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**An Evaluation of the Genesis and Construct of State-Level Climate Action Plans
Within the United States of America: Envisioning Carbon-Neutrality**

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**An Evaluation of the Genesis and Construct of State-Level Climate Action Plans
Within the United States of America: Envisioning Carbon-Neutrality**

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Key Words: *Global Warming, Sustainability, Climate Action Plan, Greenhouse Gases, Emissions, Energy*

Abstract

Purpose of Review:

Responsible environmental stewardship and the protection of our energy stability are issues being faced by the modern world, requiring the collaboration of policymakers, researchers, and the entire population. In order to avoid irreversible damage to the planet and a loss of energy sources, many countries are outlining plans with specific goals of reaching carbon neutrality and accelerating the adoption of cleaner energy production.

Recent Findings:

States within the United States of America have and are drafting climate action plans to reduce greenhouse gas emissions with some also focusing on alternative energy use. Most of these plans expect a near-complete or complete shift away from practices that release greenhouse gases into the environment, promising a net-zero release of greenhouse gases statewide within some timeframe; generally, their timelines are 2050.

Summary:

These documents and reports are integral to each state and the country as a whole to accelerate research, industry investment, and implementation of important sustainable energy practices. This review analyzes the genesis, document design protocols used, plan format, contents of note, and overriding goals of these state-created action plans.

Keywords

climate action plans, greenhouse gases, carbon-neutrality, net-zero, environment, emission modeling

Statements and Declarations

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1. Introduction

Climate change and the protection of our environment require the collaboration of policymakers, researchers, industry, and the entire population. Climate change has the potential to dramatically change biodiversity, land usage, and necessary water resources. [1] These effects potentially can have catastrophic impacts on society, leading to a scarcity of natural and necessary resources. These effects are expected not to be the same among locations in terms of timeframe and significance of impacts with countries more susceptible to significant societal disruption often being the less affluent. [2] Over the past one hundred years, the global increase in temperature was approximately 1°C, with more intense damage occurring to the ecosystems at nearing an increase of 1.5 °C. [3] The potential impacts of global warming and climate change give rise to making appropriately timely adjustments in the anthropogenic releases of greenhouse gases into the Earth's atmosphere. Yet, society must have a reliable energy infrastructure. And with pending environmental change, these energy systems must be increasingly more resilient. Society's energy base must also be affordable and carbon neutral. Thus, change must happen, and it takes plans to usher in impactful changes.

Historically, the United States of America (USA) has taken some key actions against climate change. In the 1980s, the Reagan administration implemented policies to phase out chlorofluorocarbons (CFCs) under the Montreal Protocol. This action was meant to address the depletion of the ozone layer and was not yet centered around temperature-based climate change specifically. [4] The first national-level climate action plan, or a plan centered around potential policies to reduce greenhouse gas (GHG) emissions, came in 1993 with President Clinton's *Climate Change Action Plan*, to reduce GHG emissions to 1990 levels by the Year 2000. [5] Jumping to 2015, the Obama administration passed the *Clean Power Plan*, "to reduce carbon dioxide emissions by 32 percent from 2005 levels by 2030." [6] Under the recently passed Inflation Reduction Act of 2022 (IRA) within the USA, increased incentives for carbon capture and sequestration (CCS) and carbon capture and utilization (CCU) technologies via increased 45Q tax credits have initiated a surge in CCS projects in the USA which offer the potential to substantially reduce CO₂ emissions. Both CCS and CCU are primarily being applied to end-of-stack emissions. However, also due to IRA-based incentives, Direct Air Capture (DAC) technologies are being rolled out that will capture CO₂ from the open air. [7]

As per the Center for Climate and Energy Solutions (C2ES), 33 states have released or are developing an updated climate action plan to pursue their paths to GHG reduction regardless of national-level action. [8] Many are focusing on carbon neutrality which essentially means that the flux of CO₂ equivalents (mainly as CO₂ and methane [CH₄]) emitted are offset by reduction resulting in a net release of zero or in other words – carbon neutrality.

This current study development used the list provided by the C2ES website as a sample set, choosing the most recent documents released that were framed as state-level climate action plans. The typical form of a climate action plan includes a stated reduction goal with policy recommendations to fit that goal. This excluded certain items listed on the C2ES database, such as Illinois' SB2408, but included the 2007 "Report of the Illinois Climate Change Advisory Group." [9, 10] The sample of 33 USA state-level climate action plans displayed several legal pathways for creation which varied from state to state. In examining the differences and similarities in the legal and policy pathways toward creation, this current study identified many foundational differences that may influence the construct of the climate action plan as a whole. In this paper, a review of the greenhouse gas effect to illustrate the science behind climate change is presented followed by a comparison of the processes behind the creation and drafting of state-level climate action plans to better understand the factors that shape them.

