Why Do State Emissions Differ So Widely?

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Introduction

Much of the U.S. resistance to ambitious global efforts to reduce carbon dioxide emissions reflects a fear common amongst Americans that high emissions are necessary to maintain high standards of living. While the examples of Belgium, Demark, Germany, Ireland, Japan, and the United Kingdom – countries where emissions per capita are roughly one-half of the U.S. average – demonstrate that lower per capita emissions are consistent with high living standards, many Americans remain unconvinced that the same standard of living can be produced with varying emissions levels. This is true despite the fact that some of the best evidence for this can be found within the U.S.: individual states vary only modestly in average incomes, but have widely differing per capita emissions.

If U.S. per capita carbon dioxide (CO_2) emissions were equal to those of its most populous state, California, global CO_2 emissions would fall by 8 percent. If, instead, U.S. per capita emissions equaled those of Texas, the state with the second-largest population, global emissions would increase by 7 percent. What makes Californians' emissions so different from those of Texans, and from U.S. average emissions? And are the factors that explain these differences amenable to replication as policy solutions?

In 2005, U.S. average per capita emissions were 21.2 metric tons (mT) of CO_2, compared to 9.0 in the U.K., 5.7 in Sweden and 4.3 in China.[1] The only countries with higher per capita CO_2 emissions than the United States were Luxembourg, Bahrain, United Arab Emirates, Kuwait and above all, Qatar – the highest in the world with 48.6 mT CO_2. The range of per capita emissions among U.S. states varies more than six-fold, from an astounding high of 76.5 mT CO_2 in Alaska to a low of 12.2 in Vermont.[2] Nine U.S. states have emissions under 15 mT CO_2, in the range of many European nations. On the other end of the scale, four states have per capita emissions more than double the U.S. average: Louisiana (43.9 mT CO_2), North Dakota (55.0), Wyoming (70.8), and Alaska. In contrast, U.S. states' per capita incomes vary only by a factor of two, from $37,600 in the District of Columbia, to $18,000 in Mississippi.[3]

This article analyzes the variation in energy-related per capita CO_2 emissions among U.S. states, seeking to explain why some states have much lower per capita emissions than others. Some of the state-to-state differences are based on factors beyond anyone's control, at least in the near to medium term: For instance, the coldest states have high heating needs, while the hottest states use a lot of air conditioning; densely populated states have

[1] All data are for 2005, because of the consistency of data availability, except the share of home heating BTUs from oil, which is for 2007, and average annual humidity, which is for varying ranges of years. See Appendix B for U.S. domestic data sources. Source for international emissions: World Resources Institute, Climate Analysis Indicators Tool, http://cait.wri.org.

[2] All state emissions values reported in this article have been adjusted for interstate trade in electricity using a process described below.

[3] For ease of analysis, Washington, D.C., is included throughout this article as a 51st "state." The next-highest per capita income was found in Connecticut, at $33,900.

different transportation needs than more sparsely populated ones. Other differences may be based on policies and measures that have successfully lowered emissions in some states and could be repeated in others.

Our analysis begins with reported data on emissions for the 50 U.S. states and the District of Columbia from standard government sources. We focus on energy-related carbon dioxide emissions, which account for the great majority of greenhouse gas emissions and are one of the sectors most likely to be regulated under climate legislation. Emissions from electricity generation are attributed to the sectors where electricity is used – residential, commercial, industrial, and transportation.[4] We adjust reported emissions data for interstate electricity sales, and then calculate the fractions of each state's emissions that come from transportation, household fuel use (primarily heating and cooking), and household electricity use. Statistical analysis of household emissions then identifies portions of interstate variation that can be attributed to objective factors such as climate, population density, income, and other socio-economic variables. A final section discusses potential implications for climate policy.

Interstate trade in electricity

Official measures of greenhouse gas emissions are "production-based," accounting for gases released from production and direct use within a geographical area, excluding emissions caused by the purchase of products and services (including electricity) produced elsewhere, and including emissions from the in-region production of products and services that are exported for consumption in other areas. In this article, we begin with this standard emissions measurement for the 50 U.S. states and the District of Columbia, then adjust for interstate trade in electricity to more closely reflect the carbon emitted from each state's consumption of energy. The measure of state emissions used throughout this article is total energy-related carbon dioxide emissions, consisting of industrial, commercial, transportation, and residential direct fuel use and electricity emissions, adjusted only for interstate trade in electricity.

Approximations such as the one we use are needed because there are no systematic data on interstate transactions in electricity.[5] We adjust reported carbon emissions data for electricity imports and exports by state as follows:

[4] Emissions of other greenhouse gases, such as methane and nitrous oxide from agriculture and waste management, are omitted from our analysis, as is any estimate of sequestration in soils and forests.

