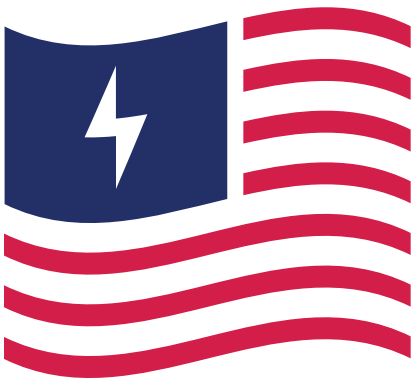

America's ZERO CARBON ACTION PLAN

The Zero Carbon Consortium

2020

Executive Summary

Climate change represents a profound policy challenge to America and the world – requiring a response at a sweeping scale and with unprecedented speed centered on remaking the energy foundations of our society. The move to a clean and renewable energy future must be advanced at the same time America works to recover from the most serious pandemic in a century and the parallel economic collapse triggered by Covid-19. The Zero Carbon Action Plan (ZCAP) presented in this document responds comprehensively to this multidimensional policy imperative.

As spelled out below, the ZCAP lays out a strategy for putting Americans back to work building a vibrant 21st century U.S. economy based on advanced technologies, good jobs, clean energy, climate safety, and economic security. It offers a pathway to achieve net-zero emissions of greenhouse gases by 2050 – thereby providing a basis for a dramatically ramped-up American contribution to the Paris Climate Agreement. The ZCAP agenda would promote efforts to limit global warming to 1.5°C, the ambitious goal that the 2019 Intergovernmental Panel on Climate Change Special Report tells us that society should adopt to avoid the worst effects of global warming including sea level rise, increased hurricane damage, and changed rainfall patterns that might dramatically affect agricultural productivity as well as resulting in more floods, droughts, and wildfires.

Taken as a whole, the ZCAP would position America as a climate change leader and provide a basis for holding other countries accountable for climate safety as well. Carefully structured to be economically efficient as well as environmentally effective, the ZCAP would spur innovation and investment, generate millions of new jobs, and ensure that American industry will not be undercut by polluting competitors abroad. It thus offers a comprehensive climate change policy strategy with both domestic and international dimensions.

In the following pages, decision-makers will find a clear outline of the technologies, investments, and policies needed to achieve net-zero carbon emissions by 2050. Building on the results of an in-depth energy infrastructure modeling exercise, this policy action plan is based on a rigorous technical quantification of the infrastructure upgrades and technology investments needed in our buildings, power, transportation, and industrial sectors. Furthermore, this plan demonstrates that not only is this energy transition possible, but it is feasible and affordable. In fact, the overall incremental costs of the transition will be just 0.4 percent GDP in 2050, a small fraction of America's annual energy spending.

The ZCAP draws from and expands upon two prior Sustainable Development Solutions Network (SDSN) reports, *Pathways to Deep Decarbonization in the United States* (2014) and *Policy Implications of Deep Decarbonization in the United States* (2015). It outlines in detail what needs to happen to maximize the gains and minimize the costs of the required energy transition. It promises economic vitality and robust job growth while reaching net-zero emissions by 2050.

The ZCAP builds on carefully structured technological analyses and transition pathways that demonstrate the feasibility of reaching zero emissions by 2050. It presents detailed background analyses of key sectors and covers all regions of the country and all major elements of our energy system.

The action items identified build on technologically and economically sound options and fit within the institutional framework of the U.S. federal system – with important roles for state and local governments as well as federal authorities. It offers a mix of top-down direction and bottom-up implementation with an emphasis on government leadership and private sector participation.

The ZCAP promises strategies of widespread experimentation, active learning, and adaptive management in the years ahead – as a way to build on the innovation capacities of both the private and public sectors as well as the creative spirit of the American people. It provides a path forward that allows federal, state and city governments to act ambitiously despite uncertainty, addressing risks with the promise of flexibility.

