Clean Energy and Climate Policy for U.S. Growth and Job Creation

An Economic Assessment of the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act

Executive Summary

David Roland-Holst

Fredrich Kahrl

UC Berkeley

in collaboration with

Madhu Khanna

University of Illinois, Urbana-Champaign

Jennifer Baka

Yale University

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College of

Natural Resources

University of California, Berkeley

College of

Climate change is the greatest challenge facing humanity in the 21st century. Without determined global action to reduce atmospheric concentrations of greenhouse gas emissions over the next four decades, scientific evidence suggests that carbon-intensive patterns of economic growth run a high risk of dangerously altering the earth's climate system.

As a leader in energy technology development and history's largest contributor of greenhouse gases, the United States has an essential leadership role to play in international efforts to mitigate climate change. Exemplifying this leadership, a detailed federal plan to reduce greenhouse gas emissions, the American Clean Energy Security Act (ACES), was introduced into the U.S. House of Representatives in March and passed in June 2009. This analysis provides the most up-to-date state-by-state examination of the economic implications of this kind of comprehensive federal climate policy.

Federal climate policy will have different implications for different states, and should ultimately be designed to account for and address these differences. The U.S. is a complex patchwork of diverse state and local economies that reflect differences in geography, climate, population, resources, and historical development paths. These physical and historical differences contribute to broad spectrum of energy and carbon intensities among states, and these are important factors in determining the economic impacts of a federal climate policy on states.

This executive summary provides general insights from an in-depth analysis of the economic implications of US national climate policy, as these would arise from clean energy and efficiency measures like those in the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act. This comprehensive economic assessment was conducted using EAGLE, a new state-of-the-art forecasting model that projects the long term economic impacts of climate legislation on the U.S. economy. The model details economic interactions within and between each of the 50 states and compares the impacts of combining a limit on carbon pollution with complementary efficiency and renewable energy policies. In addition to many detailed findings for individual states, three overarching conclusions follow from the EAGLE analysis:

Table 1: Main Findings

1. All 50 states can gain economically from strong federal energy and climate policy, despite the diversity of their economies and energy mixes. The states may differ on the supply side, but on the demand side they all have substantial opportunities to grow their economies by promoting energy saving and domestic renewable energy alternatives.
2. Contrary to what is commonly assumed, comprehensive national climate policy does not benefit the coasts at the expense of the heartland states. In fact, heartland states will gain more by reducing imported fossil fuel dependence because they are generally spending a higher proportion of their income on this low employment, high price risk supply chain. Demand side policies make a bigger difference for more carbon-dependent states, and carbon reduction opportunities represent riper and lower hanging fruit.
3. The country as a whole can gain 918,000 to 1.9 million jobs, and household income can grow by $488 to $1,176, by 2020 under comprehensive energy and climate policy. By aggressively promoting efficiency on the demand side of energy markets, alternative fuel and renewable technology development on the supply side can be combined with carbon pollution reduction to yield economic growth and net job creation. Indeed, a central finding of this research is that **the stronger the federal climate policy, the greater the economic reward.**

Every state can accelerate growth by adopting a complete national policy package that promotes three climate strategies in unison: Greenhouse Gas (GHG) mitigation via market oriented restrictions on total carbon pollution, energy efficiency, and renewable energy development. An important finding of this research is that more carbon dependent economies have more to gain from climate action, assuming they adopt balanced policies that combine all three approaches to energy efficiency and clean technology. Given the diversity of initial conditions in this regard (Figure 1), individual states need to recognize the potential of this constellation of policies to promote their growth prospects.

Aggregate Results

Policies as important as the new national climate agenda will have far reaching effects on the state and national economies. Table 2 summarizes aggregate growth effects by state, of adopting a national policy packages like ACES. Measured as percentage variations in real Gross State Product (GSP), these results show changes in aggregate real value added (wages, salaries, and profits) in 2020, compared to the Baseline baseline. The results are variegated, but a few salient findings deserve emphasis. Firstly, implementing the right combination of a Cap and Trade system and complementary measures to promote lower carbon technologies can result in net economic stimulus, for every single state. We see in many states that when market-oriented GHG mitigation is combined with efficient demand and supply side energy policies, the result can be a potent catalyst for economic growth. Even in cases where growth is less than robust, we see nothing like the adverse impacts predicted by industry-commissioned estimates. This is because complementary policies like energy efficiency save enterprises and households money, and this money is spent on domestic and in-state goods and services with higher employment intensity than the import dependent carbon fuel supply chain. Two energy efficiency trends are considered, one conforming exactly to ACES standards, and the other more aggressive. The result is higher employment and income for every state that makes significant progress in reducing its energy dependence.