[5] Our approach to interstate electricity transactions is oversimplified in two important ways, both forced on us by data limitations. First, most states are included in multi-state power pools, within which electricity frequently flows back and forth across state boundaries. Even a state which is, on balance, self-sufficient or exporting electricity may have imports from nearby states, offset by equal or greater exports. Data on electricity imports and exports in this article refer only to net interstate flows, not to actual gross flows in both directions. Second, interstate exports differ greatly in their carbon intensity, ranging from carbon-free hydroelectric and nuclear power to coal-fired electricity. Unfortunately, there is no way to track who received the exports of electricity with different carbon intensities; we have therefore applied the national average carbon intensity of exported electricity throughout the country.

1. For Hawaii and Alaska, all in-state generation emissions are assigned to that state's electricity consumers, in proportion to their use of electricity. These states do not participate in electricity exports or imports.

2. For the remaining 48 states plus the District of Columbia, we calculate the ratio of nationwide generation plus net foreign imports to electricity purchases. That ratio is greater than 1 because there are losses in transmission and distribution of electricity; it takes more than 1 kWh of generation to deliver 1 kWh of electricity to an end user. We then multiply each state's electricity purchases by that ratio, obtaining the amount of generation needed to supply each state's electricity users.

3. For each state, we compare actual generation to the generation needed to supply that state's electricity users; the difference is net exports to or imports from other states.

4. For exporting states, we assume that exports and in-state use of electricity have the same emissions intensity; that is, we allocate the state's emissions from electricity generation to in-state users and to exports, in proportion to the use of electricity.

5. All electricity exports, and the associated emissions, are combined into a single nationwide export pool.

6. Importing states are assumed to receive electricity from the export pool, with the proportionate share of emissions. That is, all interstate imports are assumed to have the average emissions intensity of the nationwide export pool.

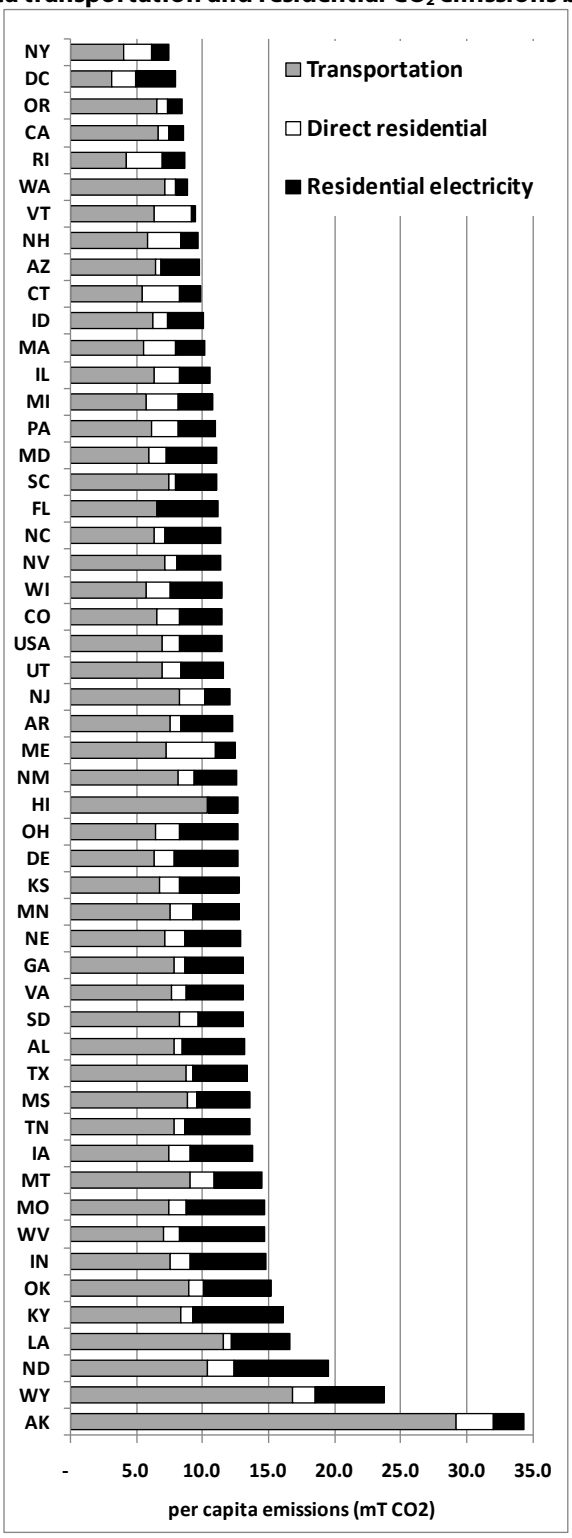
This method follows Jiusto (2006), who notes that Intergovernmental Panel on Climate Change and U.S. Environmental Protection Agency guidelines call for the official reporting of greenhouse gas emissions without any adjustment for electricity trade, and that the limited literature on U.S. state emissions that existed at the time of his writing had made no adjustments for trade. Aldy (2005; 2006) uses a similar method to Jiusto in his analyses of the relationship between income and per capita emissions among U.S. states. Boyce and Riddle (2009) calculate an implied energy intensity of consumption for each state, and find that their results have a 0.98 correlation with an unpublished, preliminary version of our calculations.

