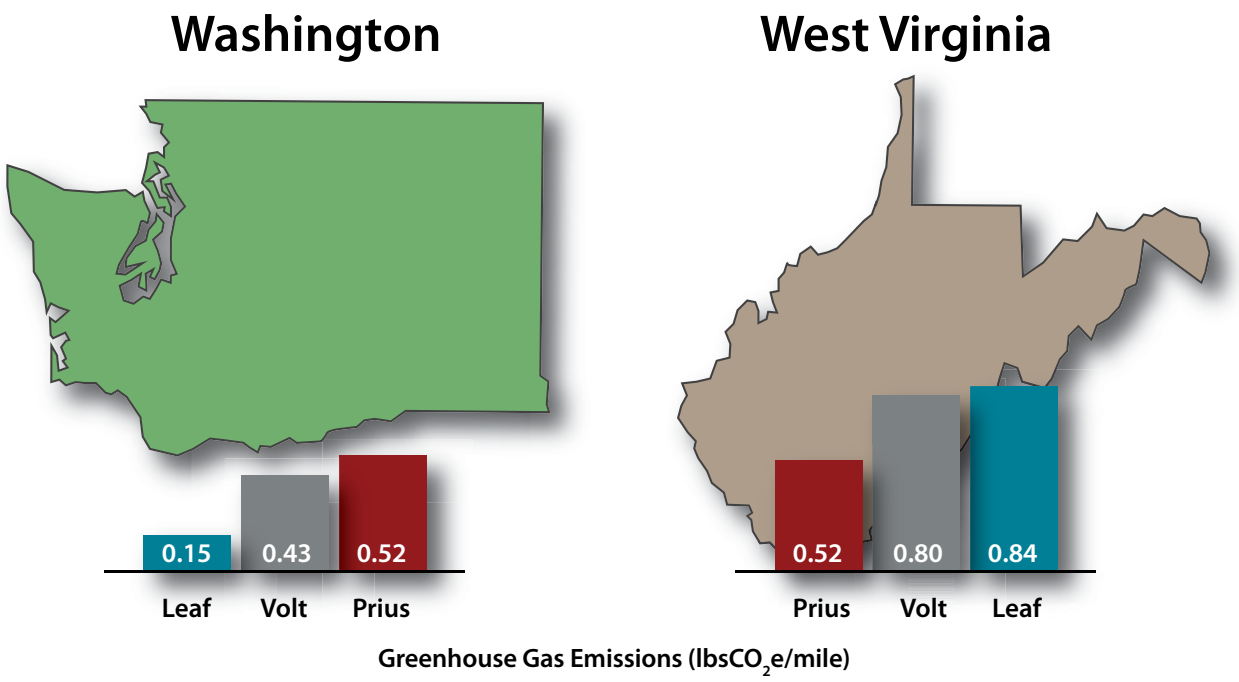


Figure 5. *In West Virginia, where most electricity comes from coal power, the gasoline-fueled Prius generates fewer emissions than the Leaf or Volt. In Washington state, where most electricity is hydroelectric, the Leaf and Volt produce fewer emissions than gas-powered cars.*

State-to-state differences in emissions for a Volt (driving half its miles on electricity and half on gasoline) are tempered by its partial use of gasoline. However, in a lower-carbon electricity state like New York or California, as the portion of miles driven using electricity increases the emissions for the Volt decrease dramatically, as illustrated earlier *(Figure 3)*. This means that if the Volt recharges each night and typically drives each day no further than its battery charge will take it (estimated to be 35 miles by the EPA), it would be a very climate-friendly car in New York or California. On the other hand, in coal-heavy states like Wyoming or Kentucky, a Volt used in this fashion — *driven mostly on electricity* — would actually be less climate friendly than if driven only using gasoline *(Figure 3)*.

Finally, Figure 6 provides a guide for determining the minimum fuel economy of a gasoline vehicle for it to have less GHG emissions per mile driven than a Nissan Leaf. For states with the least carbon-intensive electricity generation (*Figure 6*, top part), a gasoline car would need to have a very high fuel economy before it would have lower GHG emissions than a Leaf. In such states, the Leaf is a clear winner from a climate perspective over even efficient gasoline cars. On the other hand, in the states with the most carbon-intensive electricity generation (*Figure 6,* bottom), the fuel economy of a gasoline vehicle would only need to be about 30 mpg for the gasoline vehicle to emit less carbon than the Leaf.