1.1 Greenhouse Gas Effect

The dominant cause of climate change is widely believed to be centered around the release of greenhouse gases from a variety of both anthropogenic and natural sources. Anthropogenic sources are increasing and are essentially the only emission type of the two source types that can be reasonably controlled. Greenhouse gases absorb and emit infrared radiation, preventing this radiation from escaping through the atmosphere and away from

the Earth's surface. [11] There is a large variety of greenhouse gases, and most are released into the atmosphere through industrial, power, agricultural, and transportation systems. [12, 13] The most common anthropogenic gas released into the atmosphere is carbon dioxide (CO₂). An estimated 36.6 billion tons are released each year into the Earth's atmosphere. [14] It is often used as a frame of reference in the analysis of the effect of greenhouse gases on the environment; a gas's greenhouse effect is often measured by its carbon dioxide impact equivalence over one hundred years (CO₂e) which is a comparative measure of its ability to absorb heat energy. These values represent the effect on the environment at a level of magnitude. Carbon dioxide has a lower greenhouse effect than most greenhouse gases of concern; however, due to its concentration and levels of production, it is a gas that is receiving a high level of focus.

Another greenhouse gas that is receiving attention is methane (CH₄). Methane has a CO₂e of approximately 21, making it a much more potent atmospheric heat absorber than carbon dioxide. [15] Methane emissions are predicted to be around 570 million tons in 2020. [16] Another gas of particular concern is nitrous oxide (N₂O). Nitrous oxide makes up around 6.5% of all the United States' greenhouse gas emissions, this gas can have a large impact on climate thermal stability. [17] Some of the most potent GHG compounds are fluorinated gases. These include hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride, and sulfur hexafluoride which have CO₂e values of 14,800, 12,200, 17,200, and 22,800, respectively. They also have a lifespan in the atmosphere from 270 to 50,000 years. [15] These gases, though released in relatively small amounts, can have an enormous impact on the atmosphere due to their long lifespan and the effect a small amount can have on the atmosphere. It is also important to note that the gas most responsible for warming the atmosphere is water vapor, making up 90 to 95% of the overall greenhouse effect. However, the amount of water vapor in the atmosphere has declined since 1948. [11] Table 1 shows the most prominent greenhouse gases with key information regarding their effect.

Table 1: Outline of Major Greenhouse Gases with Important Associated Information [18, 17, 19]

Species	CO ₂ e	Atmospheric Lifespan (years)	Percent of Global Emissions	Common Sources in Order of Amount Produced
Carbon Dioxide	1	300-1000	76%	Transportation, Electricity, Industry, Residential, Other Combustion Sources
Methane	25	12	16%	Enteric Fermentation, Natural Gas and Petroleum Systems, Landfills, Manure Management, Coal Mining, Other
Nitrous Oxide	298	114	6%	Agriculture Soil Management, Stationary Combustion, Industry or Chemical Production, Manure Management, Transportation
HFCs	14,800	270	<2%	Substitution of Ozone Depleting Substances, Semiconductor Manufacture, Electrical Transmission and Distribution, HCFC-22 Production, Production and Processing of Aluminum and Magnesium
PFCs	12,200	2,600-50,000		
NF₃	17,200	740		
SF₆	22,800	3,200		

The large quantities of some of these compounds released into the atmosphere are due to societal dependence on fossil fuels for energy production and manufacturing. In pursuit of a complete understanding of the

path that society needs to pursue to achieve a net-zero carbon goal, it is necessary to review the current state of energy needs and dependence.

Petroleum (oil and natural gas) and coal are major sources of energy in many processes. Oil is the main fuel source for transportation worldwide. Recent research suggests that natural gas has a lower life cycle greenhouse gas emission than coal or oil if the leakage of methane is below 3.2% for natural gas power plants. [20] It is also important to note that fossil fuels have a major impact on the economic stability of many countries at the current time. [21] Additionally, carbon is used for the production of many needed goods other than fuels/energy, such as pharmaceuticals, materials, glues, and packaging. But these uses can result in fairly locked-in uses of carbon. Hydrogen, solar, wind, and geothermal do not produce carbon for use in non-energy-based manufacturing; hence, until options, like biomass-based carbon sourcing mature, carbon from fossil fuels, particularly petroleum, will likely be needed for decades into the future.