The ZCAP policy framework has been designed with an economic logic, analytic rigor, and political appeal that can win majority support with the public throughout the entire country and across party lines. It offers a basis for addressing the needs of the economic sectors, communities, and people who might be dislocated by the transition to a low-carbon future. Thus, while advancing a deep decarbonization agenda, it aims to provide for a just transition and promises economic opportunity for all Americans in the decades ahead.

The Zero Carbon Action Plan centers on the six major energy-producing and energy-consuming sectors:

- power generation;
- transportation;
- buildings;
- industry;
- land use for agriculture, forestry, and other purposes; and
- materials.

These six sectors account for almost all of U.S. CO_2 emissions. The analysis offered in support of the ZCAP focuses mostly on CO_2 emissions but also highlights the importance of other greenhouse gas (GHG) emissions including methane, nitrous oxide, and various industrial gases. Because CO_2 emissions account for 81 percent of overall U.S. emissions, any serious plan for climate neutrality by 2050 (that is, zero net emissions by 2050) must center on CO_2, but not ignore other GHGs.

The key components required for the new green-growth model presented in this document include: (1) Rapid upscaling of renewable energy; (2) Electrification; (3) Transition to hydrogen, advanced biofuels, and other clean fuels; (4) Sustainable forest and agricultural lands; (5) Reduced material wastes through Sustainable Materials Management; (6) Rejuvenation of the industrial heartland of America with a special focus on the Appalachian Region and the Midwest; (7) Government-backed financing, investments, and regulatory support; and (8) a national Research, Development, Demonstration and Deployment (RDD&D) strategy.

The ZCAP offers a framework for large-scale change that has four core elements. The first element is *technological*. The U.S. economy requires deep technological changes to continue defining the forefront of new global industries. The strategy of this plan is based on regulations and market incentives to promote high-speed innovation and rapid adoption of zero-emission technologies.

The second core element builds on *American federalism*. Large-scale change must rely on clear national goals, supported by the cooperative efforts of federal, state, and local governments with an appropriate division of labor among the levels of government and between the public and private sectors. Success in delivering on the ZCAP vision and building a resilient clean energy economy will require a national effort and the participation of all Americans.

The third core element is *foreign policy*. The U.S. share of global GHG emissions is currently around 15 percent. The world's climate future depends on global actions, not just the actions of any one country alone. The proposed new U.S. energy strategy must therefore include a strong foreign policy dimension, so that what happens domestically is matched and magnified globally. The United States must not only rejoin the Paris Climate Agreement, but also help to lead the world toward decarbonization at the needed pace.

The fourth core element is a 21st century *industrial policy* – using the heft of the U.S. government to promote new high-tech industries and advanced technologies as has been done successfully in many other areas that promised important economic prospects -- including advanced semiconductors, the space industry, the Internet, and biotechnology.

Energy and Infrastructure Pathways

The ZCAP strategy for transitioning from a high-carbon to a low-carbon energy system builds on three main pillars: (1) using energy more efficiently; (2) decarbonizing electricity; and (3) switching from fossil fuel combustion to electricity in most current uses. The underlying analysis recognizes that reaching net-zero or net-negative emissions requires an additional pillar: (4) carbon capture. Whether captured carbon is stored geologically or used to synthesize fuels depends on societal choice and relative economics.

The ZCAP team – including nearly a hundred researchers from dozens of research centers, academic institutions, think tanks, and other organizations -- developed six scenarios for meeting the net-zero target while meeting the same demand for energy services as the baseline reference scenario based on the Department of Energy's long-term forecast, the Annual Energy Outlook (AEO). The six scenarios include: a Central case (least cost); Limited land; Delayed electrification; 100 percent renewable primary energy; Low demand; and Net negative. The key finding across these scenarios was that while technology options change among the scenarios after 2030, as cost uncertainty increases and conditional variables reduce technological options, the scenarios aligned on key technology options within the first decade of action as described below.

The scenarios were modeled using two sophisticated analytic tools, EnergyPATHWAYS (EP) and RIO, which provide a high level of detail in sector (more than 60 subsectors), time (annual turnover of equipment stocks plus an hourly electricity dispatch), and geography (16 different regions of the United States, modeled separately).