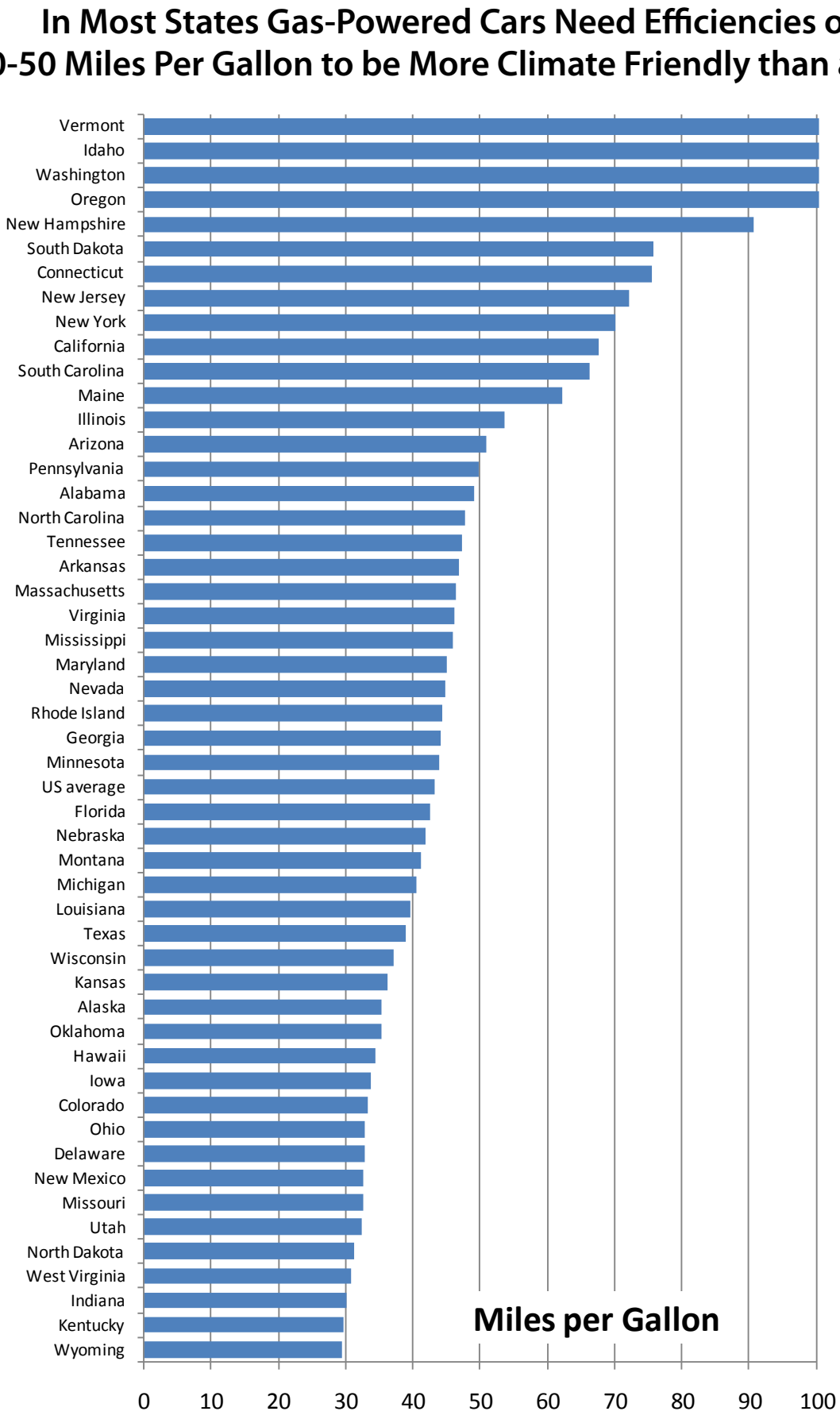


Figure 6. *Minimum fuel economy (mpg) for a gasoline vehicle to have less GHG emissions than a Leaf in each state. The top four bars are off scale.*

Methodology

Our calculations begin with the EPA's combined highway/city driving fuel economy of cars: miles per gallon for gasoline cars and kilowatt-hours per mile for electric cars. (See Appendix *Table A1*.)

For a gasoline car, the bulk of the lifecycle greenhouse gas (GHG) emissions associated with driving are due to the CO_2 emitted by combustion of the fuel in the car's engine. A gallon of gasoline releases about 19 lbs of CO_2 when burned, or about three times the weight of the gallon before it burns. To these CO_2 emissions we must add the GHG emissions associated with extracting, transporting, and refining the crude oil used to make that gallon of gasoline. When these are included, the total lifecycle GHG emissions for using gasoline in a car come to 25.9 lbs of CO_2-equivalent per gallon.[a]

In this report, the term CO_2-equivalent (or CO_2e) is used to refer to GHG emissions. This measure expresses the combined global warming impact of several different gases in terms of the amount of CO_2 alone that would give the same warming. (GHGs in addition to CO_2, such as methane (CH_4) and nitrous oxide (N_2O) are emitted over the lifecycles considered here.) Since different gases have different lifetimes in the atmosphere, the relative warming impact of the non-CO_2 molecules depends on the time frame under consideration. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change[b] gives global warming potentials (GWPs) relative to CO_2 for a large number of gases considering 20-year, 100-year, and 500-year time frames. For the results reported in the main body of this report, we have used the 20-year GWP values since 20 years is close to the typical lifetime of a car—certainly much closer than either 100 years or 500 years. Our results recalculated using 100-year GWP values are given for comparison in the Appendix (*Tables A2* and *Table A3*). (For a gasoline car, the lifecycle emissions assuming a 100-year GWP are 24.3 lbs CO_2e/gallon instead of 25.9 for a 20-year GWP.[a])

Estimating GHG emissions associated with electricity use by an electric car is more difficult than estimating emissions for a gasoline car, because it is essentially impossible to say with certainty that an electron generated at a particular power plant is the same electron that ends up in the battery of a particular vehicle. The uncertainties arise because of the nature of electricity flow and the geographical extent and interconnectedness of electricity grids.[c] Additional uncertainty is introduced by the time-varying nature of electricity demand and supply. For example, if an electric vehicle plugs in to charge during a period of peak electricity demand, the mix of power plants generating electricity (and hence the GHG emission profile of the electricity) will be different from the mix of plants during periods of lower electricity use. In general, the greater the temporal or geographic specificity with which we wish to determine the emissions associated with electricity use, the greater will be the uncertainty around whether the emissions accurately represent actual use.

