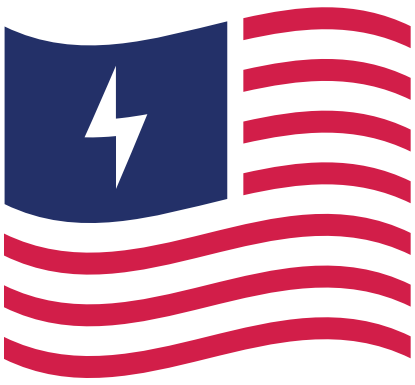

America's ZERO CARBON ACTION PLAN

The Zero Carbon Consortium

2020

4.2 States and Cities for Climate Action

Christian Braneon, NASA Goddard Institute for Space Studies
Cynthia Rosenzweig, NASA Goddard Institute for Space Studies / Center for Climate Systems Research

With Contributions from:

Elena Crete, SDSN; Leila Fanaeian, SDSN; Serpil Guran, Rutgers EcoComplex; Mital Hall, ecoPreserve; Charles Kutscher, Renewable and Sustainable Energy Institute; Kathryn McConnell, Yale University; David Randle, The WHALE Center; Jeffrey Raven, NYIT; Melissa Tier, Princeton University

4.2.1 Introduction

States and cities play an essential role in implementing and innovating decarbonization. Notably, states and cities are already innovating in regard to the Four Pillars of Decarbonization: electricity decarbonization, energy efficiency, electrification, and carbon capture. As the U.S. society undergoes significant transitions in regard to infrastructure, energy economy, jobs, land use, and policy, collaboration and coherence across scales of governance are essential. States and cities are key to the development of decarbonization infrastructure and the implementation of effective policies.

States and cities are also important agents in the mobilization of multiple actors across both the public and private sectors. They have direct contact with key stakeholders for the new energy system, as described in Chapter 2. Key stakeholders include, but are not limited to: federal, state and municipal government agencies, local communities, non-governmental organizations (NGOs), National Labs, policymakers, urban planners, public and private companies, and the scientific community.

Mitigation and adaptation strategies are widely used to frame subnational climate change efforts, and they are often closely integrated. For example, green roofs can both serve as a mitigation strategy to reduce energy use and greenhouse gas emissions, but also serve to cool building inhabitants, and are therefore an adaptation measure as well. Another example is upgrading the insulation of houses and weatherizing for extreme events which also often reduces energy needs and emissions. Actions that reduce greenhouse gas emissions while increasing resilience are win-win. Mitigation and adaptation measures should be made in the context of current resources and technical means of the city or state, community needs, and the Sustainable Development Goals (SDGs).

Disaster risk management is a critical domain at the intersection of mitigation and adaptation. In coastal areas, for example, there is a dual threat of gradual sea level rise and the increasing intensity of more sudden disasters such as extreme precipitation events, hurricanes, and accompanying storm surge. New building stock that is built via circular/regenerative methods, also described in the Buildings chapter, is more likely to both produce zero-to-low emissions (mitigation) and can be designed to be more resilient to future natural disasters (adaptation). Disaster risk management is often coordinated haphazardly across multiple tiers of government and among peer jurisdictions; further case studies and models of how to more successfully link these efforts within a region are urgently needed.

Measures to accomplish deep decarbonization need, at a minimum, to ensure that underserved communities are not disproportionately burdened, but they also offer the opportunity to address long-standing social inequities. Equity[i] fosters human well-being, social capital, and sustainable social and economic development, all of which increase a city or state's capacity to respond to climate change. Policies should include equity and environmental justice as primary goals.

4.2.2 Status of States and Cities

The U.S. federal system allows state and city governments to set policies and targets, design laws and standards, implement financial mechanisms to develop and support markets (e.g., green bonds), and enforce regulatory compliance.[1] The majority of regulatory and siting decisions for utilities, transportation planning, building codes, and other important aspects of energy and transportation decision-making take place at the state and regional levels. Many states and cities have been early adopters of climate action. The U.S. Climate Alliance is one of the best examples of bold state action, with a coalition of 25 states committed to climate action and development of sustainable and scalable policies to enable the green transition.

This sub-national U.S. effort is bolstered by a proliferation of trans-national city networks sharing best practices on climate action, such as C40, ICLEI, and 100 Resilient Cities. Knowledge providers such as the Urban Climate Change Research Network (UCCRN) also play a significant role.[2]

Since cities are a key source of emissions, and global urbanization processes will only increase that trend unless substantial local action is taken.[3] Already, cities emit 70 percent or more of the world's emissions.[4] The bulk of the country's consumption-related carbon emissions can be concentrated in just a few cities; the populations of Chicago, New York and Los Angeles combined account for nearly ten percent of U.S. consumption-related carbon emissions.[5] For U.S. cities, there is a lower household carbon footprint (HCF) in urban core cities (40 tCO_2e) and higher carbon footprints in outlying suburbs (50 tCO_2e), with a range from 25 to >80 tCO_2e in the 50 largest metropolitan areas.[6]

U.S. cities have significant power to take climate action due to their ownership of key assets, their ability to set and control budgets for city functions, and the ability to set their own vision and policy.[7] However, while cities and states are both empowered to undertake many roles in regard to climate action, they do have limited agency in regard to resources and overarching jurisdiction. These limitations can be overcome by a coherent set of policies across city, state, and federal levels.

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i Racial equity is the condition when race no longer predicts a person's quality of life outcomes in U.S. communities. For example, the City of Austin recognizes that race is the primary determinant of social equity; the City recognizes historical and structural disparities and a need for alleviation of these wrongs by critically transforming its institutions and creating a culture of equity.

State Renewable Portfolio Standards

Analysis of U.S. Renewable Portfolio Standards (RPS) in 2013 found economic benefits of an average of $2.2 billion from reduced GHG emissions, and another $5.2 billion in benefits from reductions in air pollutants.[8]

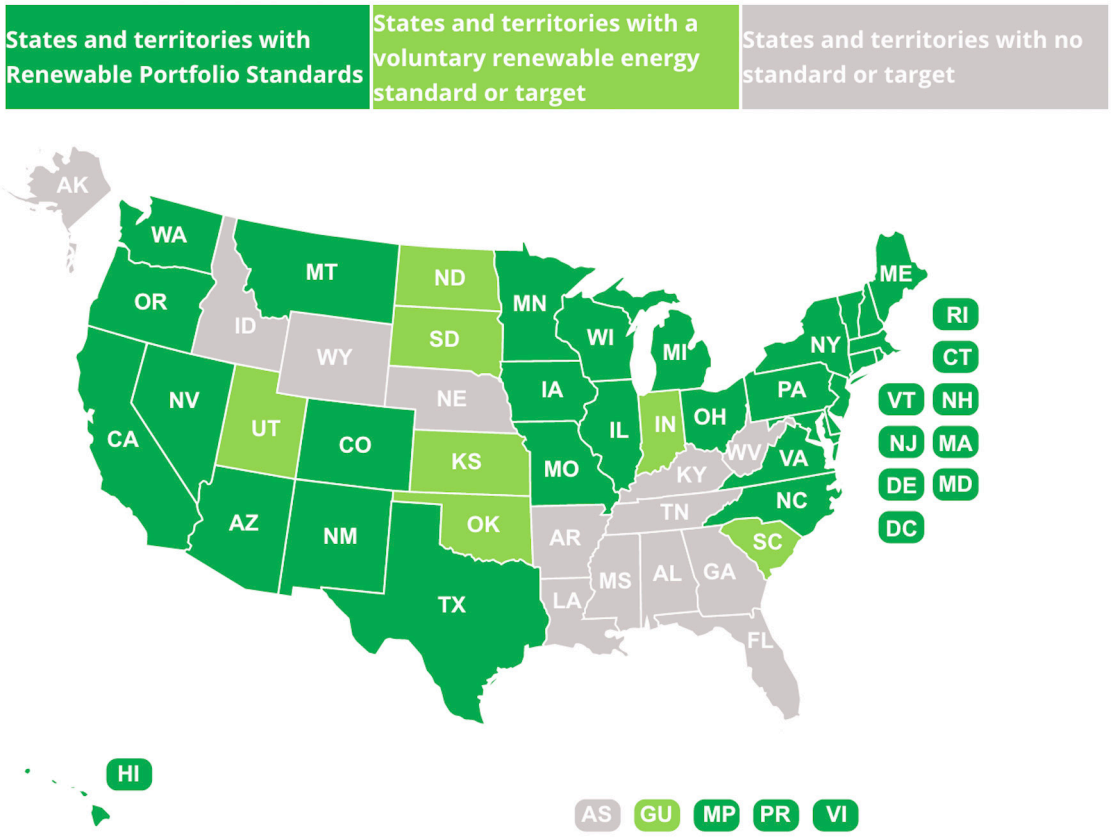

Figure 4.2.1. Renewable Portfolio Standards by state and territory ("State Renewable Portfolio Standards", 2020).

City Climate Action Plans and Legislation

Many U.S. cities have chosen to accelerate their commitment to climate action, adopting the emission goals and guidelines of the Paris Climate Agreement.[9] Following the "We Are Still In" pledges of several C40 Cities and their implementation of climate action goals, mayors of hundreds of cities across the country have followed suit. While cities are committed to upholding the goals of the Paris Climate Agreement, every city has a different approach that works for the specific culture, landscape, and economy of that municipality (see Table 4.2.1).

Table 4.2.1. Climate action plans for selected cities.

City	State	Climate Action Plan
Boston	Massachusetts	City of Boston Climate Action Plan 2019 Update
Boulder	Colorado	City of Boulder Climate Commitment
Dallas	Texas	Comprehensive Environmental & Climate Action Plan
Denver	Colorado	80x50 Climate Action Plan
Los Angeles	California	L.A.'s Green New Deal
Miami	Florida	City of Miami Climate Action Plan
Minneapolis	Minnesota	Minneapolis Climate Action Plan
New Orleans	Louisiana	Climate Action for a Resilient New Orleans
New York City	New York	New York City's Roadmap to 80 x 50
Phoenix	Arizona	2015-2016 Sustainability Report
Portland	Oregon	Local Strategies to Address Climate Change
San Francisco	California	San Francisco Climate Action Strategy 2013 Update
San Jose	California	Climate Smart San Jose
Seattle	Washington	Seattle Climate Action
St. Louis	Missouri	Climate Action & Adaptation Plan Report
Washington D.C.	n/a	Climate Ready D.C.