Adjustment for interstate trade in electricity is necessary because some states generate much more electricity than they use, while others import electricity from them. In particular, three states with relatively small populations, Wyoming, West Virginia and North Dakota, export large amounts of electricity to other states. Overall, 10 percent of all U.S. electricity is exported out of state; exports from Wyoming, West Virginia, and North Dakota account for 27 percent of all electricity crossing state lines.

Large shares of every state's emissions are the result of industrial, commercial and government activities.[6] Emissions from industrial production help to create goods that are often sold out of state, or outside of the United States altogether. If industries have to pay a price for carbon emissions and pass the cost on to their customers, that cost will be borne by customers throughout the country or even overseas, not by the residents of the state where production is located. Likewise, the emissions of the federal government are the responsibility of the entire country, regardless of where they occur. Therefore, the remainder of this article focuses exclusively on transportation and residential emissions (see Figure 1). These are the emissions for which each state's residents bear the most direct responsibility. Transportation and residential emissions can be addressed by public policy and private households' actions alike; state-by-state differences in the consequences of a carbon tax or permit system will be easier to identify by excluding industrial, commercial, and government emissions that impact the nation as a whole.

[6] U.S. emissions data include government as part of the commercial category; no data exist to disaggregate government from commercial emissions.

Figure 1: Per capita transportation and residential CO_2 emissions by U.S. state, 2005



Source: Authors' calculations.

Explaining state-by-state differences

The United States averages 11.5 mT CO_2 per capita in total transportation and residential emissions, with state emissions ranging from 34.3 in Alaska to 7.5 in New York, a ratio of almost 5 to 1. Even excluding Alaska – which stands apart as an outlier in these data – the ratio of per capita transportation and residential emissions among U.S. states is 3 to 1. In Table 1, the comparison of the two largest states, California and Texas, with U.S. averages illustrates this variance. Texas ranks fourth-lowest in direct residential emissions, but this category, primarily heating and cooking fuels, accounts for only a small share of the U.S. total. California ranks third-lowest in residential electricity, and fourth-lowest overall.

Table 1: Per capita transportation and residential emissions: California, Texas, and U.S. average, 2005 (mT CO_2)

Rank	Transportation		*Rank*	Direct residential		*Rank*	Residential electricity		*Rank*	Transportation and residential	
21	California	6.7	*4*	Texas	0.5	*3*	California	1.1	*4*	California	8.5
44	Texas	8.7	*13*	California	0.8	*33*	Texas	4.1	*39*	Texas	13.4
	U.S. average	7.0		U.S. average	1.3		U.S. average	3.2		U.S. average	11.5

Source: Authors' calculations; the state with the lowest emissions would receive a rank of 1.

Table 2 reports data for all states with variance greater than one standard deviation from the state mean for each category of emissions. Note that Alaska does not have the highest per capita direct residential or residential electricity emissions. Its unique totals are driven primarily by extraordinarily high transportation emissions. The District of Columbia, New York and Rhode Island have the lowest transportation emissions, while Vermont, Washington, California, Oregon, New Hampshire and New York have the lowest residential electricity emissions. Interestingly, there is little overlap between the states with the lowest emissions in each of the three categories we examine; there is similarly little overlap between the states with the highest emissions in each category. (See Appendix Table A1 for per capita emissions, by category, for all states. Figure 1 summarizes these data.)

Table 2: Per capita transportation and residential emissions in selected states (above and below 1 standard deviation from the 51-state mean), 2005 (mT CO_2)

Transportation		Direct residential		Residential electricity		Transportation and residential	
DC	3.2	Hawaii	0.1	Vermont	0.4	New York	7.5
New York	4.0	Florida	0.1	Washington	0.9	DC	7.9
Rhode Island	4.3	Arizona	0.4	California	1.1	Oregon	8.5
		Texas	0.5	Oregon	1.2	California	8.5
		South Carolina	0.6	New Hampshire	1.3		
		Louisiana	0.6	New York	1.3		
		Alabama	0.6	Maine	1.5		
		Mississippi	0.6	Connecticut	1.7		
				Rhode Island	1.8		
				New Jersey	1.8		
Louisiana	11.6	Michigan	2.4	Missouri	5.9	North Dakota	19.5
Wyoming	16.8	Massachusetts	2.4	West Virginia	6.4	Wyoming	23.8
Alaska	29.2	New Hampshire	2.5	Kentucky	6.8	Alaska	34.3
		Rhode Island	2.7	North Dakota	7.1		
		Connecticut	2.7				
		Vermont	2.8				
		Alaska	2.8				
		Maine	3.7				

Source: Authors' calculations.