To make our analysis tractable, we have chosen not to consider time-of-use variations in electricity emissions, choosing instead to use annual emissions per megawatt-hour generated from power plants. We also assume electricity generated in a state is consumed in that state. A recent similar study by the Union of Concerned Scientists[d] also uses annual emissions per megawatt hour, but chooses to divide the U.S. into 26 electricity-generating/consuming

[a] *This estimate is for gasoline from conventional crude oil, as calculated by the Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, version 1_2011. (See Figure 2 in A. Burnham, J. Han, C.E. Clark, M. Wang, J.B. Dunn, and I. Palou-Rivera, "Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum," Environmental Science & Technology, 46: 619-627, 2012.)*

[b] *IPCC, 2007: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Available at www.ipcc.ch.*

[c] *For a thoughtful discussion of this issue, see C.L. Weber, P. Jaramillo, J. Marriott, and C. Samaras, "Life Cycle Assessment and Grid Electricity: What Do We Know and What Can We Know," Environmental Science & Technology, 44: 1895-1901, 2010.*

[d] *Anair, D. and Mahmassani, A., "State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States," Union of Concerned Scientists, (prepublication version), April 2012.*

sub-regions defined by the EPA.[e] Another study in 2007 by the Electric Power Research Institute and the Natural Resources Defense Council divided the U.S. into 13 sub-regions.[f]

The larger the geographic region selected, the more certain one can be of the average emissions associated with each kilowatt-hour used in that region – for example, the average emissions per kilowatt-hour consumed for the entire US can be known with considerable certainty. The drawback of averaging over larger and larger areas is that less and less insight can be gained into the impact of geographic distribution of different electricity generating sources. In an effort to balance these competing considerations, we have chosen to average emissions at the state level. For large states, or for states of any size that have similar electricity generating fuel mixes as neighboring states, the uncertainty introduced by this assumption is small. The uncertainties are larger for smaller states.

To estimate state-level GHG emissions associated with electricity, the following methodology was adopted. The starting point were data published by the Energy Information Administration (EIA) on how much CO_2 was emitted on average per kilowatt-hour (kWh) of electricity generated in each state in 2010 (*Table A4* and *Figure A1*).[g] This average is most influenced by the types of fuels used in the power plants in the state. For example, a state that relies more on nuclear or hydro power will have lower average CO_2 emissions per kWh generated than a natural gas-reliant state or, especially, a coal-reliant state. But CO_2 emissions at a power plant alone are not the full emissions story because there are also emissions associated with supplying fuel to the plant (e.g., emissions that occur during coal mining or natural gas extraction). Accurately estimating on a state-by-state basis the emissions other than those at the power plant itself requires detailed lifecycle calculations.

These calculations were undertaken using the Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, version 1_2011, the same model used to estimate the lifecycle GHG emissions for gasoline mentioned above. GREET was run for each state's electricity system by specifying in GREET the mix of fuels used for electricity generation in the state.[g] The main sources of electricity in any given state in the U.S. are coal, natural gas, nuclear, and/or hydro. (Renewables other than hydro play small roles in most states today.) In the case of natural gas, the power plant technologies used vary significantly from state to state, and the average efficiency of generation from natural gas varies accordingly from state to state. (This is not the case for coal, nuclear, or hydro plants.) Efficiency directly impacts the GHG emissions per unit of electricity produced, so we provided the mix of natural gas power plant technologies in each state as an input to GREET. The mix of natural gas powerplant technologies (combined cycle, simple cycle, or steam cycle) in each state was obtained from EIA data.[h] GREET's default values for electricity generating efficiencies were then kept for all power plant technologies.

[e] *The UCS report uses an overall methodology quite similar to the one we have used. Two notable differences are in some key input assumptions, including the use of 2007 emissions data by the UCS (rather than the more recent 2010 data we have used) and 100-yr GWP values for estimating the global warming impact of non-CO_2 greenhouse gases. We have used a 20-yr GWP, but also show results for 100-yr GWP in the Appendix.*

[f] *EPRI and NRDC, "Environmental Assessment of Plug-In Hybrid Electric Vehicles, Vol. 1: Nationwide Greenhouse Gas Emissions," July 2007.*

[g] *Energy Information Agency, State Electricity Profiles 2010, US Department of Energy, January 2012. (In this reference, Table 5 for each state gives annual electricity generation by fuel type, and Table 7 gives CO_2 emissions from electricity generators.)*

[h] *The amounts of electricity generated in each state in 2010 broken down by type of power plant technology are collected by the Energy Information Administration on form EIA-923 and published in spreadsheet form. For input to GREET, the natural gas generating technologies were categorized as combined cycle, simple cycle, or steam cycle.*

The outputs from running the GREET model for each state include **A**, the average CO_2 emissions at power plants per kWh generated and **B**, the average total lifecycle GHG emissions in CO_2-equivalents per kWh delivered to the end user. (The transmission and distribution losses assumed by the GREET model are 8% of generated electricity.) For each state, the ratio **B/A** was calculated and multiplied by the average CO_2 emissions per kWh of electricity generated (derived from EIA data, as described above) to arrive at the lifecycle GHG emissions associated with electricity used in each state in 2010. For each state, separate calculations were done using 20-year and 100-yr GWP values for non-CO_2 gases (*Table A4*).