Case Study - Implementation of Climate Action in California

In 2006, California passed its landmark climate legislation, the Global Warming Act, or Assembly Bill (AB) 32. AB 32 set a total limit for statewide GHG emissions, requiring California to reduce its GHG emissions to 1990 levels, equivalent to 431 $MMtCO_2e$, by 2020.[10] It further mandated the state to address climate change through a long-term transition to a low-carbon and sustainable energy economy, by emphasizing the expansion of renewable energy, clean transportation and energy conservation, as well as energy efficiency improvements, and waste reduction.[11] Accordingly, AB32 focused on four primary energy efficiency programs: renewable portfolio standard, advanced clean cars, low-carbon fuel standard, and carbon cap and trade. While the bill allowed the state to choose from a wide range of possible approaches to achieve these goals, it excluded the implementation of a carbon tax.[12] The California Air Resource Board (CARB) was put in charge as the lead agency to adopt regulations, and the Climate Action Team was formed, encompassing 18 state agencies, to support CARB's efforts.[ii]

ii California Environmental Protection Agency; Governor's Office of Planning and Research; California Air Resources Board; Business, Consumer Services, and Housing Agency; Government Operations Agency; California Natural Resources Agency; California Department of Public Health; Office of Emergency Services; California Transportation Agency; California Energy Commission; California Public Utilities Commission; California Department of Food and Agriculture; Department of Forestry and Fire Protection; Department of Fish and Wildlife; Department of Transportation; Department of Water Resources; Department of Resources Recycling and Recovery; State Water Resources Control Board

Within ten years (2006-2016) California's emissions dropped by around 56 $MMTCO_2e$, allowing California to achieve its 2020 goal earlier than mandated.[13] Most of the reduction of GHG emissions occurred through the electricity sector switching to renewable energy sources. In 2017, 52 percent of California's in-state and imported electricity was generated by renewable energy and zero GHG resources (small and large scale hydropower, solar, wind and nuclear).[14] In contrast, California's biggest contributor to GHG emissions, the transportation sector, has experienced increasing emissions since 2013, although the rate of emissions growth has declined.[15]

According to CARB, this shift in the electricity sector is partly driven by California's Renewable Portfolio Standard (RPS), the Senate Bill (SB) 1368 power plant emissions standard, and the Cap and Trade Program.[16] However, there have been speculations on the program's efficiency in reducing California's GHGs. There has been an oversupply of compliance instruments on the market compared to emissions subject to the Cap and Trade Program for years. This condition, referred to as overallocation, is projected to last until the mid-2020s.[17]

Policymakers tend to promote the Cap and Trade Program as a tool that reduces emissions in an economically feasible manner and strengthens program links of jurisdictions.[18] However, the California Legislative Analyst's Office points out that the state's emissions were below the cap early on in the program (2013 - 2015), indicating that it likely did not have much of an effect, if any.[19] Instead, according to Michael Wara, Associate Professor at Stanford Law School, the biggest impact ascribable to policy generated from reducing emissions has been regulatory programs based on institutional experience.[20]

By setting stringent emission targets and taking a holistic, multi-sector approach, California has been able to progressively reduce its GHG emissions and lower the costs of solar and wind electricity while maintaining a growing economy.[21] California's rich economy creates a unique opportunity to put policy strategies to the test. The state's openness to policy innovation provided context to enable other U.S. states and jurisdictions to adopt successful policies and standards established by California. However, to continue this momentum, it is imperative to close the gap between California's ambitious decarbonization goals and the current implementation level.

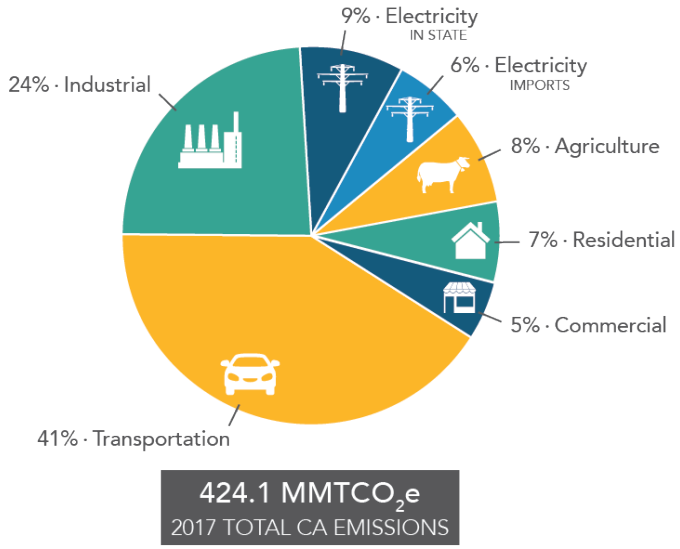

Figure 4.2.2. California's 2017 emissions by economic sector ("GHG Current California Emission Data", 2020).

Case Study - Oakland Park and Wilton Manors, Florida 2019 Joint Climate Action Plan

Municipalities are increasingly establishing their own climate action and resilience plans. A further development, still in early stages, is for local municipalities to coordinate their climate planning efforts as opposed to operating independently. For example, Oakland Park and Wilton Manors – two neighboring cities in the Miami metropolitan area – jointly released a 2019 Climate Action Plan.[22] The mayors of the two cities wrote:

> "We encourage other cities and communities to follow our lead and form collaborative relationships to fight the [climate-related] challenges that would otherwise be tough to do independently... To our knowledge this is the first time two local jurisdictions have joined forces [to write a climate action plan]."[23]

The Oakland Park/Wilton Manors Climate Action Plan stems from the growing recognition that a piecemeal approach to climate action – with each municipality only considering adaptation and mitigation within its own jurisdictional boundaries – is outdated. With southern Florida at an increasingly high risk of flooding due to sea level rise (see Figure 4.2.3), among other climate-related concerns, these two cities are reckoning with a changing reality that urgently necessitates new governance approaches.

This new reality is clearly a motivation, as stated in the Plan's Executive Summary: "With contiguous borders and waterways as well as adjacent water and sewer systems, *city boundaries are irrelevant and artificial for the purposes of climate action*" (p. 4; emphasis added). Good climate governance, for them, means greater regional coordination.

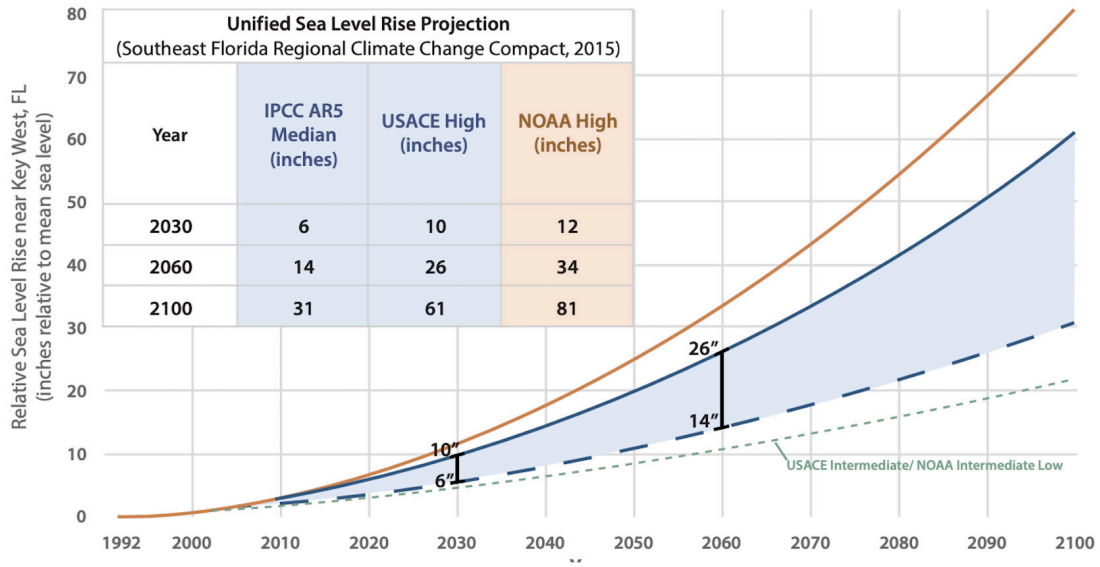

Figure 4.2.3. Sea level rise projections near Key West, FL utilizing regional adaptations of three global curves (Cities of Oakland Park and Wilton Manors, 2019).

The Plan considers transportation, water, energy, and emergency management systems from a joint perspective – encouraging the two cities to remain in conversation with each other to achieve shared goals, while simultaneously recognizing that approaches may differ slightly between them. The many goals listed in the plan prioritize equity and resilience, encourage coordination with higher levels of government, and stress the need for public participation in policy development.

The plan lays out lofty goals, but is light on next steps and milestones. It remains to be seen whether the two cities will be able to maintain their initial level of commitment to regional coordination. Still, if successful, this pilot may well lay the groundwork for other regional municipalities or greater metropolitan areas. Furthermore, states and the Federal Government would do well to champion and even finance such initiatives within and across jurisdictional borders.[24]

Decarbonization Transition and Regional Collaboration

The U.S. is a large country with a vast geography and regional variations in population, climate, culture, and energy demand. Focusing at the state and city levels enables experts to identify best practices and methods that work specifically for that region's resources, existing infrastructure, and economic opportunities.

Low-carbon emission strategy reports have been created for the Midwest and Southwest regions of the U.S., outlining unique critical issues and opportunities for each region.[25] [26] The Midwest focused report shows the region has ample opportunity for carbon capture and storage and to continue as a leader in the production of biofuels, while the Southeast has an abundance of sun exposure and, as a result, renewable energy installations. In addition to regions aligning with the strengths and opportunities the geography provides, collaboration between regions enables the sharing of resources and aid where another region is lacking. For example, the Southeast relying heavily on solar for electricity generation brings challenges to deliver clean energy during hours when the sun is not shining. These challenges are addressed by sharing resources with the Midwest and importing onshore wind from the lower-Midwest when solar energy is lacking.

With a focus on electrification, modernizing the grid and allowing the sharing and transmission of renewable resources within and between regions is crucial. In addition, this modernization of the grid along with the transition from coal to clean energy, and electrifying transportation provides opportunity to grow new industries and create jobs for Americans.

4.2.3 Policy Playbook

Ambitious state and local policy remains essential because federal interventions have their limits. For instance, state and local zoning decisions will drive the smart growth and urban densification policies that are critical for cost-effectively reducing transportation-related emissions and maintaining our terrestrial carbon sink. In the realm of energy policy, states have led the charge on energy efficiency standards, and federal policy has followed suit. Appliance standards were first established in California in 1974, followed quickly by Florida, New York, and Massachusetts. In 1978, federal standards were proposed, though national efficiency standards did not become mandatory until 1987, when the National Appliance Energy Conservation Act was enacted.[27]

State governments are responsible for power generation and within-state distribution – and play a role in coordinating regional grids. State government instruments include public investments, regulation of the utility sector, tax and other incentives for industrial location, land siting and right-of-way, building codes, design and retrofitting of state buildings and transportation fleet, public transportation policies, state building codes, public infrastructure (e.g., charging stations on state roads).