To better understand these interstate differences in emissions, we investigated whether factors that are beyond a state's control in the short term – climate, geography and income – fully explain the wide variation in per capita emissions, or if, instead, some interstate differences can be attributed to policy variables. For each of these three categories of emissions – transportation, direct (non-electricity) residential, and residential electricity – we used regression analysis to explore the importance of climate, geography, income, and other socio-economic factors in explaining the variation in per capita emissions among U.S. states in 2005.[7]

Transportation emissions

We began, in Regression 1a, by testing the hypothesis that the variation among U.S. states in per capita transportation emissions can be explained by differences in the use of transportation fuel (the coefficient is positive, as expected, and strongly significant) and the diesel share of transportation fuel (the coefficient is not significant). Transportation fuel per capita explains 64 percent of the variation in transportation emissions per capita. Diesel's

[7] Throughout all the regressions reported here, Alaska has been dropped because of problems with heteroskedasticity.

share of transportation fuel use has no statistical impact on transportation emissions per capita, but it should be noted that the carbon intensity of diesel fuel is similar to that of gasoline. (See Table 3 for all regression results.)

Per capita fuel consumption ranges from 329 gallons in the District of Columbia to 1,413 gallons in Wyoming; this variable captures both the vehicle miles traveled within a state and the average fuel efficiency of vehicles in that state. Regressions 1b and 1c examine the factors related to variation in the use of transportation fuel per capita. Both regressions include the same set of non-policy variables – the inverse of population density (that is, square miles per person) and income per capita.[8] Regression 1c adds two additional variables that states may be better able to influence through public policy – average gasoline price and share of the working population commuting via public transportation. In both regressions, the coefficient for inverse population density is positive and strongly significant; more sparsely populated states use more transportation fuel per capita. The coefficient for income per capita is negative (contrary to our expectation) in both regressions – poorer states use more transportation fuel per capita – but is only significant in Regression 1b. When policy variables are added in Regression 1c, income per capita loses its significance as an explanatory variable.

When included, average gasoline price and public transportation share have coefficients that are negative (as expected) and significant: Lower gasoline prices and less use of public transportation are associated with greater use of transportation fuel per capita. With the inclusion of these policy variables, the share of the interstate variation in transportation fuel used per capita explained increases from 57 percent in Regression 1b to 65 percent in Regression 1c.

Direct residential emissions

In Regression 2a, direct residential fuel use (measured in BTUs, or British thermal units) per capita and the share of residential energy from oil together explain 98 percent of the variation in direct residential emissions per capita; coefficients for both explanatory variables are positive, as expected, and strongly significant. Heating fuels differ greatly in their carbon intensity, with oil causing more emissions than gas for the same amount of heat; there is a surprising variation in the mix of fuels used from state to state. Ten states derive none of their residential heat from oil, while in Maine – the state with the highest per capita direct residential emissions – the oil share of home heating is 72 percent. Alaska, by far the coldest U.S. state, has only the second-highest per capita direct residential emissions; Alaskans derive 27 percent of home heating from oil and 62 percent from natural gas.

[8]Although some states have used public policy to increase population density in urban areas and combat sprawl, states cannot control for population density statewide, at least not in the short or medium term.

Table 3: Regression results

	R1a		R1b		R1c		R2a		R2b		R2c		R3a		R3b		R3c	
Observations	50		50		50		50		50		50		50		50		50	
F	43.7		33.2		23.7		1555		132.7		87.5		111.9		11.9		35.6	
R-squared	0.650		0.586		0.678		0.985		0.850		0.851		0.826		0.438		0.760	
Adjusted R-squared	0.636		0.568		0.650		0.985		0.843		0.841		0.819		0.401		0.738	
Dependent variable:																		
Transportation emissions/capita	✓																	
Transportation fuel/capita			✓		✓													
Direct residential emissions/capita							✓											
Residential fuel btus/capita									✓		✓							
Residential electricity emissions/capita													✓					
Residential electricity use/capita															✓		✓	
Independent variable:	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*	*Coef.*	*t-value*
Transportation fuel/capita	0.01	5.90 †																
Diesel share of transportation fuel	-0.80	-0.19																
Residential fuel btus/capita							0.05	35.57 †										
Residential oil fuel share							1.53	16.98 †										
Residential electricity use/capita													0.57	7.30 †				
Coal electricity generation share													3.27	9.80 †				
Inverse population density			2,461	6.27 †	2,566	7.12 †												
Income/capita (10^3)			-12.9	-3.25 †	-1.88	-0.39			0.52	3.23 †	0.57	3.20 †			-0.15	-3.87 †	-0.02	-0.51
Heating degree days (10^3)									4.47	14.88 †	4.33	11.62 †						
Cooling degree days (10^3)															0.51	2.73 *	0.82	6.32 †
Average annual humidity															0.05	2.77 *	0.05	4.01 †
Average gasoline price					-468	-2.19 *												
Public transportation share					-841	-2.95 †												
Average residential natural gas price											-0.15	-0.65						
Average retail electricity price																	-34.4	-7.76 †
constant	0.40	0.53	924.7	9.08 †	1,538	4.02 †	-0.04	-1.04	-10.2	-2.57 *	-8.50	-1.80	-0.82	-2.20 *	4.33	2.66 *	3.60	3.34 †