Appendix: Detailed Data Tables and Figures

Table A1. Fuel economies and manufacturers' suggested retail prices for several 2012 model year cars.

Vehicle Type and Make	Fuel Economy[a]		Annual Fuel Use[b]		Manufacturers' Suggested Retail Price (MSRP) in $ [c]
	Miles per Gallon Gasoline	kWh per Mile	Electricity (kWh/yr)	Gasoline (gallons/yr)	
All-Electric Vehicle					
Nissan Leaf		0.34	4080	0	32,780
Plug-in Hybrid Electric Vehicle					
Chevy Volt	37[d]	0.36[e]	2160[f]	162[f]	39,145
Hybrid Electric Vehicles (gasoline fueled)					
Ford Fusion Hybrid	39			308	28,700
Toyota Prius Hybrid	50			240	23,520
Honda Civic Hybrid	44			273	24,050
Non-hybrid gasoline vehicles					
Ford Fusion	25			480	20,200
Toyota Corolla	29			414	15,900
Honda Civic	29			414	15,805
U.S. average car, 2009[g]	20.4			588	Not applicable

[a] *Source: U.S. Environmental Protection Agency, combined city/highway rating (http://www.fueleconomy.gov/, accessed Feb. 1, 2012)*

[b] *For 12,000 miles of driving.*

[c] *For 2012 model year. Source: Edmunds (http://www.edmunds.com/new-cars/, accessed Dec. 28, 2011)*

[d] *When operating on gasoline only.*

[e] *When operating on battery only.*

[f] *Assuming half the miles are driven using the battery (electricity) and half are driven using gasoline.*

[g] *For light-duty vehicles (Source: chapter 4, 30th Transportation Energy Data Book)*

Table A2. Calculated lifecycle GHG emissions per mile by state assuming 100-year GWP values for non-CO_2 GHGs. Shown are results for an all-electric Nissan Leaf and for a partially electric Chevy Volt (driving half its miles using electricity and half using gas). For comparison, emissions for a Toyota Prius are 0.49 lbsCO_2e/mile. For the average U.S. car today, emissions are 1.2 lbsCO_2e/mile.

Rank	State	lbsCO_2e/mile	
		Leaf	Volt
1	Wyoming	0.82	0.76
2	Kentucky	0.82	0.76
3	Indiana	0.80	0.75
4	West Virginia	0.79	0.75
5	North Dakota	0.78	0.74
6	Missouri	0.74	0.72
7	Ohio	0.73	0.72
8	Utah	0.73	0.72
9	Iowa	0.72	0.71
10	New Mexico	0.72	0.71
11	Hawaii	0.71	0.70
12	Colorado	0.71	0.70
13	Delaware	0.69	0.69
14	Kansas	0.66	0.68
15	Wisconsin	0.64	0.67
16	Oklahoma	0.63	0.66
17	Alaska	0.60	0.65
18	Montana	0.59	0.64
19	Michigan	0.59	0.64
20	Nebraska	0.58	0.63
21	Texas	0.57	0.63
22	Louisiana	0.55	0.62
23	Minnesota	0.55	0.62
24	Georgia	0.53	0.61
25	Maryland	0.53	0.61
26	Florida	0.51	0.60
27	Tennessee	0.51	0.60
28	North Carolina	0.50	0.59
29	Arkansas	0.50	0.59
30	Virginia	0.50	0.59
31	Pennsylvania	0.47	0.58
32	Nevada	0.47	0.58
33	Mississippi	0.47	0.58
34	Alabama	0.47	0.58
35	Massachusetts	0.46	0.57
36	Arizona	0.45	0.57
37	Illinois	0.45	0.57
38	Rhode Island	0.44	0.56
39	South Carolina	0.36	0.52
40	Maine	0.33	0.50
41	South Dakota	0.32	0.50
42	New York	0.30	0.49
43	California	0.30	0.49
44	New Jersey	0.29	0.48
45	Connecticut	0.28	0.48
46	New Hampshire	0.24	0.46
47	Oregon	0.18	0.43
48	Washington	0.13	0.40
49	Idaho	0.11	0.39
50	Vermont	0.01	0.33

Table A3. Many high-efficiency gasoline cars emit less GHG emissions per mile than a Leaf or a Volt in many states. The estimates in this table assume 100-year GWP values for non-CO_2 greenhouse gases. See Table 3 in the main text for results with 20-year GWP.