The need for alternative sources of energy is becoming more important to address the global warming threat, and recent technological developments in energy are emerging to address this need that is spurred on by global policy incentives and company ESG (Environmental, Social, and Corporate Governance) initiatives. In 2019, the United States derived 11% of its energy from renewable energy sources. Since 2000, the use of biofuels, geothermal, solar, and wind energy tripled by 2019. [22] Power storage is an issue with resource-constrained generating power systems such as solar and wind energy. Commercial and utility-scale battery power storage and other emerging power storage systems (such as thermal storage) hold the potential to address this issue. The maturation of these promising technologies will continue which will greatly facilitate reducing GHG emissions across the globe.

1.2 Energy Efficiency

In addition to greenhouse gas emission plans, state agencies are undergoing measures to implement energy efficiency plans to encourage and sometimes mandate reduced energy consumption within their state's jurisdictions. These regulations are considered vital to meeting state and federal decarbonization goals, putting the "United States on a path to achieve net-zero emissions, economy wide, by no later than 2050." In choosing to support energy efficiency, state governors benefit from cost savings, emission reduction, health benefits, workforce development, and improved energy affordability. Improvements within energy efficiency programs reduce the demand for electricity generation, which then lowers power plant emissions. By minimizing emissions, pollutant exposure decreases which greatly aids in health benefits. Approximately 33% of the U.S. population are considered low-income households that live in older, inefficient, homes resulting in high percentages of their income being directed toward energy costs. Energy efficiency improvements would significantly reduce household energy consumption, which reduces the energy cost burdens for low-income households. [23]

Some states have faced difficulty in attempting to implement energy efficiency programs including high up-front costs, workforce gaps, low consumer awareness and prioritization. High up-front equipment costs have led states to implement energy efficiency updates rather than an abrupt change in processes. Experienced candidacy for employment in the energy efficiency sector is minimal, leading to employers struggling to hire viable candidates. State officials have the opportunity to introduce energy efficiency plans in an effort to create jobs, reduce energy consumption, and prevent pollution, all while providing affordable rates and increasing access to energy efficiency for lower income households. [23]

American Council for an Energy-Efficient Economy ranked State Energy Efficiencies based on energy efficiency policies and programs that involve energy savings and promote environmental and economic benefits. In addition to the following scorecard rankings, each state received a performance evaluation detailing possibilities for

reductions in energy burdens via changes in transportation, building plans, industry processes, state government initiatives, and appliance standards.

Table 2: States ranked based on Energy Efficiency

1. California	11. Washinton	21. Nevada	31. Florida	41. Alabama
2. Massachusetts	12. Colorado	22. Utah	32. Idaho	42. North Dakota
3. New York	13. New Jersey	23. New Mexico	33. Indiana	43. West Virgina
4. Vermont	14. Michigan	24. North Carolina	34. Iowa	44. Ohio
5. Maine	15. Illinois	25. Wisconsin	35. Nebraska	45. Mississippi
6. Rhode Island	16. Hawaii	26. Arizona	36. Arkansas	46. Louisiana
7. Maryland	17. Delaware	27. Tennessee	37. Kentucky	47. South Dakota
8. Connecticut	18. New Hampshire	28. Missouri	38. Georgia	48. South Carolina
9. Minnesota	19. Virgina	29. Montana	39. Alaska	49. Kansas
10. Oregon	20. Pennsylvania	30. Texas	40. Oklahoma	50. Wyoming

2. Climate Action Plan

2.1 Initiation

State-level climate action plans are initiated within the state government and are generally initiated through three main methods: executive order, legislative action, or departmental action. These three methods are found in 33 of the 50 states in the U.S. Among the states with an implemented plan, most state administrations (i.e., governor's initiatives) took the reins of initiating climate action plans via executive orders, with legislative action following as a close second. Departmental action was utilized by only two states. These different points of origin for a climate action plan result in varying levels of scope and depth. Both executive and legislative action result in similar outcomes in accordance with the climate action plan. However executive orders are limited to the resources of the administration, while legislative action can allocate more resources for the development of a climate action plan. [24] Initiation at lower levels within single administrative departments often results in limited climate action plans for a variety of reasons including funding, mission allowance, and expertise resources.

Climate Action Plans typically follow the order of establishing reduction goals in one action, and then establishing a task force to draft the plan in the next (these will both be discussed in greater detail in later sections). Since reduction goals are often established earliest, this section will discuss the different modes of Climate Action Plan initiations as well as the general pattern of GHG reduction goals. Table 3 details state reduction targets, the inventory tools utilized, and each states initiation method.

Table 3: Climate action plan reduction goal targets in reference to states that contain and do not contain three-step plans.