To fully appreciate the economic effects of climate policy, we must recognize the importance of complementary policies that add efficiency and yield a low carbon, higher growth economic future. Markets alone may not identify the climate change externality and markets for carbon may not provide adequate incentives for innovation and efficiency. To overcome hurdles that limit technology development, diffusion, and adoption, national climate policies include efficiency standards that will provide growth dividends for every state economy.

For most states, growth rates increase with adoption of renewable energy sources. This results from two factors, reduction in long term fossil fuel dependence and exploitation of more efficient alternative energy sources. Fossil fuels are currently depressed by demand side failure in global energy markets, but this situation is temporary and recent IEA and DOE projections foresee a strong and sustained resurgence of fuel prices. By shifting to domestic renewable substitutes, the Western states can reduce their long term external energy dependence and capture more in-state expenditure multiplier effects. In terms of relative efficiency, recent research on new renewable supplies suggests that a 30% RPS can be met from sources with marginal cost below projected fossil fuel alternatives. These savings from “low hanging” fruit in solar, wind, and geothermal sources will also contribute to higher long term regional growth.

Table 2: Job Growth by 2020

	Thousands		Percent	
State	Moderate	High	Moderate	High
United States	918	1,894	.4	.9
Alabama	21	39	.7	1.3
Alaska	1	9	.2	1.7
Arizona	9	24	.2	.6
Arkansas	10	25	.5	1.3
California	120	226	.5	.9
Colorado	11	30	.3	.8
Connecticut	11	16	.4	.6
Delaware	3	7	.5	1.2
Florida	47	78	.4	.6
Georgia	40	70	.6	1.1
Hawaii	4	10	.4	1.0
Idaho	7	14	.6	1.3
Illinois	37	68	.4	.7
Indiana	22	45	.5	1.0
Iowa	14	27	.6	1.1
Kansas	7	22	.3	1.0
Kentucky	10	30	.3	1.0
Louisiana	-6	22	-.2	.7
Maine	6	12	.6	1.2
Maryland	34	71	.8	1.7
Massachusetts	22	40	.4	.8
Michigan	42	37	.6	.6
Minnesota	19	38	.5	.9
Mississippi	8	19	.4	1.0
Missouri	18	29	.4	.7
Montana	5	13	.7	1.8
Nebraska	12	38	.8	2.6
Nevada	9	17	.4	.9
New Hampshire	5	7	.5	.7
New Jersey	13	11	.2	.2
New Mexico	5	15	.4	1.2
New York	77	126	.6	1.0
North Carolina	17	65	.3	1.0
North Dakota	4	11	.7	1.8
Ohio	35	61	.4	.7
Oklahoma	-2	20	-.1	.8
Oregon	13	26	.5	1.0
Pennsylvania	46	78	.5	.9
Rhode Island	5	8	.7	1.1
South Carolina	21	36	.7	1.2
South Dakota	5	10	.8	1.5
Tennessee	2	20	.0	.5
Texas	44	165	.3	1.0
Utah	8	21	.4	1.1
Vermont	4	8	.9	1.5
Virginia	25	50	.4	.9
Washington	1	13	.0	.3
West Virginia	10	31	.9	2.8
Wisconsin	20	28	.5	.7
Wyoming	6	20	1.3	4.5