EPA mpg Rank	Make and Model	mpg[a]	GHG Emissions lbsCO_2e/mile	Number of States Where This Car Emits Less GHGs Than a Leaf	Number of States Where This Car Emits Less GHGs Than a Volt
Cars Sold in Europe	Volkswagen Polo (diesel)	59	0.41	38 States	47 States
	Ford Fiesta (diesel)	57	0.43	38 States	46 States
	Volkswagen Golf (diesel)	54	0.45	36 States	46 States
	Ford Ka (diesel)	50	0.49	30 States	42 States
1	Toyota Prius	50	0.49	30 States	42 States
2	Honda Civic Hybrid	44	0.55	21 States	38 States
3	Lexus CT 200h	42	0.58	20 States	32 States
4	Toyota Prius V	42	0.62	22 States	37 States
5	Ford Fusion Hybrid	39	0.62	16 States	21 States
6	Lincoln MKZ Hybrid	39	0.62	16 States	21 States
7	Scion IQ	37	0.66	14 States	16 States
8	Chevy Volt	--	--	12 States[b]	--
9	Hyundai Accent (manual)	34	0.72	10 States	8 States
10	Kia Rio (manual)	34	0.72	10 States	8 States
11	Chrysler Fiat 500	33	0.74	6 States	5 States
12	Ford Fiesta	33	0.74	6 States	5 States
13	Ford Focus SFE	33	0.74	6 States	5 States
14	Honda Civic HF	33	0.74	6 States	5 States
15	Hyundai Accent (automatic)	33	0.74	6 States	5 States
16	Kia Rio (automatic)	33	0.74	6 States	5 States
17	Nissan Versa	33	0.74	6 States	5 States
18	Toyota Yaris (manual)	33	0.74	6 States	5 States
19	Chevy Cruze Eco (manual)	33	0.74	6 States	5 States
20	Hyundai Elantra	33	0.74	6 States	5 States
21	BMW Mini Cooper	32	0.76	5 States	2 States
22	Honda Civic	32	0.76	5 States	2 States
23	Hyundai Veloster	32	0.76	5 States	2 States
24	Mazda2	32	0.76	5 States	2 States
25	Toyota Yaris (automatic)	32	0.76	5 States	2 States
26	Kia Soul Eco	32	0.76	5 States	2 States
27	Ford Escape Hybrid	32	0.76	5 States	2 States
28	BMW Mini Cooper S	31	0.78	4 States	0 States
29	Ford Focus	31	0.78	4 States	0 States
30	Honda Civic (manual)	31	0.78	4 States	0 States
31	Chevy Cruze Eco (automatic)	31	0.78	4 States	0 States
32	Honda Fit	31	0.78	4 States	0 States
33	Volkswagen Passat (Diesel)	31	0.79	3 States	0 States
34	Volkswagen Jetta (Diesel)	30	0.81	1 States	0 States

[a] *EPA model-year 2012 combined highway and city fuel economy in miles per gallon of gasoline or, for diesel vehicles, miles per gallon of gasoline equivalent.*

[b] *Volt driving half its miles using electricity from plug-in charging of battery and half using gasoline.*

Table A4. Estimated average state-level lifecycle GHG emissions for electricity generation and delivery to end users. Figure A1 shows the rank ordering of the 20-year GWP emission rates in this table. The 20-year GWP values have been used for results presented in the main body of this report.

	Average 2010 GHG Emissions (lbs CO_2e per kWh delivered)	
	20-yr GWP	100-yr GWP
U.S. average	1.76	1.55
Alaska	2.15	1.77
Alabama	1.55	1.39
Arkansas	1.63	1.47
Arizona	1.49	1.33
California	1.13	0.87
Colorado	2.29	2.08
Connecticut	1.01	0.83
Delaware	2.32	2.02
Florida	1.79	1.51
Georgia	1.72	1.57
Hawaii	2.21	2.09
Iowa	2.26	2.11
Idaho	0.41	0.32
Illinois	1.42	1.32
Indiana	2.54	2.36
Kansas	2.10	1.95
Kentucky	2.57	2.41
Louisiana	1.92	1.61
Maine	1.23	0.96
Maryland	1.69	1.56
Massachusetts	1.64	1.36
Michigan	1.88	1.73
Minnesota	1.74	1.60
Mississippi	1.66	1.39
Missouri	2.33	2.17
Montana	1.85	1.74
Nebraska	1.82	1.70
Nevada	1.70	1.39
New Hampshire	0.84	0.72
New Jersey	1.05	0.86
New Mexico	2.33	2.11
New York	1.09	0.89
North Carolina	1.60	1.47
North Dakota	2.43	2.28
Ohio	2.32	2.16
Oklahoma	2.15	1.87
Oregon	0.65	0.54
Pennsylvania	1.53	1.40
Rhode Island	1.72	1.30
South Carolina	1.15	1.05
South Dakota	1.00	0.94
Tennessee	1.61	1.50
Texas	1.95	1.68
Utah	2.35	2.16
Vermont	0.02	0.02
Virginia	1.65	1.46
Washington	0.43	0.38
West Virginia	2.48	2.32
Wisconsin	2.05	1.89
Wyoming	2.58	2.41