	First Goal 2020-2025	Interim Goal 2030-2040	Final Goal 2045-2050	Inventory Tool	Initiation Method
Arizona [36]		50%		Pathways	Executive
Arkansas [37]	35%	50%		CCS	Legislative
California [38]		40%	80%	Pathways	Legislative
Colorado [27]	26%	50%	90%	EPA	Executive
Connecticut [39]		45%		LEAP	Executive
Delaware [40]	27%			EPA	Executive

Illinois [10]			60%	Bill	Legislative
Iowa [41]	16.50%		50%	CCS	Legislative
Kentucky [31]		20%		CCS	Legislative
Louisiana [7]	27%	45%	100%	EPA SIT	Executive
Maine [42]		45%	80%	SEE	Legislative
Maryland [43]		60%	100%	Pathways	Legislative
Massachusetts [44]	33%	50%	80%	Mass DEP	Legislative
Michigan [45]	27%	52%	100%	CCS	Executive
Minnesota [46]			100%	CCS	Executive
Nevada [47]	28%	45%	100%	EPA SIT	Executive
New Hampshire [48]	20%		80%	EPA SIT	Executive
New Jersey [49]	20%		80%	BEMP	Departmental
New Mexico [50]		45%		EPA SIT	Executive
New York [51]		40%	80%	ClimAID	Executive
North Carolina [52]		70%	100%	EPA SIT	Executive
Oregon [53]		45%	80%	None Listed	Executive
Pennsylvania [54]	26%		80%	ICF	Executive
Rhode Island [55]	10%	45%	80%	LEAP	Legislative
South Carolina [56]	5%			CCS	Executive
Vermont [57]	26%	40%	80%	SDSC	Legislative
Virginia [58]	30%			Moody RMS	Executive
Washington [59]		25%	50%	Economics	Executive
Wisconsin [60]	27%			EPA SIT	Executive

2.2 Executive Orders

State executive orders, like those on the federal level, are policies implemented directly by the governor. The executive order method of initiating a climate action plan can bypass the lengthy legislative processes but can only rely on the departments under the administration's supervision. These orders cannot collect or redirect taxes, so they utilize the resources the departments already have. For example, in 2007, New Hampshire Governor John Lynch signed an executive order that created a task force to develop a climate action plan. This task force was an extension of the Lynch administration's Department of Environmental Services. [25] Executive orders commencing the drafting of a climate action plan are limited by the authority of the departments at the administration's disposal, so they often utilize departments such as the environment-focused departments, though transportation and other industry-based departments have been utilized as well. [26]

Since only the governor is needed to initiate this path to a climate action plan, the process bypasses the lengthy time a legislature may take to pass a law initiating the drafting of a climate action plan. Executive orders often include rules for the creation of a climate action plan, including the creation of a task force. If reduction goals have not already been set by past legislation or executive order, the executive order can either set a series of reduction goals or allot that responsibility to the task force. In the State of Washington's climate action plan development, previous state legislation established limits on greenhouse gases, which the plan designers appended to their own reduction goals. [27] Since executive orders are limited to the timeframe of the governor's time in office, this form

of initiation does come with its time constraints. And these plans may only be impactful as long as future governors support the plan's founding governor's position.

However, legislative and executive combined coordination has occurred. In the case of Colorado, Governor Jared Polis was prompted to order the development of the Colorado Greenhouse Gas Pollution Reduction Roadmap by 2019 House Bill 19-1261, which later established GHG reduction goals in 2021. [28] The bill did not order the development of a plan by the executive, but political alignment allowed for a coordinated effort to develop the Colorado climate action plan. This still followed the pattern of goals being established first. Since a Bill already established the goals, Governor Polis needed only to initiate the drafting effort.

2.3 Legislative Assembly

Legislative action typically follows the same pattern of establishing reduction goals and ordering a task force to draft a plan around those goals. Previous reduction goal legislation or executive orders can also be accepted as a standard. California's Global Warming Solutions Act of 2006 established a target of reducing emissions to 15% below 1990 levels by 2020, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050. After passage, the first climate action plan was released by California in 2008 under the Act. [29]

Some states also passed laws to initiate climate action plans and to regularly update their plans when new information on emissions is available and/or when policies are deemed ineffective or when new emission sources arise. This is unique to the legislative process as it is binding on legislative bodies regardless of administration changes, unlike the case with executive orders. Multiple legislative climate action plans require regular updates and periodic revisions to their plans. Most states with climate action plans are currently using an updated version of their climate action plans. Many do not require this by law, but rather regional initiatives and party platforms push for updates to their climate action plans. The proportion of states of the 32 that currently have climate action plans, approximately 32% still utilize their original climate action plan, and the remaining 69% have updated their plans either voluntarily (27%) or as a law-requirement (73%).