Local governments, like state governments, have often been leaders on climate and sustainability. Local governments also have jurisdiction over urban land use, building codes, roads, transit, and much more. Recent research shows that U.S. cities have stronger powers to set their own vision and enforce policy than non-U.S. cities (around ten percent higher than the average).[28] Compared with other countries, U.S. mayoral powers are particularly strong in relation to finance (about 30 percent higher than the international average), water (~ 20 percent higher), outdoor lighting (~ 15 percent higher), buildings (~ 10 percent higher), and energy supply (~ 10 percent higher).[iii]

Renewable energy procurement strategies available to cities vary based upon the city's electricity provider and the state's regulatory environment. Renewable energy purchase options include: onsite solar projects at municipal facilities, utility programs, physical power purchase agreements (PPAs), virtual power purchase agreements (VPPAs), community solar programs, and renewable energy certificates.

Twenty-five of the 100 largest cities in the U.S. are participating in the Bloomberg American Cities Climate Challenge (ACCC). The challenge was launched in 2018 to help cities establish high-impact policies to reduce emissions from electricity, buildings, and transportation. ACCC recently released a playbook highlighting activities already underway – ranging from foundational actions such as strengthening enforcement of building energy codes to providing commuter incentives to reduce driving – as well as more ambitious actions such as achieving ubiquitous EV charging infrastructure.[29]

Electrical utilities and renewable energy standards

According to the U.S. Energy Information Administration, in 2019 about 32 percent of U.S. energy-related carbon emissions were from the electric power sector. Because wind and solar electricity are currently the lowest-cost carbon-free energy technologies, deploying them in the electricity sector would result in a major decarbonization thrust. Over 70 percent of the U.S. coal fleet is now more expensive to operate than it would be to build and operate new solar and wind energy.[30] By 2025, this will be true for nearly the entire U.S. coal system.[31] States have long led the way in promoting renewable electricity generation by enacting various RPS, which require that a certain percentage of a utility's electric generation must come from renewable sources.

According to Lawrence Berkeley National Laboratory, in 2019 RPS policies existed in 29 states and the District of Columbia (Figure 4.2.4)[32] and covered 56 percent of total U.S. retail electricity sales.[33] According to the National Council of State Legislatures, "Roughly half of the growth in U.S. renewable energy generation since 2000 can be attributed to state renewable energy requirements."[34] In the last 5 years, many ambitious state goals have been enacted, and 2019 was a particularly active year. In addition, a number of states have experimented with different carbon pricing methods, a key area of climate policy experimentation.

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iii Comparison between C40 cities in the U.S. and non-U.S. C40 cities; 1 in 5 U.S. city dwellers lives in a C40 city.

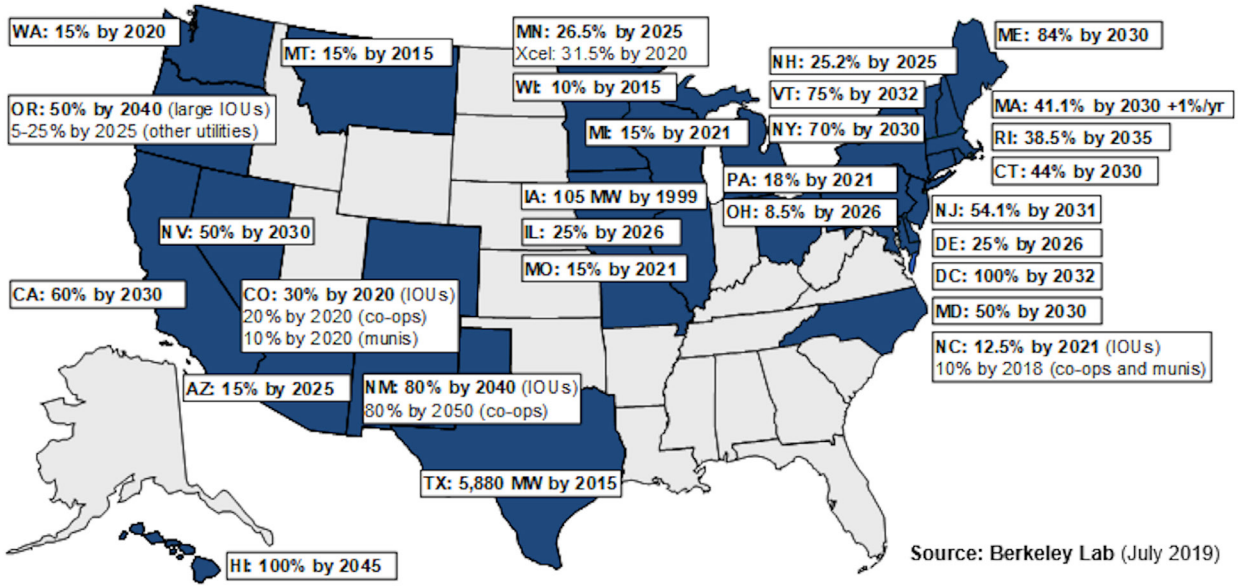
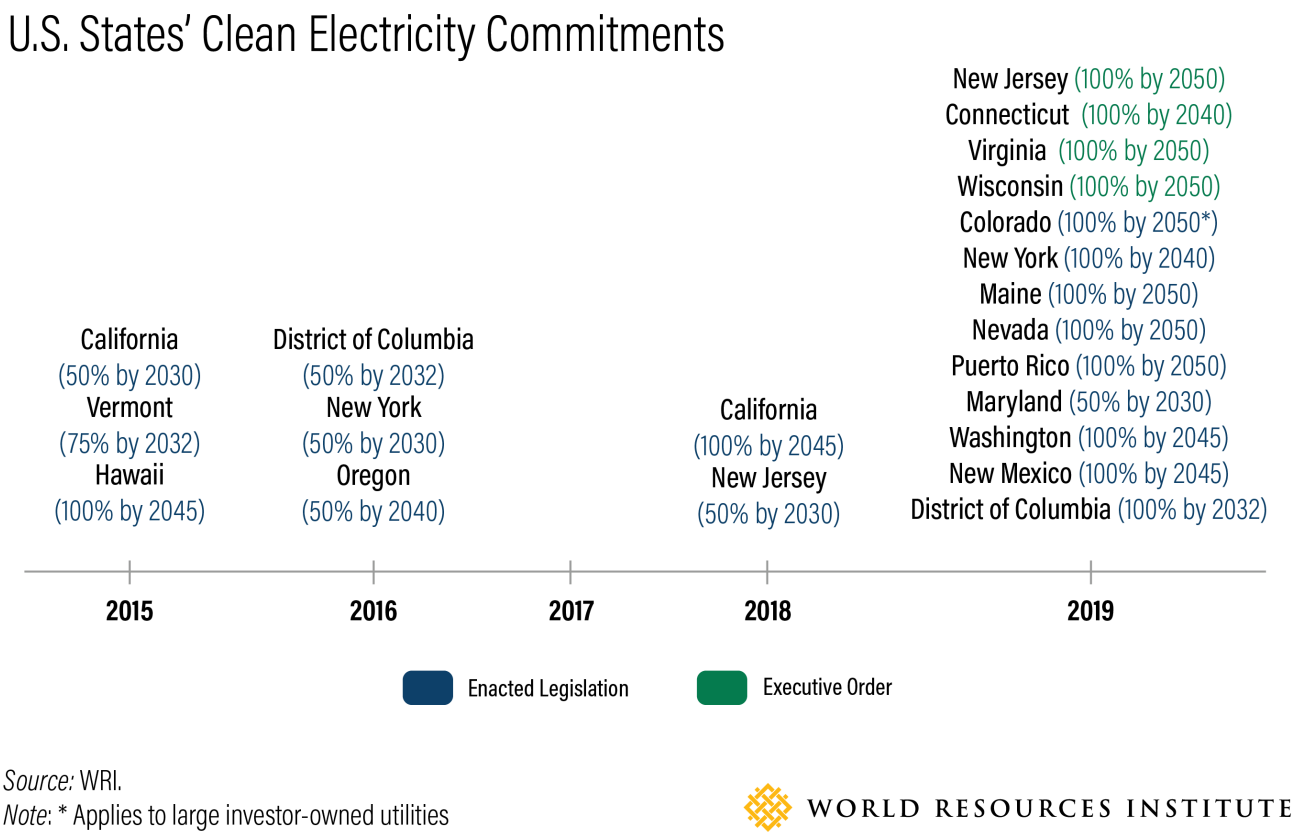


Figure 4.2.4. U.S. map showing state RPS requirements and timelines (Barbose, 2019).



Source: WRI.
Note: * Applies to large investor-owned utilities

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Figure 4.2.5. Recent clean energy commitments by U.S. states (2019 Was a Watershed Year, 2019).

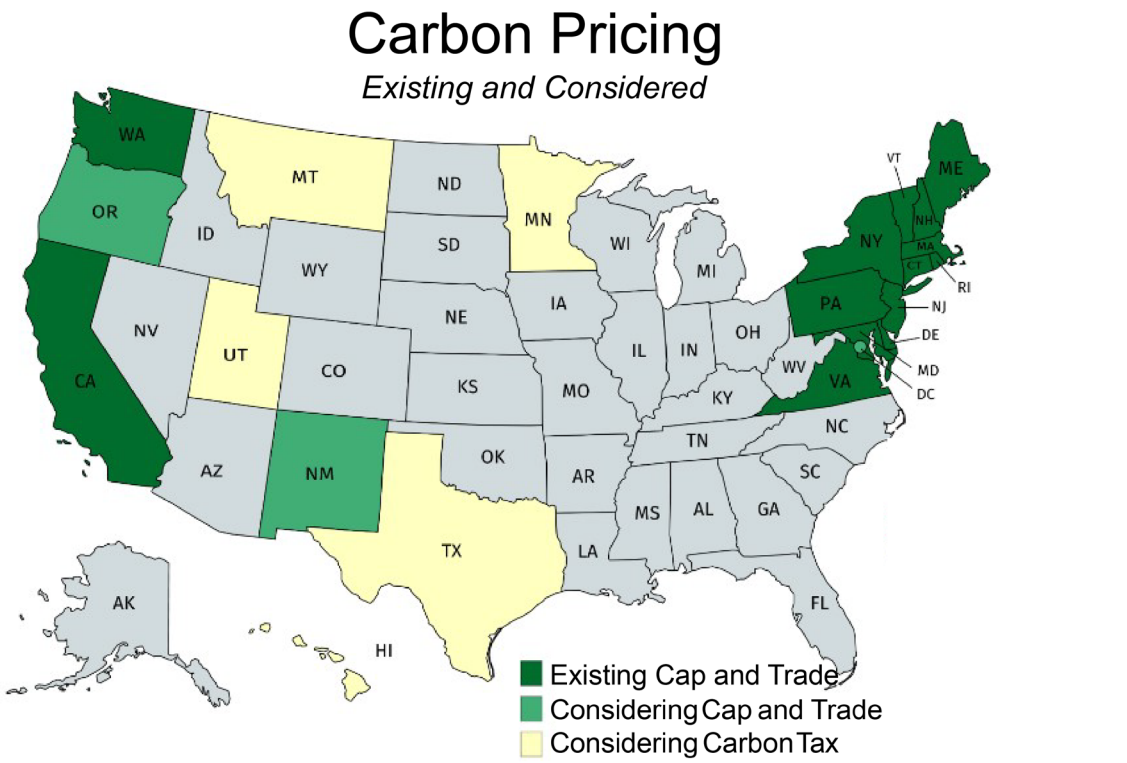

Figure 4.2.6. Carbon pricing methods existing and under consideration in U.S. states ("State Actions", 2020).