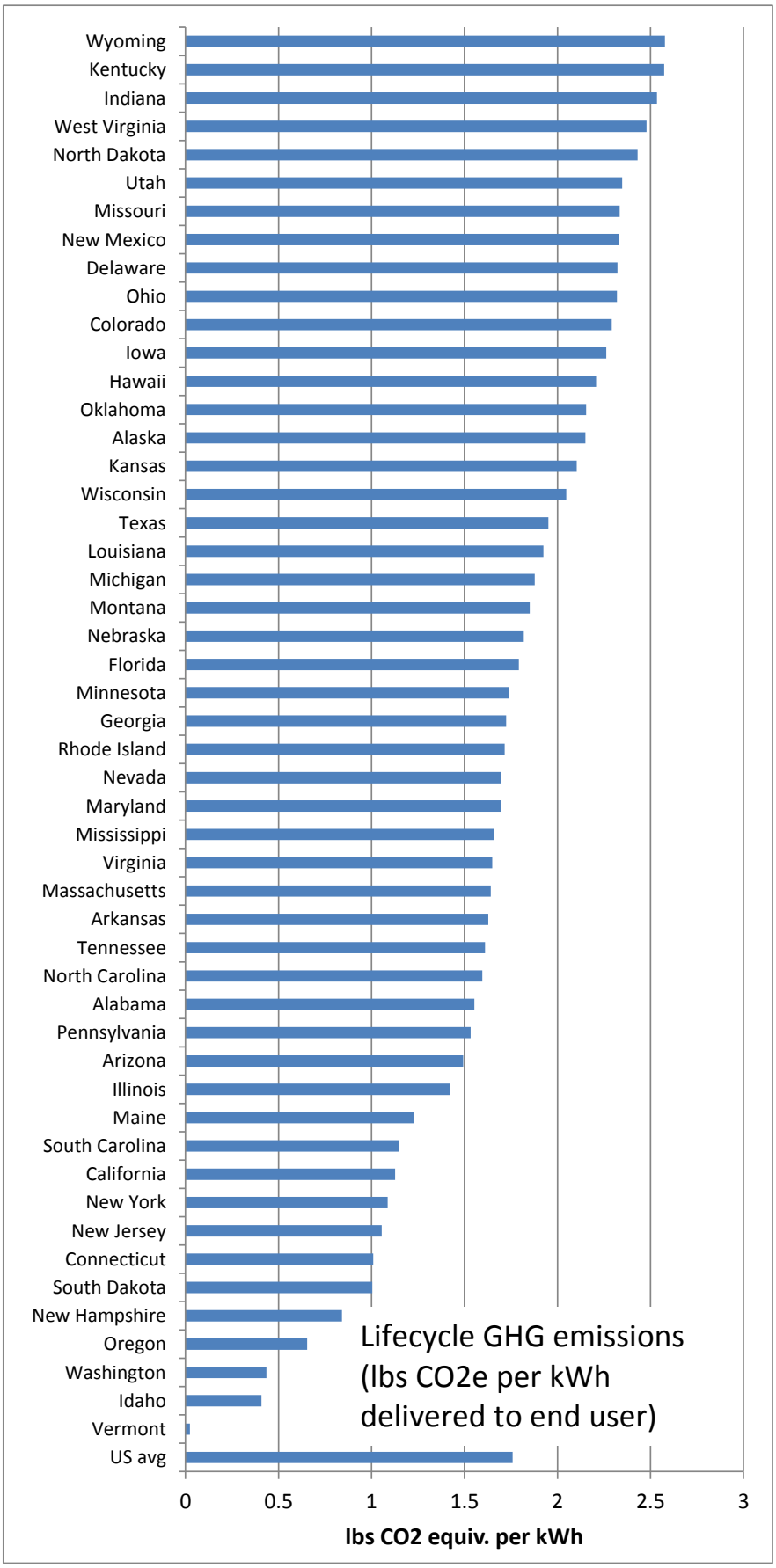


Figure A1. *Estimated lifecycle greenhouse gas emissions for electricity generation by state in 2010, assuming 20-year GWP values for non-CO_2 greenhouse gases.*

Table A5. A Volt's greenhouse gas emissions depend on how much of its driving uses electricity and how much uses gasoline. These results assume 20-year GWPs for non-CO_2 greenhouse gases.

	Volt Emissions ($lbsCO_2e$/mile)		
State	**All electricity**	**Half electric, Half Gasoline**	**All gasoline**
Vermont	0.01	0.35	0.70
Idaho	0.15	0.42	0.70
Washington	0.16	0.43	0.70
Oregon	0.24	0.47	0.70
New Hampshire	0.30	0.50	0.70
South Dakota	0.36	0.53	0.70
Connecticut	0.36	0.53	0.70
New Jersey	0.38	0.54	0.70
New York	0.39	0.55	0.70
California	0.41	0.55	0.70
South Carolina	0.41	0.56	0.70
Maine	0.44	0.57	0.70
Illinois	0.51	0.61	0.70
Arizona	0.54	0.62	0.70
Pennsylvania	0.55	0.63	0.70
Alabama	0.56	0.63	0.70
North Carolina	0.57	0.64	0.70
Tennessee	0.58	0.64	0.70
Arkansas	0.59	0.64	0.70
Massachusetts	0.59	0.65	0.70
Virginia	0.59	0.65	0.70
Mississippi	0.60	0.65	0.70
Maryland	0.61	0.66	0.70
Nevada	0.61	0.66	0.70
Rhode Island	0.62	0.66	0.70
Georgia	0.62	0.66	0.70
Minnesota	0.63	0.66	0.70
US avg elec	0.63	0.67	0.70
Florida	0.65	0.67	0.70
Nebraska	0.65	0.68	0.70
Montana	0.67	0.68	0.70
Michigan	0.68	0.69	0.70
Louisiana	0.69	0.70	0.70
Texas	0.70	0.70	0.70
Wisconsin	0.74	0.72	0.70
Kansas	0.76	0.73	0.70
Alaska	0.77	0.74	0.70
Oklahoma	0.78	0.74	0.70
Hawaii	0.79	0.75	0.70
Iowa	0.81	0.76	0.70
Colorado	0.83	0.76	0.70
Ohio	0.84	0.77	0.70
Delaware	0.84	0.77	0.70
New Mexico	0.84	0.77	0.70
Missouri	0.84	0.77	0.70
Utah	0.85	0.77	0.70
North Dakota	0.88	0.79	0.70
West Virginia	0.89	0.80	0.70
Indiana	0.91	0.81	0.70
Kentucky	0.93	0.81	0.70
Wyoming	0.93	0.81	0.70

Table A6. Most efficient cars ranked by the EPA (compared to the Leaf). These results assume 20-year GWPs for non-CO_2 GHGs.