Table 3: Real 2020 Household Income and GSP

	Income (2008$)		GSP Percent	
State	Moderate	High	Moderate	High
United States	488	1,176	.2	.7
Alabama	547	1,261	.4	.9
Alaska	1,165	5,801	-.1	2.6
Arizona	53	283	.0	.2
Arkansas	457	1,230	.4	1.1
California	735	1,477	.4	.7
Colorado	425	1,138	.0	.4
Connecticut	717	1,011	.3	.4
Delaware	398	1,416	.2	.9
Florida	303	615	.3	.6
Georgia	702	1,362	.4	.9
Hawaii	610	1,464	.3	.8
Idaho	431	1,149	.3	1.0
Illinois	508	1,137	.2	.6
Indiana	476	1,219	.3	.8
Iowa	686	1,501	.5	1.2
Kansas	229	1,182	.1	.7
Kentucky	267	1,133	.2	.9
Louisiana	-219	1,582	-.4	1.0
Maine	550	1,317	.5	1.1
Maryland	1,022	2,172	.6	1.2
Massachusetts	738	1,356	.3	.7
Michigan	667	750	.4	.5
Minnesota	579	1,240	.3	.8
Mississippi	289	889	.2	.8
Missouri	446	892	.3	.7
Montana	599	1,736	.4	1.4
Nebraska	927	4,120	.6	2.7
Nevada	471	1,025	.3	.7
New Hampshire	573	726	.3	.4
New Jersey	196	-92	.1	-.1
New Mexico	516	1,309	.0	.7
New York	902	1,580	.4	.7
North Carolina	230	1,159	.2	.9
North Dakota	1,048	2,683	.5	1.5
Ohio	452	992	.3	.7
Oklahoma	47	986	-.6	-.1
Oregon	399	941	.3	.7
Pennsylvania	637	1,092	.4	.7
Rhode Island	700	1,172	.5	.8
South Carolina	650	1,259	.5	1.0
South Dakota	784	1,602	.6	1.2
Tennessee	-129	406	-.1	.3
Texas	442	1,814	.0	.8
Utah	523	1,435	.2	.8
Vermont	816	1,535	.6	1.2
Virginia	554	1,325	.3	.7
Washington	-195	105	-.1	.1
West Virginia	684	2,737	.5	2.5
Wisconsin	513	749	.3	.6
Wyoming	4,884	9,862	1.2	4.0

Federal Climate Policy: An Overview

U.S. federal climate policy has converged around the creation of a national cap and trade (C&T) system, with a substantial program of research, development and demonstration (RD&D) and a number of mandatory alternative energy, energy efficiency, and other measures to complement the GHG emission reductions achieved through the C&T system. A detailed plan to implement this system was introduced in March of 2009 by Representatives Henry Waxman and Ed Markey through the American Clean Energy and Security Act (ACES), and passed in June 2009.

In September 2009, Senators John Kerry and Barbara Boxer introduced a Senate version of climate legislation, the Clean Energy Jobs and American Power Act (CEJAPA). This analysis takes ACES provisions as its starting point, but its conclusions will be broadly relevant for any similar comprehensive national policy that includes both carbon and energy policies.

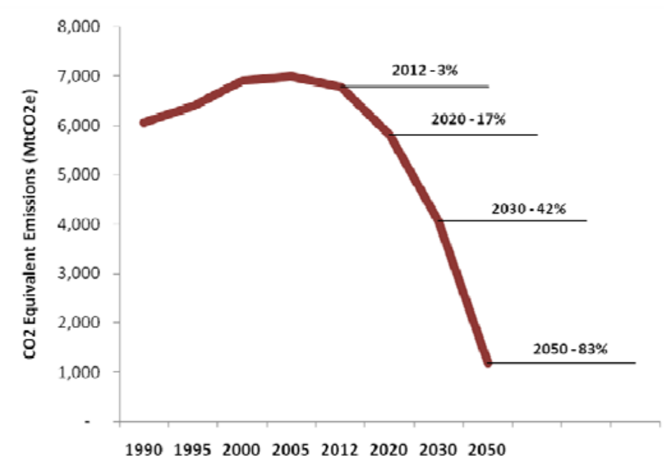
ACES includes the following four major provisions:

1. A cap and trade system (Title III) with a cap that steadily declines over time and a system to allocate allowances.
2. A requirement that electric utilities meet 20% of their sales through renewable energy by 2020, with utilities able to meet a certain portion of this obligation (25%) with efficiency (Title I).
3. Aggressive energy efficiency standards for new buildings, appliances, and vehicles (Title II).
4. A substantial program (in the hundreds of billions of dollars) to support RD&D in clean energy and energy efficient technologies, funded in part through CO2e allowances (Title IV).

The ACES cap is designed to be comprehensive, covering 84% of U.S. GHG emissions by 2016. Regulated entities must hold one allowance to emit one metric CO2e ton of any GHG included under the cap. Allowance obligations can be met by reducing emissions, through allowances saved ("banked") from a previous period, by purchasing allowances, by purchasing international offsets, or by using allowances from countries that have comparable systems. ACES places a ceiling on international offsets, but grants the EPA administrator the flexibility to adjust that ceiling.