Case Study - Colorado's Renewable Energy Portfolio

As the state of Colorado has excellent wind and solar resources, it is not surprising that in 2004, Colorado voters passed the first citizens' ballot measure to provide a statewide renewable energy portfolio standard. This required that three percent of retail electricity sales come from renewable sources in 2007, increasing to ten percent by 2015. The state legislature has increased the goals three times since 2004, the most recent requirement being 30 percent renewable energy for investor-owned utilities by 2020. (Xcel Energy, the state's largest utility, reports that 28 percent of its electricity is from renewable sources at the time of this writing.)

In 2019, Colorado Governor Jared Polis signed 11 new clean energy bills passed by the state legislature.[35] These cover carbon emissions, renewable energy, electric vehicles, and efficiency standards. Chief among them is the "Climate Action Plan to Reduce Pollution." This bill sets economy-wide carbon emissions reduction targets relative to 2005 of 26 percent by 2025, 50 percent by 2030, and 90 percent by 2040. A separate bill echoes Xcel Energy's latest 2050 goal of providing 100 percent carbon-free electricity by 2050. A public utilities commission (PUC) bill contains a groundbreaking requirement that the PUC must include a value for the social cost of carbon (SCC), beginning at $46 per short ton of carbon dioxide emissions in its economic analyses (this includes the benefits of electrification).

Colorado's shift toward renewable electricity has resulted in the closure of coal plants, which are traditionally located in low-income neighborhoods where the resulting air pollution causes asthma and other health issues for the poorest residents. A parallel shift from gasoline to EVs will also reduce vehicle emissions in those neighborhoods with the most highway traffic, which again tends to impact low-income residents disproportionately. Thus, the shift to clean energy in Colorado provides strong support for greater social equity. Investing in clean energy in Colorado by improving energy efficiency standards and expanding the supply of clean renewable energy sources will also expand job opportunities in the industry. An annual investment of $14.5 billion in clean energy from 2021 to 2030 can generate 100,000 jobs a year in the state.[36] In addition, the growth of employment will create more opportunity for women and people and communities of color.

Case Study - Whisper Valley Community in Texas

Whisper Valley is a 2,000-acre multi-use residential community located outside of Austin, Texas, consisting of 7,500 all-electric homes, two schools, two million square feet of commercial space, a pool and recreation center, and a 600-acre park.[37] Building heating and cooling are provided by heat pumps connected to vertical geothermal wells. The homes in each block are connected by a buried, uninsulated water piping loop that communicates with the geothermal wells. The piping loop provides additional surface area in contact with the ground (which is at approximately the average annual ambient temperature), thus enhancing the heat source/sink. Homeowners have the option of including a 5-kW solar photovoltaic system on their roof to operate the heat pump and the various appliances in their all-electric homes, such as heat pump water heaters, electric dryers, and inductive stovetops.

Figure 4.2.7. Geothermal heat pump piping and rooftop photovoltaic array in Whisper Valley community (Whisper Valley, 2020).

Taurus Investment Holdings, an international real estate development firm, established EcoSmart Solution to develop sustainable communities, which they view as both a business development opportunity and environmentally beneficial. Shell New Energies is also an investor in EcoSmart Solution, as they want to expand into the low-carbon energy space. Austin has long been progressive in terms of energy efficiency and renewable energy, and was a logical location for their first planned sustainable community. Taurus believes that people will want to buy homes that are sustainable not only because they are better environmentally but because they won't become obsolete. Taurus sees Whisper Valley as just the first of many similar projects in the future.

Buildings and housing

Buildings typically represent a large portion of GHG emissions at the local level. Implementing energy efficiency projects in municipal facilities is a great way for states and cities to lead by example, engage the private sector, and demonstrate that reducing emissions can also save money. States and cities should implement municipal building policies that standardize and institutionalize sound energy management, ensuring that savings are realized even with changing administrations. Municipal building energy consumption reductions benefit both a city's government as well as its residents and businesses. By investing in energy efficiency within the municipal building stock and other operations, cities can achieve significant reductions in operating costs, thereby reducing long-term taxpayer burdens.[38]

In general, it is considerably more expensive to retrofit energy efficiency measures in existing buildings than to include them in new construction. Decarbonizing existing buildings can be achieved through a combination of the lowest-cost energy efficiency retrofits and electrification, so that a building's energy comes from renewable sources, including utility-scale wind and solar, community solar projects (also called solar gardens), and rooftop solar.

The National Renewable Energy Laboratory (NREL) has developed two modeling tools that use large databases of existing buildings to rank order the cost-effectiveness of different energy efficiency measures as a function of building type, location, fuel type, and building age. These tools are ResStock for residential buildings and ComStock , for commercial buildings.[39] ResStock fact sheets have been developed for the 48 contiguous states.[iv] For determining the best energy retrofit measures for both existing and new buildings, the DOE developed building modeling tools BEopt for residential buildings and OpenStudio for both commercial and residential buildings.[40]

One significant objection many homeowners raise to eliminating natural gas is their preference for natural gas stove tops because they heat more quickly and are more controllable than electric resistance elements. However, modern electric induction stovetops offer a number of advantages over electric resistance heating. Because the heating energy occurs directly in the pot or pan, heating is very rapid, and the stovetop does not get as hot as an electric resistance stovetop. In addition, induction heating can be finely adjusted. As a result, many top chefs now prefer induction stovetops to natural gas heating.

iv Available at https://resstock.nrel.gov/factsheets/.

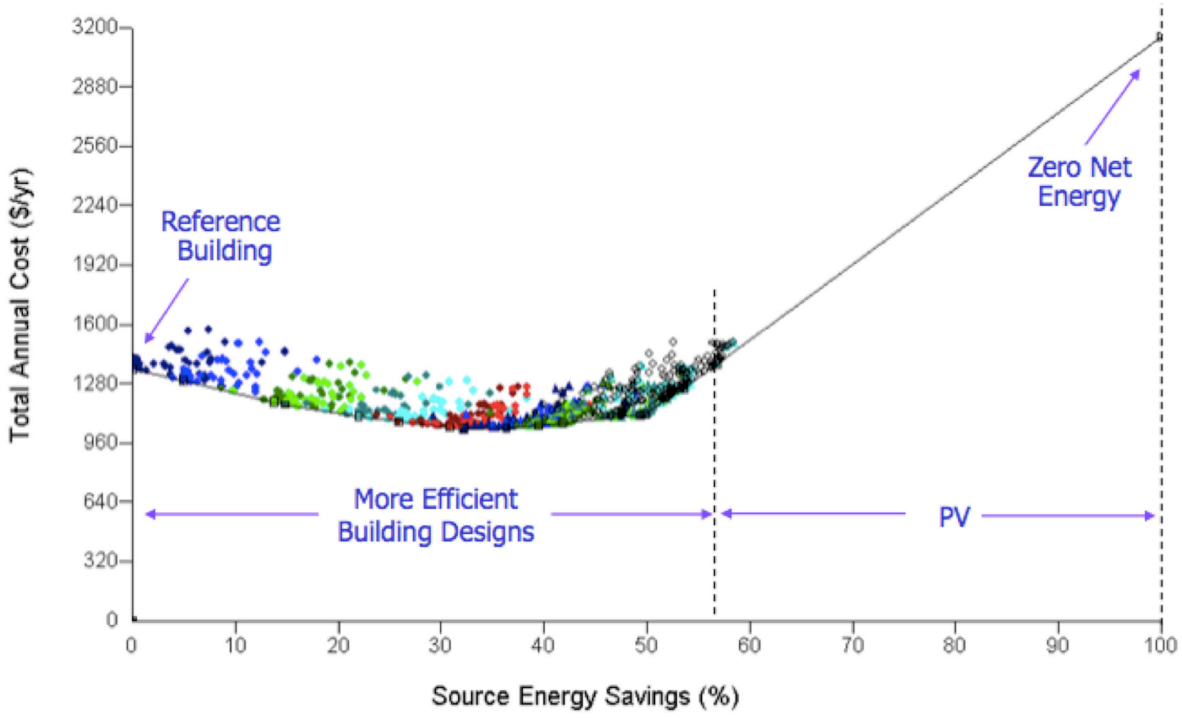

Figure 4.2.8. BEopt™ (Building Energy Optimization Tool) schematic (NREL, 2018).

Building materials

It has historically been assumed that the carbon emissions resulting from a building's energy use over the life of the building are much greater than the carbon emissions associated with the building's construction materials. That thinking is now being challenged for two reasons. First, as buildings become more efficient and as they are electrified with electricity provided by renewable sources, the carbon emissions due to energy use rapidly decrease. Second, because climate change is increasingly being recognized as an immediate crisis, the near-term carbon emissions associated with a building's construction become significantly more important. As a result, more attention is now being paid to reducing the embodied carbon emissions associated with both building construction materials and energy efficiency products.

Concrete and steel are examples of key construction materials with significant embodied carbon emissions. Also, certain types of insulation materials can contain a significant amount of embodied carbon. Blown-in materials such as fiberglass and cellulose have a lower carbon footprint than rigid and spray foam insulations. The organization Architecture 2030 has developed a Carbon Smart Materials Palette to allow designers to choose versions of materials that minimize embodied carbon.[41]

Land use and zoning

Renewable infrastructure siting, increased soil carbon sequestration, biofuel production, reforestation, and shifting away from animal agriculture all have positive and negative (and likely competing) implications for land use change and land-based activities, and authority over each of these activities is spread across several areas of the U.S. government, including the Department of Defense, Department of Energy, Department of the Interior, Department of Agriculture and the Environmental Protection Agency.