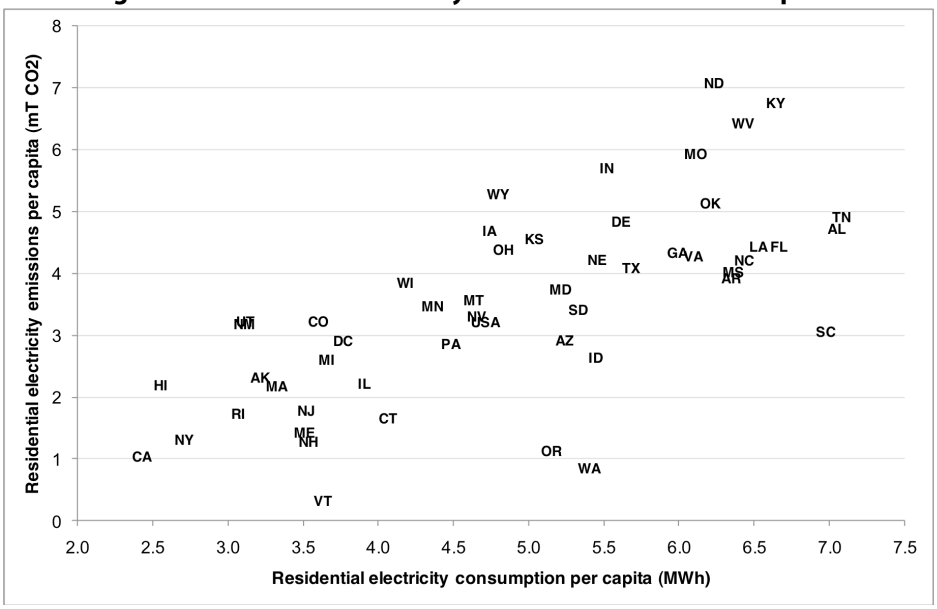
Note: * indicates significance at the 95% level; † indicates significance at the 99% level.

Regressions 2b and 2c look at explanatory variables related to interstate differences in direct residential fuel BTUs expended per capita, with and without a policy variable. In both regressions, the coefficients for income per capita and heating degree days are positive (as expected; higher income and colder weather are associated with greater use of heating fuels) and strongly significant. In Regression 2c, the inclusion of the average price of natural gas price does not have a significant impact on regression results. Eighty-four percent of the variation in residential fuel use per capita is explained by income per capita and heating degree days.

Residential electricity emissions

In Regression 3a, 82 percent of the interstate variation in residential electricity emissions per capita is explained by differences in residential electricity use per capita and the share of electricity generated from coal. Both explanatory variables have coefficients that are positive and strongly significant. Figure 2 illustrates the variation in residential electricity consumption as compared to that of residential electricity emissions. Outliers such as Vermont and Washington rely on nuclear and hydropower for electricity generation, using little or no coal; at the opposite extreme, Indiana, Kentucky, North Dakota, Utah, West Virginia, and Wyoming rely on coal for more than 90 percent of their electricity.

Figure 2: Residential Electricity: Emissions versus Consumption



Sources: Residential electricity emissions from authors' calculations; residential electricity consumption, see Appendix B.

Regressions 3b and 3c test the importance of income per capita, cooling degree days and average annual humidity in explaining interstate variation in residential electricity use per capita; Regression 3c includes the additional policy variable, average retail electricity price. In both regressions, coefficients for cooling degree days and average annual humidity are positive (hotter, more humid weather is associated with higher electricity use, likely due to

the use of air conditioning and other cooling needs) and significant. The coefficient for income per capita is negative in both regressions (contrary to expectation; poorer states use more electricity per capita) but is only significant when the policy variable is not included. The average retail electricity price has a coefficient that is negative (as expected; lower electricity prices are associated with more electricity use) and strongly significant.

In Regression 3b, only 40 percent of the variation in residential electricity use per capita is explained, but with the addition of the policy variable in Regression 3c, 74 percent of this variation is explained. Thus a substantial share of the interstate variation in electricity use can be explained by electricity prices.

In summary, sparsely populated states with low gasoline prices and little public transportation have high transportation emissions per capita. States where oil heat is common, average income is high, and the climate is cold, have high direct residential emissions per capita. States that have a lot of coal used in electricity generation, a hot and humid climate, and low electricity prices, have high residential electricity emissions. The important policy variables in this analysis are the price of gasoline and electricity, which can and do vary with state taxes, and public transportation use, which depends on both the availability of public transportation, and other policy tools and incentives to encourage its use.

In comparable research, Metcalf's (2008) U.S. state-by-state analysis showed that since the 1970s, higher energy prices have increased energy efficiency and, consequently, increased energy intensity. He also found that income has had a similar impact on energy efficiency. Our regressions showed little, and often contradictory, evidence regarding the relationship between income and per capita greenhouse gas emissions. Aldy (2006) found that, with no adjustment for electricity trade, per capita emissions diverged among states from 1960 to 1999, while incomes converged. After adjusting for interstate electricity trade, he found neither divergence nor convergence in per capita emissions.