This study focuses on how to eliminate CO_2 from the use of fossil fuel for energy and industrial feedstocks, which constitutes more than 80 percent of current U.S. GHG emissions. The scope of this analysis does not include negative CO_2 emissions from the "land carbon sink" or the emissions of non-CO_2 GHGs such as methane and nitrous oxide. Combined, these currently have net emissions of about +500 MMT CO_2e. Mitigation in these areas, from a combination of increasing the sink and reducing non-CO_2 GHG emissions, will be needed for total U.S. GHG emissions to reach net-zero or below, even if the energy system by itself is carbon neutral. Suggestions for doing so are covered by our chapters on the federal framework, land use, and materials.

In the modeling results, the shares of fossil fuel in the primary energy supply decrease dramatically from today's level -- replaced mainly by power from wind, solar, and biomass. Under the ZCAP strategy coal, which has a very high carbon content per unit of energy, is eliminated entirely. Natural gas (~75 percent reduction) and petroleum (~90 percent reduction) are reduced to niche roles including industrial feedstocks, certain forms of transportation, and a limited amount of natural gas power generation needed to maintain reliability in an electricity system composed primarily of wind and solar generation. Electricity increases to meet 50 percent of end-use demand, with zero-carbon drop-in fuels providing most of the rest. Conversion processes that play a minimal role today – advanced biofuel refining, and the production of hydrogen and synthetic fuels from electricity – become key components of a carbon-neutral energy system. CO_2 emissions from the small remaining fossil fuel use in energy and industry are captured directly or offset using carbon capture and storage.

Despite all of the heated debate surrounding the energy transformation, the ironic fact is that the incremental cost of running the U.S. economy on clean energy as opposed to fossil-fuel energy is very small. We find that as of 2050, the clean-energy economy costs only 0.4 percent of GDP more per year than the fossil-fuel economy. In other words, for less than one-half of 1 percent of GDP, we can fundamentally shift to a clean energy foundation for our economy – and thus avoid climate disaster.

Implications for Key Sectors

The single most important transformation occurs through the decarbonization of power generation, which accounts for around 32 percent of total CO_2 emissions from energy and industry in 2019 (see Table 1.1). The ZCAP analysis anticipates a major shift to wind and solar energy -- with continued production from other zero-carbon sources, notably nuclear and hydropower. For purposes of maintaining electricity system reliability, a substantial fleet of gas-fired power generators needs to remain in place in 2050, roughly comparable to today's level of capacity. However, these generators will run much less often than they do at present, comprising only a few percent of total electricity generation.

The **transportation** sector includes light-duty vehicles, heavy-duty vehicles (trucks), off-road vehicles, buses, rail, shipping, and aviation. Transportation emissions accounted for 37 percent of total CO_2 emissions from energy and industry in 2019. The principal strategy for decarbonizing transportation is electrification (including battery, plug-in hybrid, and hydrogen fuel cells) of all light-duty vehicles, urban-based trucks and buses, rail, much of long-haul trucking, and some short-haul shipping and aviation. For long-haul aviation and long-haul ocean shipping, advanced low-carbon biofuels and synthetic liquids or gases produced with renewable energy are the leading energy contenders. The second strategy builds on initiatives to reduce vehicle use and miles traveled while enhancing accessibility to health, education, jobs, and other services for the mobility disadvantaged. This transition will require a variety of actions by federal, state, and local governments as spelled out in detail in the report that follows.

Buildings, both residential and commercial, account for 12 percent of direct CO_2 emissions. Buildings built between now and 2050 will comprise 30 percent of the building stock in 2050, making low-carbon buildings an essential element of any deep decarbonization strategy. In this regard, the ZCAP proposes a new National Energy Code for Buildings (NECB) to ensure that new buildings constructed after 2025 will not burn fossil fuels onsite, will be highly energy efficient, and will be constructed using low-carbon techniques and materials. The NECB and federal appliance standards should also ensure that replacement equipment and appliances in existing buildings will be energy efficient and largely electrified.