Land use, land use change, and forestry have the potential to address a significant portion of domestic greenhouse gas emissions. Forests, grasslands, and wetlands currently play a vital role in sequestering 10 to 15 percent of U.S. carbon emissions. Cities aiming to create or expand their urban forestry initiatives can receive technical assistance, financial guidance, peer-to-peer learnings, and scientific advice through groups like Cities4Forests, an initiative that aims to catalyze political, social, and economic support among city governments and urban residents to integrate forests into development plans and programs.[42]

Effective land zoning policies are needed to achieve decarbonization in agriculture, forestry, transportation, bioenergy, and low-carbon gaseous fuels.[43] Cities should adopt transit-oriented development policies that decrease single occupant vehicle trips and vehicle-miles traveled, such as expanded public transportation options, improved infrastructure for safe walking and biking, and urban mixed-use development with legitimately affordable housing.

Municipal permitting offices and public utility commissions should streamline and accelerate the build-out of EV charging infrastructure, particularly for public chargers near commercial areas or multifamily residential units. New pricing systems may be developed to encourage EV charging and integrate with local grid needs.

Single-family zoning and large lot size requirements are just two traditional land use planning policies that should be reformed by cities and states across the U.S.[v] Single-family zoning laws prevent the development of any housing that is not a detached, single-family home. Originally designed to separate homes from highly polluting industries, single-family zoning has also proliferated as a tool to segregate neighborhoods by affluence and race. In addition to single-family zoning, many cities across the country currently require that homes be built on large lot sizes, another contributor to sprawl. For most of today's urban and suburban communities, these rules are unnecessary, impede the densification of housing, and reduce the viability of reasonable access to public transit. Minimum lot sizes also hamper affordable housing developments by resulting in large, expensive homes.[44]

Avoiding lock-in

Path dependencies in infrastructure, technologies, institutions, and behavioral norms need to be considered when integrating strategies for mitigation and adaptation to climate change to avoid locking into high-emission pathways and low-resilience urban futures.[45] An effective decarbonization plan focuses on long-lived infrastructure, replacing assets at the end of their life with low-carbon successors, and policy interventions (see the Buildings chapter for more on this). A learning-by-doing approach, combined with permanent intervention, is necessary for effective structural change.[46]

v Oregon, Minneapolis, and Houston have recently changed policies related to single-family zoning or lot size.

Case Study - New Mexico's 100% Clean Energy Future

In March 2019, New Mexico passed the Energy Transition Act (SB 489), putting the state at the forefront of energy transition in the United States. The bill requires New Mexico's electricity to be carbon free by 2045 with several interim goals, including:

- The shutdown of New Mexico's last coal plant by 2022,
- 50 percent carbon-free by 2030, and
- 80 percent of energy consumption from renewable energy by 2040.[2]

One of the methods New Mexico is adopting to meet the bill's goals is called securitization. Securitization is "a low-cost financing method to pay off coal plant costs and close the facilities." It can reduce the price of closing a coal plant by up to 40 percent, accelerating the transition to renewable energy, which is also cheaper for consumers.

New Mexico was previously dependent on coal plants, which are no longer economical. They were responsible for the harmful nitrogen oxides (NO_X) and sulfur dioxide (SO_2) emissions that were compromising the state's air quality. With New Mexico 50 percent carbon-free by 2030 commitment, the power sector's NO_X and SO_2 emissions are expected to decrease by 90 and 70 percent, respectively (based on 2017 levels), greatly decreasing respiratory related health issues and improving public health. In addition, a clean energy economy in New Mexico is anticipated to create 8,830 new jobs and $4.6 billion of new investment by 2030.

Since 1970 New Mexico's annual average temperature has warmed by 1.5°C, making it the United States' sixth fastest warming state. The warming temperatures are causing extreme summer temperatures and exacerbating drought and wildfire risk. With the Energy Transition Act, New Mexico has become a leading example for the rest of the country.

Case Study - Climate Resilience Planning in the Treasure Valley, Idaho

The Treasure Valley of Idaho is a rapidly growing metropolitan region of around 750,000 people encompassing rural agricultural communities, exurban towns, several small cities, and the state capitol, Boise. Situated within a high desert ecosystem in the Intermountain West, the Treasure Valley faces a range of growing climate impacts, such as droughts, chronic wildfire smoke, and heat waves. While the region is composed of numerous distinct municipalities, their capacity to mitigate and adapt to climate change are interlinked through transportation and economic networks, shared environmental resources such as watersheds and public lands, and mutual exposure to trans-boundary climate impacts. Coordinating collective climate action across this varied landscape of communities – whose population size, economic bases, and politics vary widely – is a central challenge for this region.

The Hazard and Climate Resilience Institute (HCRI) at Boise State University, one of the region's anchor institutions, is bringing together stakeholders from across the Treasure Valley to build climate resilience.[47] Starting in 2017, the group began building relationships across the Treasure Valley, and is convening a multi-year, collective process to develop a "Resilient Treasure Valley" plan. This plan will emphasize the communities' capacity to respond to a broad range of hazards and disasters, including both climate change impacts as well as non-climate hazards such as earthquakes.

HCRI's framing of "resilience planning" – instead of "climate planning" – speaks to local notions of self-reliance in one of the most geographically isolated metropolitan regions in the country. This planning process is unique in that it is being facilitated by a local, well-regarded public university, rather than directly by governments themselves. Leveraging their status as both facilitator and research institution, HCRI is convening a wide range of stakeholders, including both government officials and academic researchers. By doing so, HCRI is opening up avenues for collaborative, applied research that will also serve to evaluate the effectiveness of new resilience-focused policies as they are adopted.

Several municipalities within the Treasure Valley have also begun to adopt their own climate strategies, with Boise most actively driving new policy.[48] The city recently established a Climate Action Division, which is tasked with advancing climate resilience efforts. In tandem with this Division, recent initiatives brought forward under the city's new mayor emphasize equity as a central tenet of climate action. For example, existing energy and water efficiency programs will be redirected towards low-income earners in an attempt to integrate climate mitigation and affordability goals. Additionally, funding has been allocated for a citywide environmental justice assessment, which will map the distribution of environmental harms and climate impacts (e.g., wildfire risk, and heatwave hotspots), as well as environmental amenities and climate adaptation resources (e.g., tree canopy cover, and parks). By pairing these spatial evaluations with demographic data, Boise will be able to strategically focus climate mitigation and adaptation efforts towards more vulnerable and traditionally underserved communities.

The Federal Government can provide resources to support a transition from single-occupant vehicles to transit and shared/pooled services in ways that enhance accessibility by disadvantaged travelers. In addition to funding Federal Government building retrofits, the Federal Government should provide financial resources via grants to states, counties, and cities, for extensive building retrofits.

Some combination of federal and state financial incentives may still be necessary to ease the fuel-switching cost for the consumer. Carbon pricing could also help by increasing the cost of natural gas or other fossil fuels compared to renewable electricity.

A key barrier to implementing programs to increase soil carbon at large scale is the need for credible and reliable monitoring, reporting and verification (MRV) platforms. There is a need for more investment in GHG inventories and other measuring and monitoring programs, such as remote sensing,[vi] to track progress toward net carbon goals. For natural and working lands, enhanced techniques for measuring, monitoring, and modeling soil and forest carbon can be developed through partnerships between states and universities.

4.2.4 Economic and Financial Resources

Cities and states cannot fund all of the needed climate change actions on their own. Multiple funding sources are required to deliver the full complement of financing that is essential to low-carbon development and climate risk management (see Figure 4.2.9).[49]

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vi Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft).

As one example, Portland adopted a resolution backing green bond issuance in the city in 2015. Green bonds can support cities with financing the infrastructure needed to reduce carbon emissions and become more resilient to the effects of climate change. Portland's action could drive the wider development of the green bond market in other cities.

Public-sector finance can facilitate action, and public resources can be used to generate investment by the public sector; however, private-sector contributions should extend beyond financial investment. The potential role of the private sector in urban climate mitigation and resilience is important and multifaceted.

Climate-related policies should also provide cities and states with economic development benefits as they shift to infrastructure systems associated with low-carbon development.

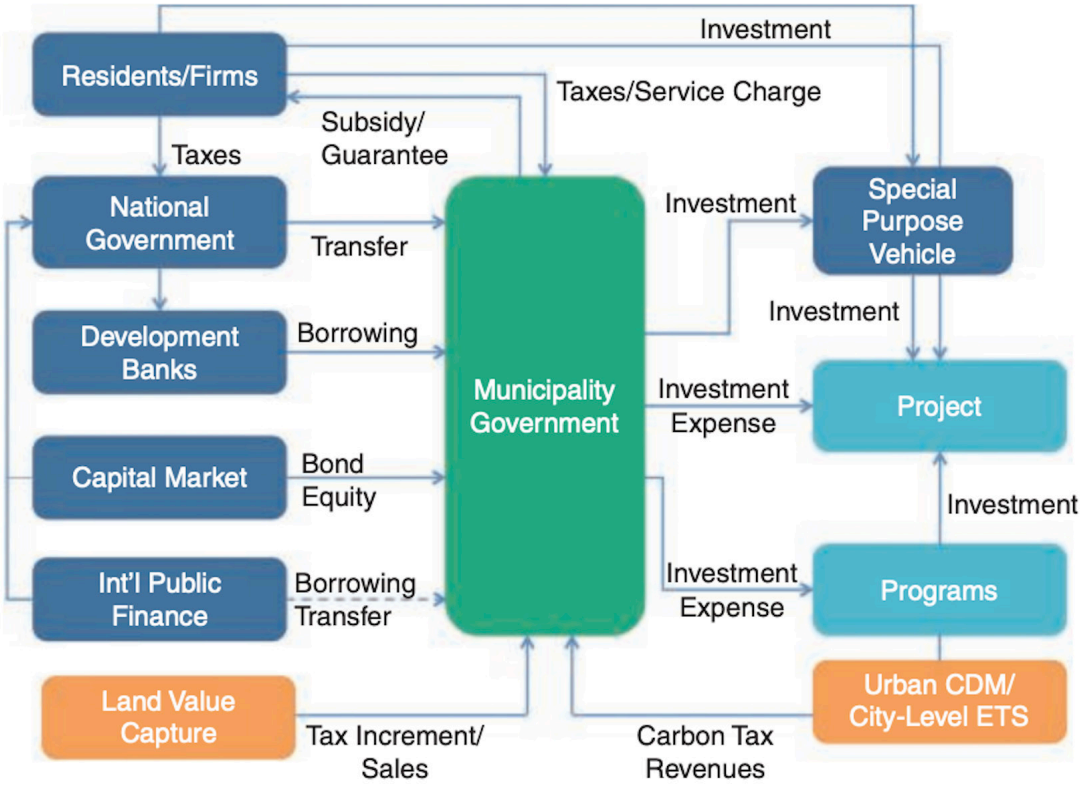

Figure 4.2.9. Potential sources of municipal climate finance (UCCRN, 2015).