Climate action plans are updated based on new information regarding emissions and policy effectiveness. New Jersey, for example, released an updated climate action plan that included intentions "to release an updated report every three years so that emissions reduction recommendations may continually be reassessed, remodeled, and reprioritized as early objectives are achieved, and newly emerging pathways mature." [30] An updated climate action plan tends to keep the framework and structure of the policy previously established, often reassessing the efficacy of enacted policies and basing policy recommendations on previous policies. As seen in Table 3, most of the states with climate action plans follow the same ideology as New Jersey, in setting performance goals to reach desired emission reduction. As technology, such as zero-emissions vehicles develops over time, climate action plans adapt to include these developments.

2.4 Departmental Action

With two state plans, these climate action plans were drafted within state departments without the prompting of legislative action or executive order. Departments have typically been delegated the drafting of climate action plans, so this initiation follows a similar pattern to the previous two cases while simply skipping those steps. Departmental action cases involve the selection of a task force, the establishment of reduction goals, and the initiation process of community engagement to develop a climate action plan. Climate action plans formed through departmental action appeared in Kentucky in 2011 and Florida in 2019.

Kentucky's Final Report was initiated by the Energy and Environment Cabinet due to beliefs that the US would soon impose greenhouse gas limits. The Energy and Environment Cabinet developed a climate action plan via a secretary-chosen task force, dubbed the Kentucky Climate Action Plan Council. Kentucky's task force also coordinated with the Center for Climate Strategies, to model green energy policies. [31] By contrast, the Florida Energy and Climate Plan (2019) was developed over a decade after the state considered a comprehensive climate action plan. Florida's climate action plan was delegated to the Department of Agriculture and Consumer Services,

Office of Energy. Which limited the start and scope of Florida's 2019 climate action plan. The plan does not provide reduction targets or GHG modeling. Rather, it is "a guide for the Office of Energy and the Florida Department of Agriculture and Consumer Services." [32] Both cases reflect the limitations of this mode of initiation. While the departments were able to skip executive and legislative permission, they were limited to the resources of their department, especially in Florida.

2.5 Reduction Goals

Climate action plans implement various forms of reduction goals that the recommended policies are seeking. The most broadly used reduction goal discussed in this paper is a decrease in GHG emissions per year by a certain percentage relative to the emissions of a specified reference year, normally expressed as "reducing GHG emissions by x% below 20XX emissions." Reference years are typically selected based on relevance to climate change. The most common reference years for emissions are 1990 and 2005. The Year 1990 finds its precedent within the Intergovernmental Panel on Climate Change Emissions Assessment initiated in 1992, serving as one of the foundational documents of climate change policy. [33] This baseline year was further utilized in the 1992 Kyoto Protocol, cementing itself as a baseline year for emissions reduction recommendations. [34] The reference Year 2005 has precedence in Obama-era climate change policy because it was a high emissions year for the United States. [35]

In 21 of the 33 climate action plans researched, reduction targets were presented in a sequenced series that are time-based (years). In 11 of the 21 climate action plans with series reduction targets, reduction targets were split into three parts. Comparison of these emission targets revealed three common date ranges as a three-part reduction goal: 2020-2025, 2030-2035, and 2045-2050. These similarities applied even to states without a three-fold reduction target. As such, all state reduction targets were included in Table 3 regardless of whether the climate action plan followed the three-part reduction target or not. All percentages are set relative to the reference years. The climate action plans with a reduction target of "net-zero" or "carbon neutral" are considered to have a 100% reduction of emissions from the reference. Varying levels of reduction were witnessed between different regions across the United States, of which could be in reference to different emission types, and carbon sequestration exploration. Some states contain higher levels of industrial plant emissions, such as those in the southeastern regions, while transportation systems may generate higher levels of emissions in the east in comparison to the westward regions. Information regarding each states key social, environmental, and economic priorities is commonly provided in relation to the contextual information of the goals within the climate action plans. Relevant national, regional, and local laws are also commonly provided to support the stated regulations to be put into place.

Table 3 is meant to show the average three-part phase-out of emissions, as well as the average rate at which states expect to be able to reduce emissions. Some states seek only to reduce emissions to the point of a certain reference year, showing either a reluctance or a lack of state capacity to change course. On average, it was found that climate action plans seek to reduce GHG emissions by 21% from a given baseline by 2023, 45% by 2032, and 84% by 2050. The roadmap for mitigation and adaptation actions highlight climate targets, goals, and benefits for other state specific priorities.