Industry accounts for 20 percent of CO_2 emissions from energy. A relatively large share of industry emissions from light industries such as manufacturing of durable goods, food and textile processing, and even mining and non-ferrous metal production may be avoided by coordinated efficiency improvements, electrification, and decarbonization of electricity generation. Other industries – such as iron and steel, cement, and feedstock chemicals – are of particular interest in a decarbonization context precisely because their conventional production processes entail emissions that are difficult to avoid and their capital infrastructure tends to be long-lived. Fortunately, even for these sectors, there are technical solutions available such as carbon capture and storage (CCS) at industrial facilities, hydrogen, supplementary materials and fillers, and other synthetic fuel replacements and substitutions.

Land use policies impact every aspect of the transition to zero greenhouse emissions, including: siting of renewable energy, next generation biofuels, reforestation, soil carbon, and emissions from agriculture and livestock. The complexity of policy choices in this area will require new efforts at RDD&D, new inter-agency planning, and enhanced cooperation of all levels of government with each other and with impacted communities.

Finally, the ZCAP calls for a new national framework for Sustainable **Materials** Management (SMM) and a Circular Economy (CE) based on the pillars of "reduce, reuse, recycle." Much of the negative climate impact in the United States comes from the materials and food consumed. This includes the entire materials supply chain, from manufacturing, transportation and usage, to final disposition of materials. An integrated SMM and CE approach would help to reduce pollution, drive job creation, spur energy efficiency, and lower GHG emissions. SMM and CE objectives should thus be incorporated into a range of federal policies as well as free-trade agreements and the work of international organizations.

Job Creation and an Equitable Transition

By comparing the investment patterns of the main *central scenario* and baseline *reference scenario,* and then using an Input-Output analysis, we can estimate the number of new jobs created net of the jobs that will be lost in the fossil-fuel-related industries. The full set of investments to achieve a net zero emissions U.S. economy between 2020 – 2050 will generate about 2.5 million jobs per year, considering jobs created through "direct" channels, such as manufacturing electric cars, and "indirect" channels (i.e., jobs along the supply chain to manufacture electric cars). Over four million jobs per year will be created if we also include jobs generate through "induced" channels (i.e., multiplier effects of newly-employed workers spending their earnings). Government policy at all government levels should commit to industrial policies that will support domestic clean energy investments, especially in manufacturing. Effective industrial policies can increase total job creation by up to about 10 percent.

Public policy at all levels should commit to ensuring that that the jobs created through clean energy investments are high-quality in terms of wages, benefits, and working conditions. Strong labor unions and effective job training programs are both necessary to promote high-quality job opportunities and support a just transition. Since climate change affects people and communities of color in distinct and significant ways, policies to reduce GHG emissions and other pollutants should be crafted and implemented with engagement of those most affected. Attention to procedural fairness as well as substantive equity can also help to ensure that women and people of color have equal access to the emerging clean energy jobs. These groups are currently underrepresented in all areas of the U.S. energy sector.

The federal and state governments should also enact *just transition* policies for workers and communities that are currently dependent on the fossil-fuel economy. About 12,000 workers per year in the coal industry will face job displacement between 2021 – 2030 as the coal industry is phased out as of 2030. About 34,000 workers per year in the oil and gas industry will face displacement as oil and gas are significantly phased down between 2031 - 2050. All displaced workers should receive pension and re-employment guarantees, as well as generous income, retraining and relocation support. The combined overall cost of such a generous program will be modest. Fossil-fuel dependent communities should receive major federal and state-level support to reclaim and repurpose land and generate new investment projects, including in a range of clean energy areas.