Rank	Gas-Powered Car	States Where This Car is More Climate Friendly Than an All-Electric Nissan Leaf
1	Toyota Prius	Alabama, Alaska, Arkansas, Colorado, Delaware, Florida, Georgia, Hawaii, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming
2	Honda Civic Hybrid	Alaska, Colorado, Delaware, Florida, Hawaii, Iowa, Indiana, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming
3	Lexus CT 200h	Alaska, Colorado, Delaware, Hawaii, Iowa, Indiana, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming
4	Toyota Prius V	Alaska, Colorado, Delaware, Hawaii, Iowa, Indiana, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming
5	Ford Fusion Hybrid	Alaska, Colorado, Delaware, Hawaii, Iowa, Indiana, Kansas, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming
6	Lincoln MKZ Hybrid	Alaska, Colorado, Delaware, Hawaii, Iowa, Indiana, Kansas, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming
7	Scion IQ	Alaska, Colorado, Delaware, Hawaii, Iowa, Indiana, Kansas, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Oklahoma, Utah, West Virginia, Wyoming
8	Chevy Volt	Colorado, Delaware, Hawaii, Indiana, Iowa, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
9	Hyundai Accent (manual)	Colorado, Delaware, Iowa, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
10	Kia Rio (manual)	Colorado, Delaware, Iowa, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
11	Chrysler Fiat 500	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
12	Ford Fiesta	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
13	Ford Focus SFE	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
14	Honda Civic HF	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
15	Hyundai Accent (automatic)	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
16	Kia Rio (automatic)	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
17	Nissan Versa	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
18	Toyota Yaris (manual)	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
19	Chevy Cruze Eco (manual)	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
20	Hyundai Elantra	Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming
21	BMW Mini Cooper	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
22	Honda Civic	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
23	Hyundai Veloster	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
24	Mazda2	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
25	Toyota Yaris (automatic)	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
26	Kia Soul Eco	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
27	Ford Escape Hybrid	Indiana, Kentucky, North Dakota, West Virginia, Wyoming
28	Ford Focus	Indiana, Kentucky, West Virginia, Wyoming
29	Honda Civic (manual)	Indiana, Kentucky, West Virginia, Wyoming
30	Chevy CruzeEco (automatic)	Indiana, Kentucky, West Virginia, Wyoming
31	Honda Fit	Indiana, Kentucky, West Virginia, Wyoming
32	Volkswagen Passat (diesel)	Indiana, Kentucky, Wyoming
33	BMW Mini Cooper S Coupe	Kentucky, Wyoming
34	Volkswagen Golf (Diesel)	Kentucky, Wyoming

Table A7. Gas-powered cars that are more climate-friendly than the Nissan Leaf in each state (based on Table A6).

State	Cars
Alabama	Toyota Prius
Alaska	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius,V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Arizona	*No Gas-Powered Cars Better Than the Leaf*
Arkansas	Toyota Prius
California	*No Gas-Powered Cars Better Than the Leaf*
Colorado	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
Connecticut	*No Gas-Powered Cars Better Than the Leaf*
Delaware	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra.
Florida	Toyota Prius, Honda Civic Hybrid.
Georgia	Toyota Prius
Hawaii	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt
Idaho	*No Gas-Powered Cars Better Than the Leaf*
Illinois	*No Gas-Powered Cars Better Than the Leaf*
Indiana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra, Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid, Ford Focus, Honda Civic (manual), Chevy Cruze Eco (automatic), Honda Fit, Volkswagen Passat (diesel, manual).
Iowa	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual)
Kansas	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Kentucky	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra, Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid, Ford Focus, Honda Civic (manual), Chevy Cruze Eco (automatic), Honda Fit, Volkswagen Passat (diesel, manual), Mini Cooper S Coupe, Volkswagen Golf (diesel)
Louisiana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Maine	*No Gas-Powered Cars Better Than the Leaf*
Maryland	Toyota Prius
Massachesetts	Toyota Prius
Michigan	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Minnesota	Toyota Prius, Honda Civic Hybrid
Mississippi	Toyota Prius
Missouri	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra
Montana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Nebraska	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Nevada	Toyota Prius
New Hampshire	*No Gas-Powered Cars Better Than the Leaf*
New Jersey	*No Gas-Powered Cars Better Than the Leaf*
New Mexico	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra
New York	*No Gas-Powered Cars Better Than the Leaf*
North Carolina	Toyota Prius
North Dakota	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra, BMW Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid
Ohio	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra
Oklahoma	Toyota Prius, Honda Civic Hybird, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Oregon	*No Gas-Powered Cars Better Than the Leaf*
Pennsylvania	Toyota Prius
Rhode Island	Toyota Prius
South Carolina	*No Gas-Powered Cars Better Than the Leaf*
South Dakota	*No Gas-Powered Cars Better Than the Leaf*
Tennessee	Toyota Prius
Texas	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Utah	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra
Vermont	*No Gas-Powered Cars Better Than the Leaf*
Virginia	Toyota Prius
Washington	*No Gas-Powered Cars Better Than the Leaf*
West Virginia	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra, BMW Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid, Ford Focus, Honda Civic (manual), Chevy Cruze Eco (automatic), Honda Fit
Wisconsin	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Wyoming	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Chevy Volt, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundai Elantra, BMW Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid, Ford Focus, Honda Civic (manual), Chevy Cruze Eco (automatic), Honda Fit, Volkswagen Passat (diesel, manual), BMW Mini Cooper S Coupe, Volkswagen Golf (diesel)