3. Task Forces

From legislation or executive order, a lead for the climate action plan is delegated the task of assembling a task force. If the state government has a department or office in place that collects GHG emissions data, the secretary is often chosen to convene the task force. [61] These leaders assemble the task force to create the climate action plan. The members selected are crucial to creating an effective climate action plan. The majority of the climate action plans include a diverse group of individuals, including government officials, environmental organizations, business leaders, academics, and technical experts. Each of the stakeholders provides different viewpoints for constructing the plans and implementing strategies to reduce greenhouse gas emissions. [47]

The appointed organizer can choose individuals from within the government, convening representatives from across state departments such as energy or transportation, invite experts from industry, and/or they can reach into the communities for members. Aside from government officials, the task force is typically composed of a diverse group of stakeholders including representatives from state agencies, local governments, academia, environmental organizations, and industry, all of which often have expertise in climate policy and sustainability issues. The task force may also include subject matter experts, such as scientists or engineers, who can provide technical expertise on climate-related issues. In recent climate action plans, such as California's 2017 plan, environmental justice committees were included within task forces. These groups represent communities directly impacted by climate change emissions, especially minority racial or ethnic groups that live near industry centers. [51]

Task forces generally determine the entire drafting of the climate action plan, including the background research necessary to initialize the report and the emission modeling tools utilized to sell their recommendations to policymakers. With some groups, facilitators and advisory groups have been used. Following formation, the task force begins convening to initialize plans for a climate action plan. The task force chooses a schedule for meetings with community leaders to discuss potential policies, analyzes policy impacts using emissions modeling techniques, and decides what is to be included and excluded in the final draft of the climate action plan. The formation of the task force is critical to the climate action plan creation process, which makes its importance impossible to overstate. [61] By bringing together a diverse group of stakeholders with expertise in climate policy and sustainability issues, a task force can develop a comprehensive and inclusive plan that reflects the priorities and concerns of a broad range of stakeholders.

4. Modeling Systems

One crucial component of the formation of the climate action plan is deciding on modeling tools to use with policy analysis, technical goal setting, and evaluating methods to achieve goals. Tools range from climate simulators with economic inputs to equations for emission estimations. The tools often focused upon will be those used to measure emissions or their impacts, such as flooding, droughts, and storms. Some focus on net GHG reductions via simulated implemented technologies (i.e., replacing coal power generation with solar energy, hydrogen utilization in place of natural gas, and/or the use of CCS as a means of reducing net emissions). Though they are important for weighing the costs and benefits of the policy, economic modeling tools, such as those used to calculate job sector growth or decline due to climate policy, and/or switching energy source switching scenarios. The modeling tools in focus are emission inventory, inventory modeling, and trajectory modeling. Emissions modeling is further divided into tools that track past and future emissions. Some of these models are available free of charge; however, care should be taken as to the accuracy and technical competency of the model developers and/or sources. Sometimes, the development or model management source may come from groups with some level of policy/end-goal bias. Each state does not follow a specific format or a guided outline when publishing their climate action plans, thus each planned trajectory is dependent on a variety of elements including demographics, specific economic growth, city planning, transportation, energy systems, costs, etc. There is not a singular specific approach to climate action planning, thus many states design their own flexible framework that is compatible to their industrial growth, transportation systems and technological progress.

4.1 Emissions Data Sources

Most states used four sources for emission modeling: federal government research, local research, regional research, and consultant firms. A significant overlap is found between federal government research and local research since local research often relies on federal government research. However, since local research tends to add additional data on top of federally recorded data, they have been denoted as separate entities. Some states also used multiple sources for greater accuracy.

4.1.1 Federal Government Research:

This category contains two major sources of emission-related data: the US Environmental Protection Agency (EPA) and the US Department of Energy's Energy Information Administration (EIA). The EPA gathers emission data for each state based on its data collection. The EPA also hosts its emission inventory tool, called the State Inventory Tool (SIT), which provides default data on state inventories and allows states to input their emission data for localization of data on a state-by-state basis. Many states also use data from the EIA, which hosts its system called the State Energy Data System (SEDS) that tracks state energy usage. States such as Rhode Island and Vermont used SEDS as a supplement to EPA data. These sources were often used in tandem for greater accuracy. [62]

4.1.2 Local Research:

Local research sources are from state departments and state-based university research programs. State departments tend to have their emission reporting process for emission sources within their state. This data is often supplemented with EPA data or fed into the SIT system to create emission inventories and is often paired with EIA data. University research programs also follow a similar process, such as research from Colorado State University for New Mexico, and Louisiana State University at Baton Rouge for Louisiana. Both universities used EPA and EIA tools and data in addition to their research and analysis to output past and future emissions. [63] These federal model sources tend to be used to estimate state-level GHG inventories.