Key Federal Actions in 2021 should include commitments to:

- Rejoin the Paris Climate Agreement and establish a new and stronger Nationally Determined Contribution for U.S. greenhouse gas emissions – including the goal of net-zero or net-negative anthropogenic GHG emissions by 2050 and an updated interim goal for 2030.
- Adopt a Zero Carbon Action Plan by legislation committing the nation to net-zero GHG emissions by no later than 2050.
- Require a Presidential report to Congress in January 2022 that provides a detailed roadmap to put the country on the path toward carbon neutrality by 2050.
- Invite the Department of Energy, Environmental Protection Agency, Department of Transportation, and other relevant agencies to translate the Zero Carbon Action Plan into intermediate and sector-specific emissions reduction goals and timelines for power, transport, industry, buildings, land use and materials, and a process for updating such goals.
- Establish a White House Office on Climate Change to coordinate federal agency climate-change activities for both mitigation and adaptation, and to the extent authorized by law, direct the development of plans, establish program metrics, track progress, and otherwise oversee these activities.
- Provide funding for the first four years of the ZCAP at a minimum of $2 trillion and provide long-term mechanisms for adequate future funding, including federal support for state and local actions.

- Enact a national clean energy standard for electricity to reduce emissions compared to the present by at least 60 percent by 2030, 80 percent by 2040, and >95 percent by 2050.
- Accelerate the transition to electric cars, trucks, buses, and other vehicles through the implementation of new vehicle performance standards, expansion of the incentives for zero-emissions vehicle purchases, and investments in electric vehicle charging station infrastructure.
- Establish a mechanism by which states, territories, and tribes specify how they will achieve their specific Zero Carbon Action Plan milestones.
- Make operational through procedural and substantive commitments the principle that environmental and jobs benefits of the energy transition are to be shared equitably in terms of geography, race, gender, and ethnicity – thereby ensuring that disadvantaged communities benefit fully.
- Invest directly in key parts of the national energy system, including inter-state power transmission, public land use for power generation, and supporting infrastructure.
- Launch innovative green financing mechanisms, such as government guarantees for green bonds, tax incentives on utility bonds for renewable energy, direct equity, and funding of state-level green banks.
- Promulgate new Securities and Exchange Commission (SEC) reporting requirements that require disclosure of climate-change-related risks and broader Environmental/Social/Governance impacts.
- Accelerate, intensify, and fully fund research and development for zero-greenhouse-gas emitting technologies, energy efficiency technologies, and carbon removal technologies.
- Clarify the National Environmental Policy Act (NEPA) requirement that all federal action should be undertaken with an eye toward environmental impacts.
- Each federal agency should exercise its existing powers and duties to contribute to the fullest possible extent to the achievement of the Zero Carbon Action Plan including national climate change goals and with specific emission reduction targets.
- Specify a Social Cost of Carbon or shadow cost of carbon to guide policy formulation and regulatory decision-making as well as to serve as the basis for market mechanisms such as clean-energy subsidies, carbon taxes, feed-in tariffs and auctions, and other market-based instruments that will vary by sector and over time.

Key State Actions in 2021

- In line with the National Clean Energy Standard and the associated goal of net-zero emissions by 2050, all states should prepare Renewable Portfolio Standards (RPS) or equivalent Zero Carbon Energy Standards for the goal of zero-carbon power by 2050. Currently 31 states have RPS of which 8 have the goal of 100 percent renewable energy on or before 2050.
- All states should prepare a comprehensive plan for net-zero GHG emissions by 2050 covering transport, buildings, and industry.
- All states should prepare financing strategies to align with new federal funding programs
- States and cities should implement land use policies that promote densification, transit-oriented development, and complete streets.

Key Local Actions in 2021

- Local governments, working in tandem with state and federal agencies, should prepare local plans for net-zero greenhouse emissions by 2050 covering all local sectors.
- Cities and local governments should adopt building codes and practices that encourage or require zero-emission, all-electric buildings so that all new buildings are 100 percent electric and retrofits for existing buildings are actively underway.
- Cities should align incentives and programs for building retrofits with state climate goals and begin efficient retrofit of existing buildings.

The **Zero Carbon Action Plan (ZCAP)** is a publication of the Sustainable Development Solutions Network. The Zero Carbon Action Plan (ZCAP) comprises multiple sector groups, convened under the auspices of the Sustainable Development Solutions Network United States chapter (SDSN USA). The report was jointly prepared by the Zero Carbon Consortium Chairs and members organized across several working groups.