Case Study - University of Michigan

As previously stated, the clean energy transition is going to take collaboration from various stakeholders across various levels of government and our community institutions. The University of Michigan, a top-ranked public university, announced its Sustainability Plan that included a goal of a 25 percent reduction in greenhouse gas emissions by 2025. In January 2019, Mark S. Schlissel, the President of the University, announced a new Commission on Carbon Neutrality to further this goal.[50] In June 2020, the Commission released its interim report.[51] The Commission started from a strong base of interest and programs for sustainability throughout the University through its Planet Blue program.[52]

The Commission's charge is to outline a timeline, pathway and approaches for achieving carbon neutrality that are environmentally sustainable; involve the regional community; create scalable and transferable models; include the participation and accountability of all members of the university community; and are financially responsible in the context of University of Michigan's mission of education, research and service. The major areas and potential pathways include, but are not limited to:

- Heat and Power. Geo-exchange, high-, mid- and low- temperature hot water systems, thermal energy storage, bio fuels, and sequestration.
- Mobility Electrification. Investments in new electric vehicles and associated campus infrastructure.
- Electricity Purchasing. Power Purchase Agreements and Virtual Power Purchase Agreements.
- Carbon Neutral Building Retrofits. Specific energy reduction measures/strategies (e.g., electrical and mechanical systems, and the building envelope), with estimated capital investment needs and return on investment.
- Building Standards. Building performance minimums; timeframes for economically feasible net-zero emissions outcomes relative to new standards; holistic algorithm to determine optimal solutions in terms of cost per emission.
- Internal Energy Consumption Policies. Internal price on carbon, and revolving energy fund to be used for energy efficiency projects.
- University Sponsored Travel. Changes for travel-related data management systems; strategies to educate the University of Michigan community on the carbon footprint of travel; mechanisms to reduce the amount of university travel, including internal price on travel emissions.
- External Collaboration. Engagement framework outlining how the university should engage, and which stakeholders it should engage, as it moves towards carbon neutrality.
- Biosequestration. Protecting existing natural lands as passive carbon sinks; restoring and enhancing natural lands in lieu of external offsets; prioritizing environmentally and ecologically friendly landscaping practices on campus.
- Carbon Offsets. Third-party validated project credits, cap-and-trade program credits, direct partnerships to develop new projects, offset project decision matrix.
- Carbon Accounting. A multi-dimensional model spanning all emission categories that will allow the Commission to evaluate various scenarios.

Multiple public engagement activities have been key to developing the plan, both to educate the community and to gather input from multiple stakeholders. The final report promises to be a global model for universities and communities.

Case Study - Feed in Tariff Program in Gainesville, Florida

In 2009, the city of Gainesville, Florida wanted to respond to the climate change crisis but had few financial resources to do so. The solution was to create a feed-in-tariff (FIT) program. Feed-in-tariffs are a popular policy tool for communities to accelerate the use of renewable energy, particularly solar, with little cost to the city. The city modeled their program after successful programs in Germany, and became the first city in the U.S. to offer a FIT program.[53]

The city of Gainesville, which controls the electric utilities, agreed to pay a higher price for any electricity produced from renewable resources, including electricity from residential homes. Gainesville's guaranteed rate of 32 cents per kWh for renewable energy was locked in for 20 years. The high cost for renewable energy was offset by increasing everyone else's bill by about 74 cents a month. In addition, while rates for other energy sources for the city will increase over the next 20 years, the 32 cent rate will stay fixed, and at some point the city anticipates actually paying less for the renewable energy than its other sources.[54]

The city contract with homeowners only pays for the 32 cents per kWh rate for energy generated by the home in excess of what they actually use for themselves. This policy keeps homeowners from using all of their solar energy to make profits on the high rate without cutting down any fossil fuel use themselves.

Because the city guaranteed the rate for 20 years, local banks agreed to loan homeowners the money to install the solar panels. In many cases, the loans were structured so that the homeowner would not have any additional cost, even with the loan, above what they were paying for utilities before. Once the loan is paid off, the homeowner receives all the benefits of the savings on utilities each month plus the extra fees for the energy they produce over their needs. This in turn encourages conservation and energy efficiency to make the solar investment pay back faster.

This method of financing allowed the city to achieve remarkable growth in solar without having to finance the solar development. The program began in March 2009 and by September 2010, electricity from solar panels in Gainesville had grown by more than 500 percent, with a combined capacity of more than 2 MW.

Since then, the program has continued to grow beyond expectations. Thirty megawatts of solar capacity were successfully applied for and reserved by 2017. In addition, two solar "farms" designed to produce nearly 2,400 MWh of energy each year are currently in construction, and a 2 MW rooftop system will crown Gainesville's largest shopping center by the end of the year.

Since the Gainesville FIT program began, several communities across the U.S. have adopted and implemented their own version of the program.

FITs are one of the best and easiest ways for local governments and utility companies to promote the acceleration of renewable energy.

4.2.5 Measurement, Reporting, Verification (MRV)

Emission inventories (EIs) are the fundamental tool to quantify the amount of man-made emissions and to keep track of their change over time. For GHGs, nationally reported EIs are regularly compiled following the guidelines prepared by the Intergovernmental Panel on Climate Change (IPCC) (e.g., IPCC 2006). National EIs are primarily based on statistical data (e.g., on fuel production, consumption, and trade data), and emission estimates are often made at the national scale by economic sector or by fuel type.

Production footprints account for flows associated with all in-boundary activities and trans-boundary flows of key infrastructures, whereas consumption footprints account for all in- and trans-boundary flows associated only with local household consumption. The two approaches may yield different "footprint" estimates for any one community. As a result, debates remain as to the best way to inventory GHG emissions at the local level, and inconsistencies often exist among city inventories.[55] World Resources Institute, C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability (ICLEI) have partnered to create a GHG Protocol standard for cities known as the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).[56]

Using national household surveys, econometric models of demand for energy, transportation, food, goods, and services may be used to derive average household carbon footprints (HCF) for U.S. zip codes, cities, counties, and metropolitan areas.[57] Carbon footprint estimates are available for 31,000 zip codes in the United States. Carbon footprint profiles of almost all U.S. zip codes, cities, counties and states are available on the *CoolClimate* project website and an interactive mapping website.[58]

States and cities need to measure, report, and verify (MRV) data associated with climate mitigation and adaptation actions to understand trends, create strategy, determine the effectiveness of adaptation and mitigation approaches, assure accuracy of information, and adjust strategies.[59] MRV can be applied to greenhouse gas emissions, mitigation actions, or support (see Figure 4.2.10).

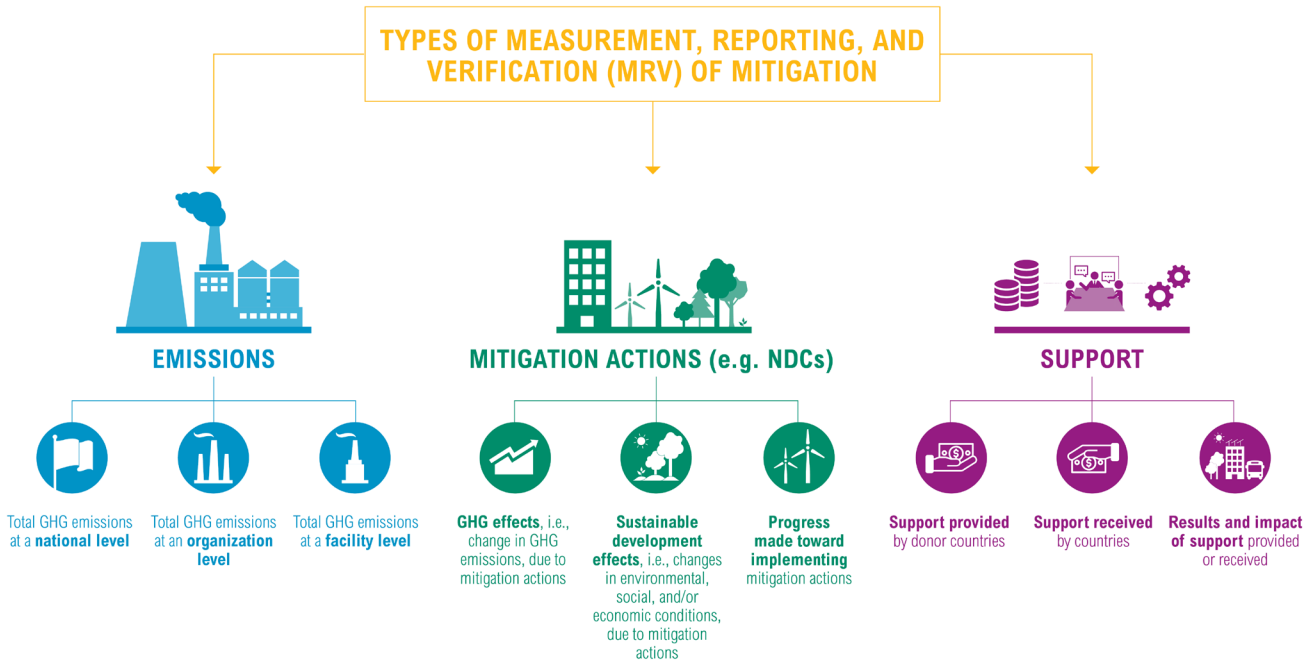

Figure 4.2.10. Types of measurement, reporting, and verification (WRI, 2016).

Remote sensing may be utilized to granularly observe and measure atmospheric CO_2 with satellite data, making it especially useful for accurately and consistently measuring changes in the spatial patterns of emissions as well as monitoring urban heat island effects and air quality.[60] By utilizing remote sensing technology, scientists can improve the accuracy of emission inventories, inform key stakeholders of climate risks and patterns, and advise policymakers. Researchers have mapped the carbon footprint of over 13,000 cities globally.[61]

Case Study - Using Remote Sensing to Track Air Pollution in Northeast United States

By using remote sensing, National Aeronautics and Space Administration (NASA) scientists are able to effectively monitor changes in air pollution. Shortly after the northeast U.S. was under shelter-in-place orders due to COVID-19, NASA observed a 30 percent drop in air pollution due to the decrease in human activity. Nitrogen oxide is a gas emitted primarily from burning fossil fuels, and can be used as a measure for human activity. As shown in Figures 4.2.11 and 4.2.12, air pollution in the northeast U.S. is significantly less in March 2020 when compared the average atmospheric nitrogen oxide levels in March from 2015 to 2019.[62] The average atmospheric nitrogen oxide levels in March 2020 were the lowest on record since tracking began in 2005. Similar reductions were consistent in other regions of the world, such as China and Italy.