4.1.3 Regional Research:

Two regional organizations were sourced by the states studied containing climate action plans: the Northeastern States for Coordinated Air Use Management (NESCAUM) and the Western States Air Resources Council (WESTAR). Considering emissions do not respect state boundaries, regional discussions on policy are mutually beneficial to all states involved. These groups coordinate emissions data collection across state borders and potential shifts in emissions due to coordinated policy change. Various regions of the US face different impacts of climate change, thus greenhouse gas emissions are addressed respectively. These groups can also account for emission outsourcing, where major emission sources move from one state to another based on policy changes. These groups also provide a level of consistency for emission reporting in their region. [64, 65]

4.1.4 Consultant Firms:

Some states outsource data collection, inventory, or trajectory to various consultant firms, which are companies dedicated to policy analysis in a particular field. Such firms are private and as such, are incentivized to conceal certain trade practices for competitive purposes. Consultant firms often appeared within inventory modeling and trajectory modeling.

These emissions data sources were used every step of the way, from inventory modeling to trajectory modeling. They provide data to evaluate both the extent of the problem and forecast how various changes to energy policy and/or technology use may impact the movement toward carbon neutrality. This is further discussed in subsequent sections of this paper.

4.2 *Inventory Modeling*

All climate action plans are initialized with research of their past and current emission levels, known as emission inventory or greenhouse gas inventory. These inventories represent past GHG emissions over several

years. Emission inventories act as the baseline to which emissions trajectories of certain policies are compared. They inform policymakers of the urgency of emissions within their state as well as point to specific sectors where the most attention is needed. These sectors typically include electricity production, agriculture, transportation, and industry. [66] Most inventory reports are measured as net GHG emissions, though many states lack sufficient data on their carbon sinks, such as forests or swampland, and therefore data on net emissions are incomplete. Sometimes model default numbers for that state are used.

Inventory modeling sources are split into the categories listed above federal, local, regional, and consultant firms. Some climate action plans detail the use of multiple sources, while some do not. The most common sources represented in climate action plans were federal inventory research tools and local research. EPA data was most often paired with EIA data and state-level research. Most states compiled their data into a state inventory tool. Further, both instances of university inventory research utilized EPA and EIA data. Considering their accessibility and established presence within the federal government, the EPA and EIA have the most influence over emissions data available to states. [67]

4.3 Trajectory Modeling

Following the calculation of the states' emission inventory, task forces calculate future emission levels under a variety of technology and policy implementation scenarios. This is formatted as a projected inventory, having the same characteristics and sector divisions as a historical emissions inventory. The data are often based on past and current emission trends. These projections often take two forms within climate action plans: business-as-usual and policy-specific projections. Business-as-usual refers to projections in which the state implements no new climate policy. This is essentially a "worst-case scenario" line, as it shows unabated future emissions. Policy-specific projections focus either on a suite of policies being implemented or a single policy's impact on emissions. Technology adaptation and/or use reduction track policy changes. These allow policymakers to compare current trajectories to potential trajectories with suggested policies from the climate action plan.

Policy-specific projections are also important due to their allowance for policymakers to compare the costs and benefits of various policies and technologies implemented, as well as gauge the effectiveness of certain options. [62] Both projections are critical to contextualizing climate action plans as well as gauging their long-term effectiveness. Trajectory modeling sources are split into the categories of College Research, State Research, Consultant Firms, and Varying Conventional Methods. Consultant firms were sourced most at 85% of the trajectory modeling sources. Calculating future emissions for sector-specific emissions or emissions cut by certain options is much more complex than aggregating past emissions data. While there are certain projection models available to states, outsourcing this task to consultant firms specializing in emissions data projection is more common. A handful of states utilized local college expertise, and New York specifically developed their software platform called ClimAid. [51] This is rare. By contrast, there were 27 uses of consultant firms across the states studied. Figure 1 below further breaks down consultant firm usage into specific firms.