Conclusion: Carbon Costs and State Burdens

If a new climate policy, such as a cap-and-trade system or a carbon tax, imposes a price on greenhouse gas emissions, households across the United States will experience higher direct energy costs and higher indirect energy costs in proportion to the carbon content of the goods and services they consume. Our analysis helps to explain *why* the impacts of climate policy may vary across states due to differences in direct energy use for transportation, home fuels, and residential electricity. It identifies factors that largely explain the variation in states' per capita emissions, and clarifies which factors states can potentially control through effective public policy.

How much will the burden of climate policy vary from state to state? The differences in per capita emissions between states, which look enormous at first glance, become smaller but do not entirely vanish as the data are examined more closely. The costs imposed on electricity producers will be borne by the consumers of electricity, not by the states where it

is produced. Correction for this factor results in a distribution of per capita emissions where the ratio of the highest to the lowest state emissions is about 6 to 1.

An additional correction is needed to identify the impacts on households in different parts of the country. Industrial and commercial emissions vary widely from state to state; costs imposed on these emissions will be borne by each industry's customers throughout the country and overseas, not by the states where production occurs. Emissions attributable to federal government activities are the responsibility of the country as a whole; their costs are borne by taxpayers nationwide, regardless of where the emissions occur. The remaining categories, the transportation and residential sectors, are the areas where household activities result in emissions. As seen in Figure 1, the range from highest to lowest states, excluding Alaska, varies about 3 to 1 in transportation and residential emissions.

If a climate policy imposes a price on carbon, under a carbon tax or cap-and-trade system, would a ratio of 3 to 1 in costs per capita be unfair to high-emission states? Many existing taxes, as well as farm payments, unemployment compensation, military spending, and other government programs display comparable or greater inequalities between states.[9] In general, there is not, and could not be, a guarantee that states will experience equal per capita costs or benefits from every federal initiative.

The 3-to-1 interstate variation in carbon emissions from household activities is the result of many factors, some more controllable than others. People who live in rural, low-density states drive more than those who live in urban, high-density areas, resulting in more transportation emissions. Some parts of the country are colder than others, and face greater heating requirements; some are hotter, and need more energy for cooling. These factors are difficult or impossible to change. Public policy can provide incentives for improved insulation and more energy-efficient heating and cooling units for residences and businesses; but even the best efficiency programs cannot eliminate the need for heating in colder states, and for air conditioning in hotter, humid states. Note that the District of Columbia, New York, Oregon, Rhode Island, Vermont, and Washington, all colder than the national average, are among the states with the lowest total transportation and residential emissions per capita.

Regression analysis shows that climate (heating and cooling degree days and average annual humidity) and geography (inverse population density) are important but incomplete explanatory variables for transportation, direct residential and residential electricity emissions. In the regressions that included variables that could be more readily influenced by policy, per capita income was only significant in the case of heating fuels, the smallest of the three categories of emissions we examined. The lack of correlation between income per capita and transportation and electricity emission per capita demonstrates that, at least

[9] For example, the distribution of farm payments per capita, as shown in the Environmental Working Group subsidies database, and the distribution of military contracts per capita, as shown at http://www.statemaster.com/graph/mil_def_con_exp_percap-defense-contracts-expenditures-percapita, are far more unequal, with less than half the states falling between 50 percent and 150 percent of the national average on both measures. In contrast, 48 of the 51 states (including D.C.) fall within that percentage range in transportation and residential emissions per capita; only Alaska, North Dakota, and Wyoming are outside it.

among states of the U.S., there is no rigid relationship between affluence and emissions.[10] Similar incomes can be associated with very different levels of emissions. It is possible – as evidenced by the contrast between California and Texas – to enjoy the typical American lifestyle with per capita emissions that are widely divergent from the U.S. mean.

Energy prices (average gasoline and retail electricity price) and public infrastructure (share of working population commuting via public transportation) were important in explaining the interstate variation in the use of transportation fuels and residential electricity and are readily addressed by climate and energy policies. The level of gasoline taxes differs widely from state to state; the extent of public transportation differs as well. Both of these policies have a direct, measurable effect on automobile usage and thus on transportation emissions. The reliance on coal power for electricity generation, where fuel choice is a function of existing infrastructure, has large impacts on residential emissions. So too does reliance on oil for home heating. Both factors are amenable to change via public policy. Electricity tax rates, more direct, government-sponsored conservation initiatives, and development of alternative energies can have far-reaching impacts on home electricity consumption and its emissions.

Information about policies that have succeeded in reducing emissions in some states should be circulated to the rest of the country. How have some states managed to reduce their emissions well below the national average? In broad strokes, states with low per capita emissions:

- Drive less per person and have, on average, better fuel economy;
- Use less electricity per person in their homes;
- Have higher gasoline and electricity prices;
- Rely more on public transportation; and
- Use less oil for heating and less coal for electricity generation.