The ACES cap has two primary targets (Figure 1): economy-wide GHG emissions must be reduced by 17% from 2005 levels by 2020 and by 83% from 2050 levels by 2050. Two intermediary targets require a 3% reduction in 2005 GHG emissions levels by 2012 and a 42% reduction from 2005 levels by 2030. The CEJAPA has proposed a more aggressive 2020 target of 20%, but has adopted the same 2050 target.

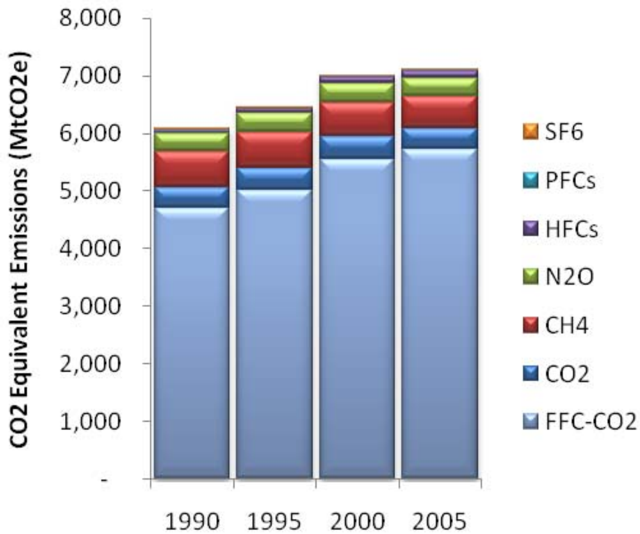
Figure 1. GHG Emission Reduction Targets under ACES



Source: GHG emissions data are from EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1980-2007," April 2009.

U.S. GHG emissions are and have historically been dominated by fossil fuel combustion (Figure 2), accounting for 80% of total GHG emissions in 2005. Reducing GHG emissions by 17% by 2020 will require significant changes in the way that the U.S. produces and consumes energy; reducing emissions by 83% by 2050 will require a fundamental transformation of the U.S. energy system.

Figure 2. U.S. Greenhouse Gas Emissions, 1990-2005 (FFC = Fossil Fuel Combustion)



Source: EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1980-2007," April 2009.

Within fossil fuel combustion, GHG emission sources are more diffuse. The two largest emission sources — coal-fired electricity generation (33%) and motor gasoline (20%) — accounted for roughly 53% of energy-related GHG emissions in 2005. The next largest sources of energy-related GHG emissions each account for less than 10% of total energy-related GHG emissions. In recognition of this distribution, ACES includes both a comprehensive cap and specific measures that target both the electricity and transportation sectors.

Policies Assessed

A comprehensive climate policy package can be complex. It is also generally the product of detailed negotiations that take account of very heterogeneous economic interests. For this reason, the current analysis aims to provide overall guidance by considering only the most salient components of a national climate initiative. To improve visibility for public and private stakeholders regarding economic impacts of a comprehensive national climate policy like that currently being discussed, the EAGLE model assesses a package consisting of five generic policy types:

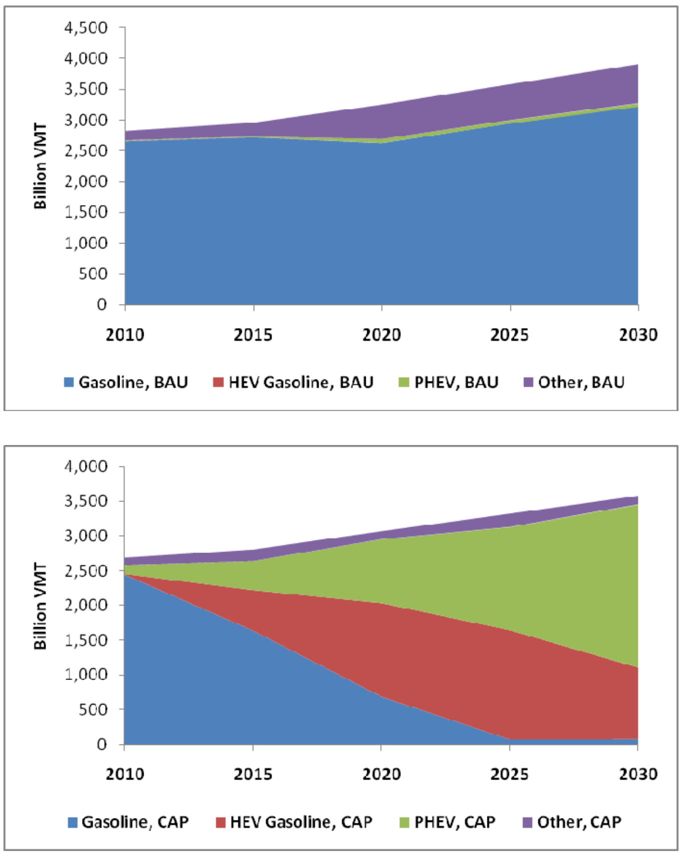
Carbon Emission Reductions that reflect market based measures to restrict total atmospheric emissions of CO2. In this analysis, we do not consider detailed design characteristics for such a mechanism, but only impose a national limit on total emissions and assume that a mechanism of trading pollution rights leads to a market premium that provides incentives for energy conservation and investments in more efficient technology.