Because remote sensing technology allows NASA scientists to monitor and track air pollution, it is also a powerful way to determine the effectiveness of strategies for mitigating and adapting to climate change. These changes in atmospheric composition were observable to NASA satellites after only a few weeks. By continuing to utilize remote sensing technology, scientists can inform policymakers, track changes in pollution, and monitor environmental injustices associated with emissions.

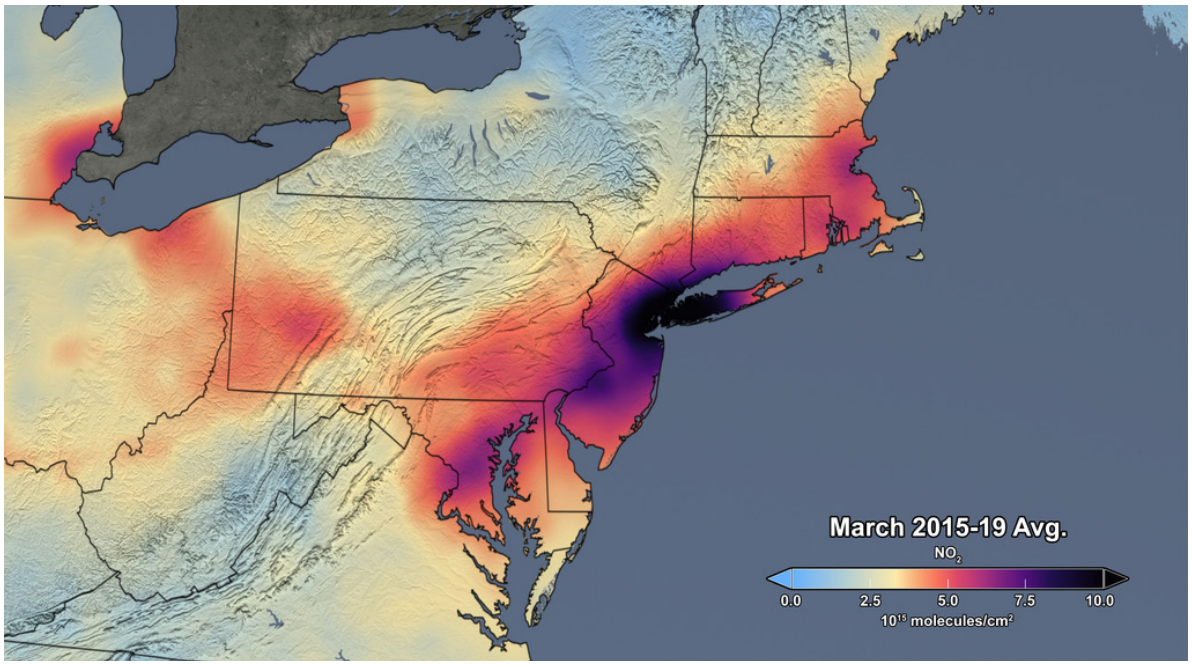

Figure 4.2.11. Average nitrogen dioxide (NO_2) concentration in March (2015-2019) (NASA, 2020).

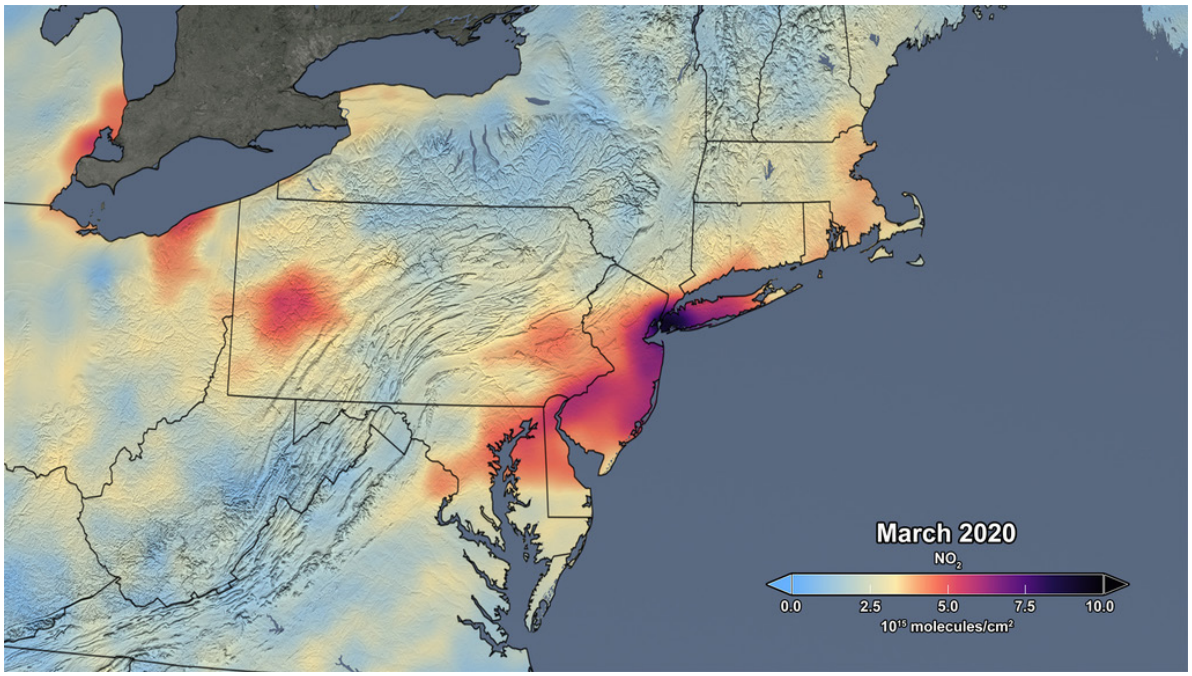

Figure 4.2.12. Average nitrogen dioxide (NO_2) concentration in March 2020 (NASA, 2020).

4.2.6 Leveraging New Technologies and Partnership Frameworks

According to Lazard, wind and solar electricity now have the lowest levelized costs of all electricity-generating technologies.[63] Because they are carbon-free sources (except for some carbon emissions associated with equipment manufacture), they offer the best options for transitioning away from fossil fuels. To take advantage of them, states and cities need to electrify as much of their energy services as possible. The two sectors that will be the easiest to electrify are light-duty transportation and buildings.

Transportation

Policies to reduce vehicle emissions are largely under the jurisdiction of federal and state governments. As of 2020, nine states have adopted California's zero emission vehicle requirements, and thirteen states have adopted California's GHG vehicle emission standards. These states account for 30-40 percent of total light duty vehicle (LDV) sales, and the emissions requirements have accelerated emissions reductions, as well as the development and commercialization of advanced technology.

Great strides have already been made in developing electric vehicles. Both federal and state tax incentives have been enacted to incentivize the purchase of EVs. Electrify America, which resulted from the Volkswagen diesel lawsuit, has been installing thousands of fast-charging stations around the country.[64] Because battery costs are dropping rapidly, EVs are now approaching the cost of gasoline vehicles for light-duty transportation.[65] Nissan, Chevy, Kia, and Hyundai are among the growing number of manufacturers that produce EVs with a range of over 200 miles and a retail price under $35,000.

Heavy duty vehicles (HDVs) typically run on diesel engines that emit a variety of air pollutants, like particulate matter and black carbon, which are linked to cardiovascular and respiratory illness, and NOx, which undergo reactions to create ground-level ozone and smog. These vehicle types are commonly used in shipping logistics settings like ports, rail yards, and warehouses, which tend to be located near low-income communities in which the pollution disproportionately impacts Black, Indigenous and People of Color. Thus, pursuing HDV electrification has important implications for human health, environmental justice, and emissions reduction goals.[66]

Private Sector Engagement

Cities are showing leadership in their ability to collaborate with the private sector to promote sustainability while enhancing safety and livability.[67]

- In 2014, the City of Houston partnered with private sector providers to convert 165,000 conventional light bulbs to LEDs. This initiative is expected to reduce street light electricity usage by about 50 percent and reduce municipal emissions by 5 percent. As a result, the city will save around $1.4 million on its annual electricity bill. Long-term reductions in maintenance costs are also expected to offset the up-front cost of installation.[68]
- Colorado is home to an important new all-electric housing development that will demonstrate the use of heat pumps and demand response measures in a cold climate. The Basalt-Vista project consists of 27 new housing units located in the Colorado mountain town of Basalt, located 18 miles from Aspen.[69] It is being developed by Habitat for Humanity Roaring Fork. Financial assistance is being provided by the local electric utility, Holy Cross Energy, as well as by the Community Office for Resource Efficiency, a local nonprofit. The houses will serve as a test bed for the performance of heat pumps in a very cold climate and for using various electric loads such as EV charging, hot water heating, and batteries. The goal is to better match the building loads to the utility supply. The challenge ahead will be to convert existing home heating systems from cheap natural gas to electric heat pumps without causing an increase in homeowner heating bills.

Figure 4.2.13. Air source heat pump (Best, 2020).

New Technologies

As the U.S. works towards decarbonization, further Research, Development, Demonstration, and Deployment (RDD&D) is still required to achieve a future carbon-free energy system. RDD&D is especially important for technologies that have been identified as needed to reach decarbonization goals, but are not available at a commercial scale. For example, technology for carbon capture and storage and biofuel production still need to be advanced in order to be fully utilized as a decarbonization approach. Additional funding for RDD&D is needed.

Federal and state governments should also work together to revise building and infrastructure codes to incentivize the commercialization of green industrial products.

Case Study - The Hawai'ian Clean Energy Initiative

The state of Hawaii has high electricity prices because of the high cost of imported petroleum. Transitioning to lower-cost renewable electricity sources could greatly reduce electricity bills, benefitting lower-income families and positioning Hawaii to be a model for other states. To address the high electricity costs as well as environmental concerns, the Hawaiian Clean Energy Initiative was launched in 2008.[70] Its goal was to achieve 70 percent of the state's energy needs through renewable energy by 2030. Progress has been ahead of schedule, and the goal has been expanded to achieving 100 percent renewable electricity by 2045.

One concern that arose is how to limit overvoltage caused by too much solar electricity feeding into the grid. Whereas California can export excess electricity to other states, Hawaii's isolation prohibits that option. Based on concerns about reliability and safety to line workers, the Hawaii's Public Utilities Commission has directed Hawaiian Electric Company (HECO), the utility for the most populated island, Oahu, to limit the amount of solar electricity on the distribution system.