What does our analysis say about the difference between per capita emissions in California and Texas? Transportation emissions are almost one and a half times as great in Texas as in California. Texas is more sparsely populated, it has lower gasoline prices, and 2 percent of its labor force commutes via public transportation, as compared to 5 percent in California. Per capita emissions from electricity are also four times as large in Texas as in California. With lower electricity prices and triple the heating degree days, Texans use twice the electricity per capita of Californians; 37 percent of Texans' electricity is generated from coal compared to 15 percent in California.[11] Public policy can't make Texas more densely populated (in the short or even medium run) or cooler, but it could promote public transportation, increase gasoline and electricity prices, and shift electricity production towards less carbon intensive alternatives to coal.

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[10] It has been established that differences in emissions per capita across nation-states are correlated with income per capita (Baumert et al. 2005), and that emissions vary widely across income quintiles within the United States (Boyce and Riddle 2009).

[11] Authors' calculation for California based on an assumed coal generation share of 50 percent (the U.S. average – see U.S. Energy Information Administration 2010) for California's electricity imports.

The data analyses provided in this report offer only a partial explanation. There is much more to be learned from a detailed examination of the policies of the lowest- and highest-emitting states. States with the lowest per capita transportation and residential emissions (New York, District of Columbia, Oregon, California, Rhode Island, Washington, Vermont, and New Hampshire) are by no means the poorest in the nation; indeed, these states are all above the national average in per capita income. These high-income, low-emissions states demonstrate that it is possible to produce a comfortable American lifestyle with carbon emissions well below average. Following their example more widely is an important first step on the road to reducing our greenhouse gas emissions to a sustainable level.

Appendix A: Data

Table A1: Per capita CO_2 emissions by U.S. state, 2005 (mT CO_2)

	transportation	direct residential	residential electricity	transportation and residential	commercial	industrial	total
United States	7.0	1.3	3.2	**11.5**	3.8	5.9	**21.2**
Alabama	7.8	0.6	4.7	**13.2**	3.7	10.3	**27.2**
Alaska	29.2	2.8	2.3	**34.3**	6.3	36.0	**76.5**
Arizona	6.5	0.4	2.9	**9.8**	3.0	2.0	**14.7**
Arkansas	7.6	0.8	3.9	**12.3**	3.4	8.2	**23.9**
California	6.7	0.8	1.1	**8.5**	1.9	2.8	**13.2**
Colorado	6.6	1.7	3.2	**11.5**	4.8	5.4	**21.7**
Connecticut	5.5	2.7	1.7	**9.9**	2.8	1.5	**14.2**
Delaware	6.4	1.5	4.9	**12.7**	5.3	8.5	**26.6**
District of Columbia	3.2	1.8	2.9	**7.9**	16.6	0.5	**25.1**
Florida	6.6	0.1	4.5	**11.1**	3.8	1.5	**16.4**
Georgia	7.8	0.9	4.4	**13.1**	4.1	5.1	**22.3**
Hawaii	10.3	0.1	2.2	**12.6**	2.7	4.3	**19.6**
Idaho	6.2	1.1	2.7	**10.0**	2.6	5.8	**18.5**
Illinois	6.3	2.0	2.2	**10.6**	3.3	5.5	**19.3**
Indiana	7.5	1.5	5.7	**14.8**	5.0	17.3	**37.1**
Iowa	7.4	1.6	4.7	**13.8**	5.2	11.8	**30.7**
Kansas	6.7	1.5	4.6	**12.8**	5.6	8.3	**26.7**
Kentucky	8.4	0.9	6.8	**16.1**	5.5	15.9	**37.5**
Louisiana	11.6	0.6	4.5	**16.6**	3.8	23.5	**43.9**
Maine	7.3	3.7	1.5	**12.5**	2.8	3.5	**18.8**
Maryland	6.0	1.3	3.8	**11.1**	3.3	4.1	**18.4**
Massachusetts	5.6	2.4	2.2	**10.2**	3.9	1.8	**15.9**
Michigan	5.7	2.4	2.6	**10.7**	4.0	5.1	**19.8**
Minnesota	7.5	1.8	3.5	**12.8**	4.7	6.6	**24.1**
Mississippi	8.9	0.6	4.0	**13.6**	3.3	6.9	**23.8**
Missouri	7.5	1.2	5.9	**14.7**	5.9	4.9	**25.5**
Montana	9.1	1.8	3.6	**14.5**	5.0	10.6	**30.0**
Nebraska	7.2	1.4	4.2	**12.9**	5.0	7.4	**25.3**
Nevada	7.1	1.0	3.3	**11.4**	3.3	5.0	**19.7**
New Hampshire	5.8	2.5	1.3	**9.6**	2.8	1.4	**13.9**
New Jersey	8.2	2.0	1.8	**12.0**	3.7	2.6	**18.3**
New Mexico	8.1	1.2	3.2	**12.5**	5.5	7.7	**25.8**
New York	4.0	2.1	1.3	**7.5**	3.6	1.3	**12.3**
North Carolina	6.3	0.8	4.2	**11.4**	4.0	4.2	**19.7**
North Dakota	10.4	2.0	7.1	**19.5**	9.3	26.2	**55.0**
Ohio	6.5	1.8	4.4	**12.7**	4.8	8.2	**25.7**
Oklahoma	9.0	1.1	5.2	**15.2**	4.9	9.8	**30.0**
Oregon	6.6	0.8	1.2	**8.5**	1.5	2.6	**12.6**
Pennsylvania	6.1	2.0	2.9	**11.0**	3.5	6.7	**21.3**
Rhode Island	4.3	2.7	1.8	**8.7**	3.1	1.1	**12.9**
South Carolina	7.4	0.6	3.1	**11.1**	2.6	6.2	**19.9**
South Dakota	8.3	1.4	3.4	**13.1**	4.4	4.5	**22.0**
Tennessee	7.9	0.8	4.9	**13.6**	4.1	7.0	**24.7**
Texas	8.7	0.5	4.1	**13.4**	4.1	11.2	**28.6**
Utah	6.9	1.4	3.2	**11.6**	5.0	7.1	**23.6**
Vermont	6.4	2.8	0.4	**9.5**	1.4	1.3	**12.2**
Virginia	7.6	1.2	4.3	**13.1**	5.0	4.5	**22.6**
Washington	7.1	0.8	0.9	**8.8**	1.3	3.4	**13.5**
West Virginia	7.1	1.2	6.4	**14.7**	5.2	13.5	**33.4**
Wisconsin	5.8	1.8	3.9	**11.5**	5.0	7.4	**23.9**
Wyoming	16.8	1.7	5.3	**23.8**	10.0	37.1	**70.8**