EAGLE is an economic forecasting model. To estimate patterns of technology adjustment in the underlying energy economy, we draw upon results from the MARKAL national energy simulation model. These provide inputs to EAGLE in the next four policy categories, each dealing with a different dimension of energy use.

Transportation includes changes in the energy requirements and fuel mix of the light duty vehicle (LDV) and heavy duty vehicle (HDV) fleets. Transportation adjustments include shifts in the fuel and fuel economy composition of the LDV and HDV fleets. For the LDV fleet, the primary shift captured in MARKAL is toward greater adoption and use of hybrid electric vehicles (HEVs) and ultimately plug-in hybrid electric vehicles (PHEVs). Figure 3 shows the changing composition of LDV vehicle miles traveled (VMT) over time in the

MARKAL results. For HDVs, we consider only heavy truck results as there are no major changes in the fuel economy or per vehicle emissions of other HDVs in the MARKAL results. The primary shift in heavy trucks is toward more efficient vehicles, with a small shift toward biodiesel. In the Policy case, by 2030 roughly one-third of all heavy truck VMT is accounted for by post-2020, high efficiency vehicles, whereas in the Baseline case none of these vehicles are adopted.

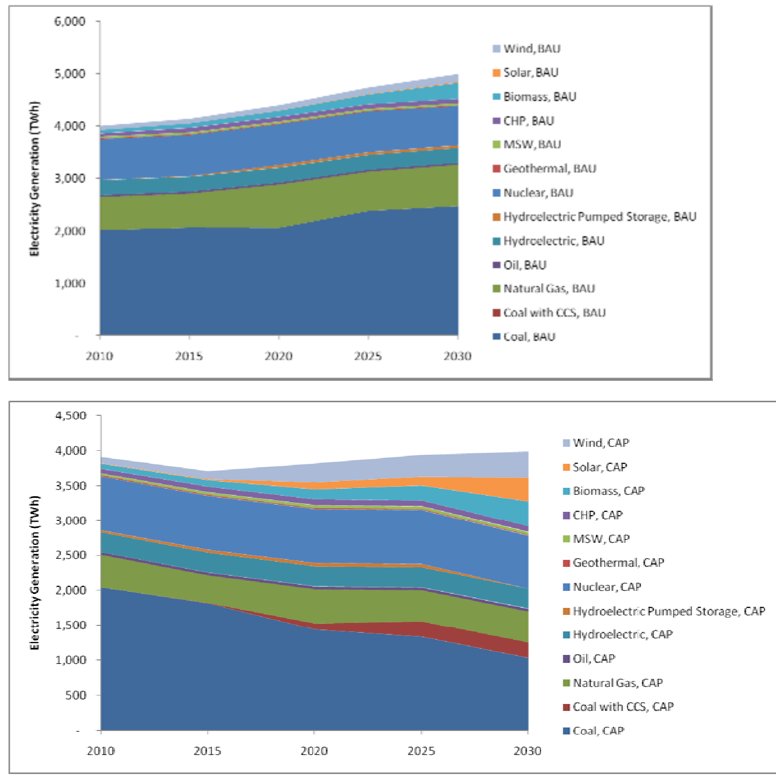
Figure 3. Composition of LDV VMT, 2010-2030, Baseline and Policy Cases



Notes: "Other" here includes E100, all-electric, diesel, CNG, and LPG-powered vehicles.