Table A8. Most efficient cars ranked by the EPA (compared to the Volt). These results assume 20-year GWPs for non-CO_2 GHGs.

Rank	Gas-Powered Car	States Where This Car is More Climate Friendly Than an Plug-in Hybrid Chevy Volt
1	**Toyota Prius**	Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.
2	**Honda Civic Hybrid**	Alabama, Alaska, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.
3	**Lexus CT 200h**	Alabama, Alaska, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.
4	**Toyota Prius V**	Alabama, Alaska, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Hawaii, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.
5	**Ford Fusion Hybrid**	Alaska, Colorado, Delaware, Florida, Hawaii, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming.
6	**Lincoln MKZ Hybrid**	Alaska, Colorado, Delaware, Florida, Hawaii, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, Nebraska, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming.
7	**Scion IQ**	Alaska, Colorado, Delaware, Hawaii, Indiana, Iowa, Kansas, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Oklahoma, Texas, Utah, West Virginia, Wisconsin, Wyoming.
8	**Hyundai Accent (manual)**	Colorado, Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming.
9	**Kia Rio (manual)**	Colorado, Delaware, Indiana, Kentucky, Missouri, New Mexico, North Dakota, Ohio, Utah, West Virginia, Wyoming.
10	**Chrysler Fiat 500**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
11	**Ford Fiesta**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
12	**Ford Focus SFE**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
13	**Honda Civic HF**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
14	**Hyundai Accent (automatic)**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
15	**Kia Rio (automatic)**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
16	**Nissan Versa**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
17	**Toyota Yaris (manual)**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
18	**Chevy Cruze Eco (manual)**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
19	**Hyundai Elantra**	Indiana, Kentucky, North Dakota, West Virginia, Wyoming.
20	**BMW Mini Cooper**	Kentucky, Wyoming.
21	**Honda Civic**	Kentucky, Wyoming.
22	**Hyundai Veloster**	Kentucky, Wyoming.
23	**Mazda2**	Kentucky, Wyoming.
24	**Toyota Yaris (automatic)**	Kentucky, Wyoming.
25	**Kia Soul Eco**	Kentucky, Wyoming.
26	**Ford Escape Hybrid**	Kentucky, Wyoming.

Table A9. Gas-powered cars that are more climate-friendly than the Chevy Volt in each state (based on Table A8).

State	Cars
Alabama	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Alaska	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Arizona	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Arkansas	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
California	Toyota Prius
Colorado	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual)
Connecticut	Toyota Prius
Delaware	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
Florida	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Georgia	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Hawaii	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Idaho	*No Gas-Powered Cars Better Than the Volt*
Illinois	Toyota Prius, Honda Civic Hybrid
Indiana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundia Elantra
Iowa	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Kansas	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Kentucky	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundia Elantra, BMW Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid
Louisiana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Maine	Toyota Prius
Maryland	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Massachesetts	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Michigan	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Minnesota	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Mississippi	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Missouri	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
Montana	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Nebraska	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid
Nevada	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
New Hampshire	*No Gas-Powered Cars Better Than the Volt*
New Jersey	Toyota Prius
New Mexico	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
New York	Toyota Prius
North Carolina	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
North Dakota	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundia Elantra
Ohio	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
Oklahoma	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Oregon	*No Gas-Powered Cars Better Than the Volt*
Pennsylvania	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Rhode Island	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
South Carolina	Toyota Prius
South Dakota	Toyota Prius
Tennessee	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Texas	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Utah	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual).
Vermont	*No Gas-Powered Cars Better Than the Volt*
Virginia	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V
Washington	*No Gas-Powered Cars Better Than the Volt*
West Virginia	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundia Elantra
Wisconsin	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ
Wyoming	Toyota Prius, Honda Civic Hybrid, Lexus CT 200h, Toyota Prius V, Ford Fusion Hybrid, Lincoln MKZ Hybrid, Scion IQ, Hyundai Accent (manual), Kia Rio (manual), Chrysler Fiat 500, Ford Fiesta, Ford Focus SFE, Honda Civic HF, Hyundai Accent (automatic), Kia Rio (automatic), Nissan Versa, Toyota Yaris (manual), Chevy Cruze Eco (manual), Hyundia Elantra, BMW Mini Cooper, Honda Civic, Hyundai Veloster, Mazda2, Toyota Yaris (automatic), Kia Soul Eco, Ford Escape Hybrid

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