Appendix B: Data sources

All data are for 2005 with the exception of share of non-electricity residential energy consumption from oil, which is for 2007 because of data availability.

Population, income per capita, and share of workers commuting by public transportation: U.S. Census (2005), *American Community Survey 2005,* http://www.census.gov.

Emissions by sector: EIA (2008), *Environment: energy-related emissions data & environmental analyses*, "Table 2. 2005 State Emissions by Sector (Million Metric Tons of Carbon Dioxide)," http://www.eia.doe.gov/environment.html.

Electricity consumption by sector, electricity generation, and share of electricity generated from coal: EIA (2009), *Electric Power Annual 2007 — State Data Tables*, "Retail Sales of Electricity by State by Sector by Provider, 1990-2007" and "1990-2007 Net Generation by State by Type of Producer by Energy Source (EIA-906)," http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html.

Transportation fuel: U.S. Department of Transportation, Federal Highway Administration (2005), *Highway Statistics 2004*, "Motor Fuel Use — 2005," http://www.fhwa.dot.gov/policy/ohim/hs05/motor_fuel.htm.

July 2004/June 2005 annual heating degree days: NOAA (2005), *Historical Climatology Series 5-1, Period July 2003 through June 2005*, "State Heating Degree Days (Divisions Weighted by 2000 Population)," http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hdd.200307-200506.pdf. Data for Alaska and Hawaii are "normal" data for 1971-2000: NOAA (2000), *Historical Climatography Series No.5-1, State, Regional, and National Monthly Heating Degree Days, Weighted by Population (2000 Census), 1971-2000 (and previous normal periods)*, "Alaska-Hawaii-Territories-Census Regions," http://cdo.ncdc.noaa.gov/climatenormals/hcs/HCS_51.pdf.

January to December 2005 annual cooling degree days: NOAA (2005), *Historical Climatology Series 5-2, Period January 2004 through December 2005*, "State Cooling Degree Days (Divisions Weighted by 2000 Population)," http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/cdd.200401-200512.pdf. Data for Alaska and Hawaii are "normal" data for 1971-2000: NOAA (2000), *Historical Climatography Series No.5-2, State, Regional, and National Monthly Cooling Degree Days, Weighted by Population (2000 Census), 1971-2000 (and previous normal periods)*, "Alaska-Hawaii-Territories-Census Regions," http://cdo.ncdc.noaa.gov/climatenormals/hcs/HCS_52.pdf.

Land area: U.S. Census (2000), "GCT-PH1-R. Population, Housing Units, Area, and Density (geographies ranked by total population): 2000," http://factfinder.census.gov/servlet/GCTTable?_bm=n&_lang=en&mt_name=DEC_2000_SF1_U_GCTPH1R_US9S&format=US-9S&_box_head_nbr=GCT-PH1-R&ds_name=DEC_2000_SF1_U&geo_id=01000US.

Average gasoline price per gallon: EIA (2008), *Petroleum Navigator*, "Gasoline Prices by Formulation, Grade, Sales Type," http://tonto.eia.doe.gov/dnav/pet/pet_pri_allmg_a_EPM0_PTA_cpgal_a.htm.

Average electricity price per kWh: EIA (2005), *State Electricity Profiles 2005*, "Table A1. Selected Electric Industry Summary Statistics by State, 2005," http://tonto.eia.doe.gov/ftproot/electricity/stateprofiles/05st_profiles/062905.pdf.

Share of non-electricity residential energy consumption from oil: EIA (2007), *State Energy Data System: Consumption, Price and Expenditure Estimates,* "Table S4. Residential Sector Energy Consumption Estimates, 2007," http://www.eia.doe.gov/emeu/states/_seds.html.

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