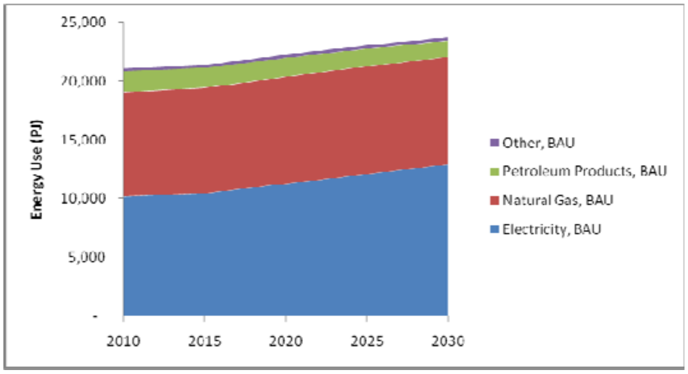
Electricity Generation under a carbon cap will experience changes in the composition of the mix of electricity generation resources, including shifts toward low or zero carbon energy sources, including coal-fired generation with offsetting CCS. Two main resource shifts are notable in the MARKAL results (Figure 4). First, with a significant ramp up in generating capacity over the 2010-2030 period biomass, solar, and wind power account for roughly one quarter of total national generation by 2030. Second, in the Policy case a small but significant amount of coal with CCS begins to come online. These two shifts displace coal and natural gas generation, with the majority of CO_2 emission reductions coming from reductions in coal-fired generation.

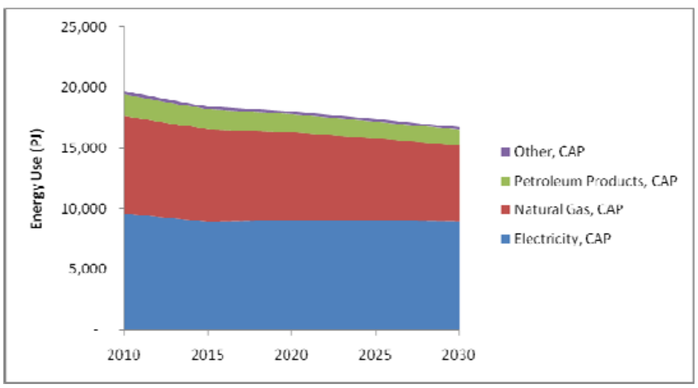
Figure 4. Changes in the National Generation Mix, 2010-2030 Baseline and Policy Cases



Residential and Commercial Energy Efficiency includes changes in the energy requirements of residential and commercial buildings, appliances, and electronics. Residential and commercial energy efficiency includes improvements in the efficiency of buildings, appliances, and electronics that use electricity, natural gas, and petroleum products. The MARKAL results also include the introduction of solar water heaters on a larger scale.

Figure 5. Changes in the Total, Aggregated Residential and Commercial Energy Use, 2010-2030 Baseline and Policy Cases





As shown in Figure 5 (residential and commercial aggregated), residential and commercial energy efficiency gains in MARKAL result in the flattening out of electricity demand and absolute reductions in natural gas and oil use relative to Baseline. As a result, total residential and commercial energy use declines in absolute terms (by about 15%) from 2010 to 2030 in the Policy case, and total residential and commercial energy use in the Policy case is about 30% lower than in the Baseline case.

Sequestration and Offsets include terrestrial carbon sequestration and landfill gas projects. Sequestration and offsets include four major categories: agricultural (mostly soil carbon sequestration), livestock (mostly manure management), forestry (mostly changes in forest management), and landfills (landfill gas capture and generation). Table 4 shows estimated abatement potential for domestic sequestration and offsets, aggregated by region.[1]

Table 4. Annual Abatement Potential for Sequestration and Offsets by Region, Year 2030

Region	Abatement Potential ($MMTCO_2$)				
	Agriculture	Livestock	Forestry	Landfill	Total
Midwest	4	15	16	20	55
Northeast	1	3	12	7	26
Plains	3	13	7	25	61
South	2	9	30	24	72
West	3	13	58	25	137
TOTALS	12	4	236	100	351