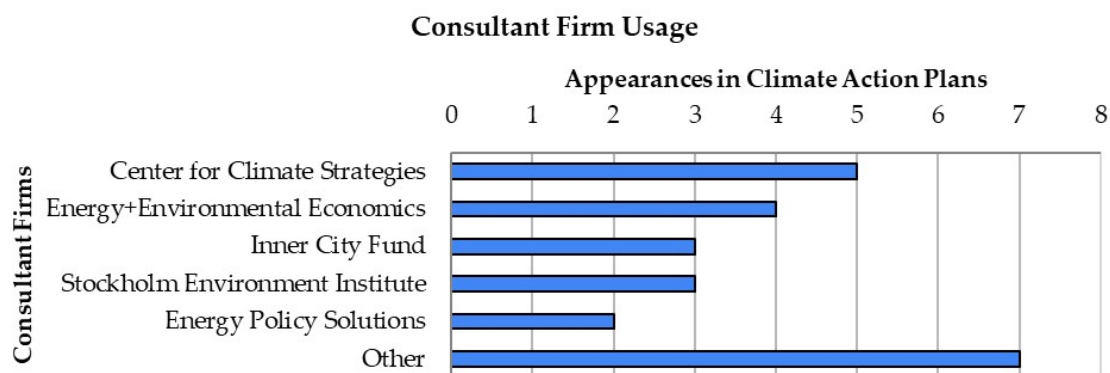


Figure 1: Consultant firm usage in Trajectory Modeling for Climate Action Plan

While most climate action plans used consultant firms unique to them; however, a few firms appeared multiple times: the Center for Climate Strategies, Energy + Environmental Economics, the Inner-City Fund, the Stockholm Environment Institute, and Energy Policy Solutions. It is noteworthy that some of these firms are tied to specific climate action goals.

4.4 Modeling Software

Each climate action plan, with the exception of Oregon, details its emission goals using modeling software, or base projections on existing economics. Of the 33 climate action plans, 9 states utilized the EPA's State Inventory Tool or SIT to detail their climate action plan targets. The SIT is designed as an interactive spreadsheet that provides preloaded default data with allowable customization to detail transparency for each state's custom needs and requirements. The annually updated spreadsheet is available for immediate download to the public and details results in tabular and graphical formats. [62]

Seven states utilized the Center for Climate Strategies (CCS) as their basis for emission goal projections. CCS works alongside a state task force to develop and implement smart solutions for climate change providing economic and governmental outlooks for future climate projections. The Center for Climate Strategies compiled its team of analysts, consultants, and project managers who are representatives of universities and organizations, to tackle the issues related to climate change and environmental security. [68] Three states utilized the PATHWAYS Model to detail emissions goals within their designated climate action plans, which were designed and distributed by Energy + Environmental Economics, otherwise known as E3. The PATHWAYS Model identifies greenhouse gas emission reduction measures via a broken-down outlook of individual emissions for each industrial sector: transportation, buildings, electricity, etc. The models detail realistic timelines of investments made to minimize emissions and their impact across an extended period. [69]

Three states utilized the International Climate Fund (ICF) as a means of detailing emissions goals within their climate action plans, which were designed by the Department of Energy and Climate Change in the United Kingdom. The International Climate Fund assists countries that are adapting to climate change, adopting low-carbon growth, and tackling deforestation. The priorities include the ability to demonstrate the feasibility of low carbon climate growth at higher scales, the ability to support international negotiations regarding climate change efforts, and the ability to drive innovation and ideas for future organizations pursuing climate change efforts. [70] Two states utilized the Low Emissions Analysis Platform (LEAP) as the software system to detail energy planning and climate change mitigation. As a planning tool, LEAP is a free, user-friendly system utilized at a variety of levels ranging from city climate plans to global applications. [71] The remaining 9 states either designed their form of climate change using existing economics or formulated plans based on their state needs and requirements. For example, New York detailed their model, ClimAid, as a tool to provide information on the state's ability to adapt to

climate change noted as an *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*. [72]

5. Summary

In response to the need for climate action, over half of the states within the United States of America have committed themselves to plans with detailed goals and objectives to minimize global carbon emission levels. Numerous plans are continuously updated, with developments made to better respond to and predict technological advancements. Serving as a benchmark for states to quantify their progress toward limiting greenhouse gas emissions, climate action plans provide an understanding of the effects of industry and their methods as a collective force to minimize carbon emissions. Many plans detail an outline of current and past state emissions, to detail the need for change, which serves as a baseline for future objectives and goals to take place. Climate change involves the collaborative efforts of scientists, policy makers, stockholders, and the population, to effectively reach net zero.

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Key References:

- "Overview of Greenhouse Gases," USEPA, 2023.
 - Greenhouse gases have a largely negative impact on the climate, and emission levels are heavily studied in terms of atmospheric abundance, timeline following release, and ultimate impact on the environment. This article greatly summaries the difficulties for controlling each of the main greenhouse gases, and their effect on the atmosphere.
- ☒ R. Lindsey, "Climate Change: Atmospheric Carbon Dioxide," Climate.Gov, 2023
 - Carbon Dioxide is the largest greenhouse gas emitted into the atmosphere via fossil fuel burning. This article details the historic increase in carbon dioxide over time, as well as the current efforts to minimize emissions and remove carbon dioxide in the atmosphere.
- ☒ "Renewable Energy Explained," EIA, Washington, D.C., 2023.
 - Renewable resources are of the utmost importance due to being inexhaustible and having less of an environmental footprint in comparison to fossil fuels. This article details the importance of implementing renewable resources in the energy sector, ultimately reducing greenhouse gas emissions.

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