Economic Diversity

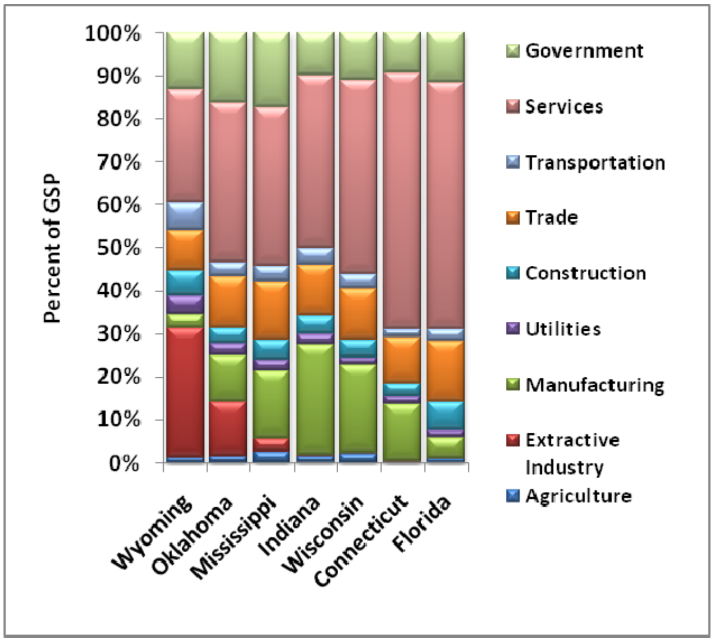
The U.S. is a patchwork of diverse state economies that reflect different geography, climate, resource endowments, and historical development paths. Differences in economic structure contribute to differences in energy and carbon intensity among states.

At an aggregate level, the most significant differences among state economies are in the shares of extractive industries, manufacturing, and services as a share of gross state product (GSP). More than 30% of Wyoming's GSP in 2007, for instance, was generated by coal, natural gas, and oil extraction, whereas manufacturing (3%) and services (26%) played much smaller roles. Indiana had the highest GSP share of manufacturing (26%) in the U.S. in 2007 and a moderately large services industry (40%), but negligible resource extraction (0%). At the other end of the spectrum, services dominated the Florida

[1] Note that these estimates show significantly less offset abatement potential than the bill allows. Also, this analysis assumes no international offsets are used. Thus this could be considered a low-offset scenario. We conclude that high levels of offsets are not economically necessary, but if more low-cost offsets are indeed available, the CO2 cap could be met with higher net benefits.

economy (57%) in 2007, whereas manufacturing (5%) and extractive industries (0%) were not major activities. Figure 6 shows aggregate sectoral GSP shares for seven states that illustrates the spectrum of economic activity among states.

Figure 6. Differences in Economic Structure among Seven Representative States, 2007



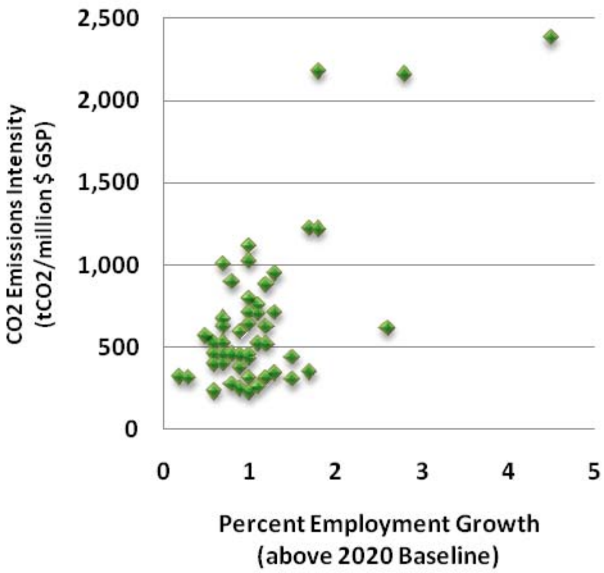
Source: Data are from BEA website, http://bea.gov/regional/index.htm#gsp

These differences in economic structure will play an important role in how states adjust to the requirements of a federal climate policy. For instance, the economic impact on states that are more dependent on fossil fuel extraction will depend on the feasibility and cost-effectiveness of carbon capture and storage (CCS), the timing of shifts to alternative energy sources, and the effects of a range of energy and climate policies on fossil fuel prices. Manufacturing is typically more energy intensive than services, and states where manufacturing is a larger share of GSP will have to give greater consideration to managing the impacts of a federal climate policy on retail energy prices.

However, focusing on industry and commercial energy use overstates both the diversity of states and the costs of reducing carbon intensity. In most states, consumer demand is over half of GSP and in many states much more so. In terms of household spending patterns, state-by-state differences are much smaller, and the scope of energy efficiency improvements much more comparable. State's may have different initial levels of CO2 intensity in demand, but the tools of demand side management are the same. Moreover, historical record of leading state clearly shows that efficiency improvements are not merely feasible, but represent a potent source economic growth. Over three decades (1972-2006), California's energy efficiency measures saved households $56 billion and created 1.5 million additional jobs with $45 billion in additional payrolls. More than anything else, it is these savings opportunities from energy efficiency that drive the positive economic results across the board.

The results of our EAGLE assessment send an even stronger message about demand side opportunities. As Figure 7 indicates, **the greater the initial level of CO2 intensity in overall state demand, the larger will be the employment dividend to that state from adopting a comprehensive package of national climate policies**. This is true because demand side policies make a bigger difference for them, and carbon reduction opportunities represent riper and lower hanging fruit for investments in efficiency and renewable energy.

Figure 7: State Initial (2006) CO2 Intensity and Employment Effect (2020) of Climate Policy



Sources: Energy data are from the EIA website. Economic data are from BEA website, http://bea.gov/regional/index.htm#gsp.

Methodology

The primary tool for this economic assessment was the Environmental Assessment in GeneraL Equilibrium (EAGLE) model, a state-of-the-art forecasting tool that details patters of demand, supply, energy/resource use, employment, income, and emissions across each of the 50 United States. Full technical documentation of the model is available from the authors.

Data Sources

Economic Data

The primary economic data resource used to calibrate the EAGLE model is IMPLAN, a nationally consistent collection of economic data that detail patterns of supply, demand, and resource use for over 500 sectors of the economy in each of the 50 states. Based on a twenty-year data management initiative begun by the US Forest Service, IMPLAN offers the most up-to-date detailed data on economic structure of the US economy.

Emissions Data

A large collection of the latest official statistics were used to calculate a state-by-state, sectoral greenhouse gas (GHG) emissions inventory for the EAGLE model. Basic GHG emissions inventories are not yet available at a state level,[2] much less at a sectoral level, in the U.S. In constructing an emissions inventory for the model we use a number of data sources and assumptions, documented more fully in the overall project documentation. To our knowledge, these estimates represent the first state-by-state, detailed sectoral emissions inventory for the U.S. Here we summarize the constituent data sources.

The U.S. Energy Information Administration (EIA) maintains detailed data on fossil fuel CO_2 emissions, with CO_2 emissions estimated from both national and state-level fossil fuel use data. The U.S. Environmental Protection Agency (EPA) maintains a more comprehensive national inventory that covers all GHG emissions, but lacks detail at a state and sectoral level. In building the CO_2 portion of the EAGLE GHG inventory we make use of both EIA and EPA data. The non-CO_2 portion relies exclusively on EPA estimates.

EIA and EPA both use five major sectors to categorize CO_2 emissions from fossil fuel use: Transportation, commercial, electric power, industrial, and residential.

EIA's state-level estimates of CO_2 emissions by sector are based on detailed assessments of coal, natural gas, and petroleum product use

[2] See the EPA's State Greenhouse Gas Inventories, http://www.epa.gov/climatechange/emissions/state_ghginventories.html.

by state. In order to maintain consistency between the EIA's national and state-level CO_2 emissions estimates, we adjust state-level CO_2 emissions by fuel to match estimates of national CO_2 emissions by fuel. The data that we ultimately use as inputs are the EIA's state-level CO_2 emissions estimates by major sector, adjusted to match the EIA's national estimates of CO_2 emissions by fuel.

Our economic data is from 2006, and we update EIA's 2005 CO_2 emissions data using EIA national CO_2 emissions estimates for 2006. This approach assumes that the sectoral structure of CO_2 emissions remains unchanged from 2005 to 2006. Final fossil fuel CO_2 emissions inputs are listed in Table 4.

Table 4. Final Fossil Fuel CO_2 Emissions Inputs Used in the EAGLE GHG Emissions Inventory

	Transport	Commerce	Electric Power	Industrial	Residential	Total
Coal	0	9	1,949	182	1	2,141
Natural Gas	32	159	312	410	256	1,169
Petroleum	1,758	47	91	606	89	2,591
Total	1,790	215	2,351	1,198	346	5,901

Note: Totals do not necessarily add due to independent rounding.

Prepared by
David Roland-Holst
Department of Agricultural and Resource Economics
Fredrich Kahrl
Energy and Resources Group
UC Berkeley
dwrh@are.berkeley.edu

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