To address these concerns, HECO partnered with the National Renewable Energy Laboratory (NREL) to study the issues. NREL tested four "smart" inverters to determine how they would handle the overvoltage situations on a simulated Oahu grid. The tests showed that all the inverters would safely and quickly reduce power under transient overvoltage conditions.

The Hawai'i example demonstrates showing that solar energy systems can provide similar types of grid services as well as conventional fossil fuel power plants, despite lacking the generator inertia of conventional plants. As reported by NREL, "Tests determined that the inverters successfully provided six grid functions—fixed-power-factor operations, volt-watt control, volt-VAR control (baseline testing only), voltage ride-through, frequency ride-through, and soft-start reconnection – during normal and abnormal conditions, and two of the inverters provided ramp-rate control during normal operation."[71]

Case Study - Carbon Sequestration in Indiana

Carbon sequestration officially began in Indiana in July 2019. A carbon sequestration pilot project was authorized in Terre Haute under Indiana Code section 14-39-1-3.5, permitting Wabash Valley Resources (WVR) to build an ammonia production facility to reduce Indiana's carbon footprint by storing it underground.[72] With funding from the Oil and Gas Climate Initiative (OGCI) Climate Investments and the Department of Energy's Carbon Storage Program, WVR is anticipating to capture and store an estimate of 1.5-1.75 million tonnes per annum in Indiana's Mount Simon Sandstone.[73] In addition to carbon sequestration, the plant will produce an affordable, low-carbon fertilizer.

While some stakeholders, such as members of the Citizens Action Coalition, are concerned about the potential effects of injected carbon on ground water and earthquakes, other stakeholders view carbon sequestration as a method to quickly reduce the state's carbon footprint and encourage economic development. Indiana is still heavily reliant on its coal industry for electricity. The Wabash Valley Resources pilot project will provide valuable lessons regarding carbon sequestration as a whole and inform future projects.

4.2.7 Integrating Mitigation and Adaptation

Investing in mitigation strategies that yield concurrent adaptation benefits should be prioritized in order to achieve the transformations necessary to respond effectively to climate change. Cities and towns should use improved bond ratings to fund infrastructure improvements that increase resilience to climate impacts, including updates to buildings, backup power, and stormwater and emergency management systems.[74]

Developing urban areas into denser, more compact areas with mixed land use and mass transit can reduce a city's carbon footprint. Dense urban districts can be reconfigured to reduce the impact of urban heat and storms due to the changing climate, while enhancing quality of life for residents.[75] Over 35 percent of total U.S. carbon dioxide emissions are associated with residences and cars, so changing patterns of urban development and transportation is critical for decarbonization. U.S. cities generally have significantly lower emissions than suburban areas, and the city-suburb gap is particularly large in older areas (e.g., New York).[76]

Case Study - Gowanus, Brooklyn – Integrating Climate Adaptation and Climate Mitigation

The Urban Land Institute's (ULI) New York District Council and Urban Resilience Program partnered with the New York Institute of Technology (NYIT), and the Urban Climate Change Research Network (UCCRN), a global consortium of climate experts on the Gowanus Cool Neighborhood Project. The project was initiated by an Urban Design Climate Workshop (UDCW) for the Gowanus neighborhood in Brooklyn, New York, focused on urban heat stress adaptation integrated with flood resiliency and GHG emission mitigation.

UDCWs were conceived by UCCRN and NYIT as hands-on, capacity-building exercises to engage the local community, industry professionals, and city officials as they confront climate challenges in a 21st-century neighborhood. This planning process, which derives its value proposition from positive public health and economic growth outcomes, envisions that urban design can help shape transformative climate action in evolving districts like Gowanus. It also shows how a rezoning or other redevelopment initiative can incorporate climate projections to better understand not only likely climate impacts, but also opportunities for climate mitigation.

The Gowanus UDCW addressed how to mitigate local greenhouse gas emissions and address resilience to climate impacts in ways that are aligned with New York City's Gowanus Rezoning Proposal. The primary goal of the Gowanus UDCW was to propose regulatory strategies that can be "actionable" in a complex city like New York.

This project integrates climate mitigation and climate adaptation by prioritizing actions that reduce greenhouse gas emissions while strengthening climate adaptation (to both urban heat stress and coastal floods).

This project intersects with another project, the *Climate Mitigation: Net-Zero District* initiative, which is led by the American Institute of Architects New York Chapter and NYIT, in collaboration with the In-Source Belmont Forum-National Science Foundation, a European-American research consortium. The two Gowanus efforts overlap: integrated climate adaptation to reduce cooling loads, and climate mitigation (net-zero) to achieve net-zero carbon emissions, by balancing a measured amount of carbon (or CO_2 equivalency) release with an equivalent amount of CO_2 generated on-site or offset. Peer-reviewed scientific research shows that integrating mitigation and adaptation can be an important approach for confronting climate change in cities.[77]

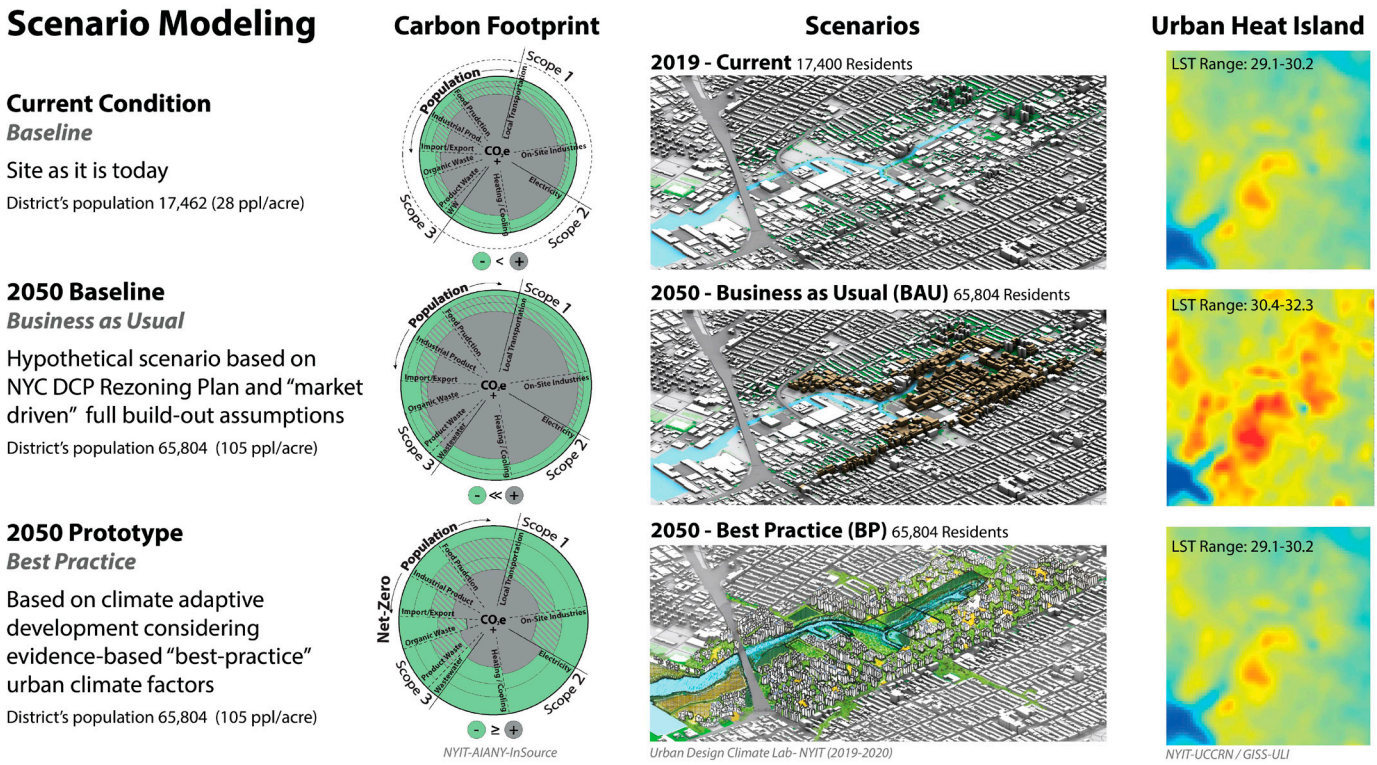

Figure 4.2.14. Carbon footprint and urban heat island scenarios for Gowanus community in Brooklyn, NY under different development scenarios (Raven et al., 2018).

Case Study - Microgrids and Disaster Risk Management in Puerto Rico

Puerto Rico, the United States' largest unincorporated territory, is an archipelago with rich cultural and ecological diversity. Located in the Caribbean Sea, Puerto Rico has a tropical climate that hosts El Yunque rainforest in the northeast, coastal mangroves and coral reefs, and much more. Puerto Rico is experiencing rising sea levels, intensified storms, decreased total rainfall, ocean acidification, ecosystem shifts, and other impacts due to the changing global climate.[78]

Efforts to both mitigate and adapt to these changes are of the utmost importance. Worsening climate systems, vulnerable populations, and unresponsive governments have already led to catastrophe in Puerto Rico – most horrifyingly when Hurricane Maria, a Category 5 hurricane, hit the island in the fall of 2017. What would have been a devastating storm under most circumstances led to prolonged suffering due to a fragile island power grid and subsequent lack of response from the U.S. Federal Government.[79] (The territory's government has also been criticized for corruption that led to delays in aid delivery and, ultimately, the resignation of the governor at the time).[81] Three months after Maria hit, about half (more than 1.5 million people) of the archipelago's residents still lacked power[82] – and continued to have limited access to food and other necessities.[83]

Growing efforts are underway to shore up Puerto Rico's energy grid resilience for the future, which will hopefully both decarbonize its energy sources and decrease its dependence on often slow-moving disaster relief funds. A series of 2019 laws established by the territorial government call for all power to be generated by renewable resources by 2050 (40 percent by 2025), among other stipulations.[84] To keep pace with the electrification of the grid, the Puerto Rico Electric Power Authority (PREPA) is now focused on developing a robust "microgrid" system.

Microgrids are "mini-energy service stations that maximize locally generated renewable energy, such as wind and solar power, and are backed by battery storage and intelligent software."[85] Such systems, though still in development, are ideal for hurricane- or other natural-disaster-prone areas. Despite these encouraging possibilities, the Environmental Defense Fund has argued that the current microgrid plan put forth by PREPA does not sufficiently address the urgency of deep decarbonization.[84] Ultimately, it may not be possible for Puerto Rico's communities to build resilient, decentralized energy grids (and other disaster risk management necessities) without deeper financial commitments at both the territorial and federal levels – demonstrating a striking need for both localized resilience methods and multi-level government coordination.[86]

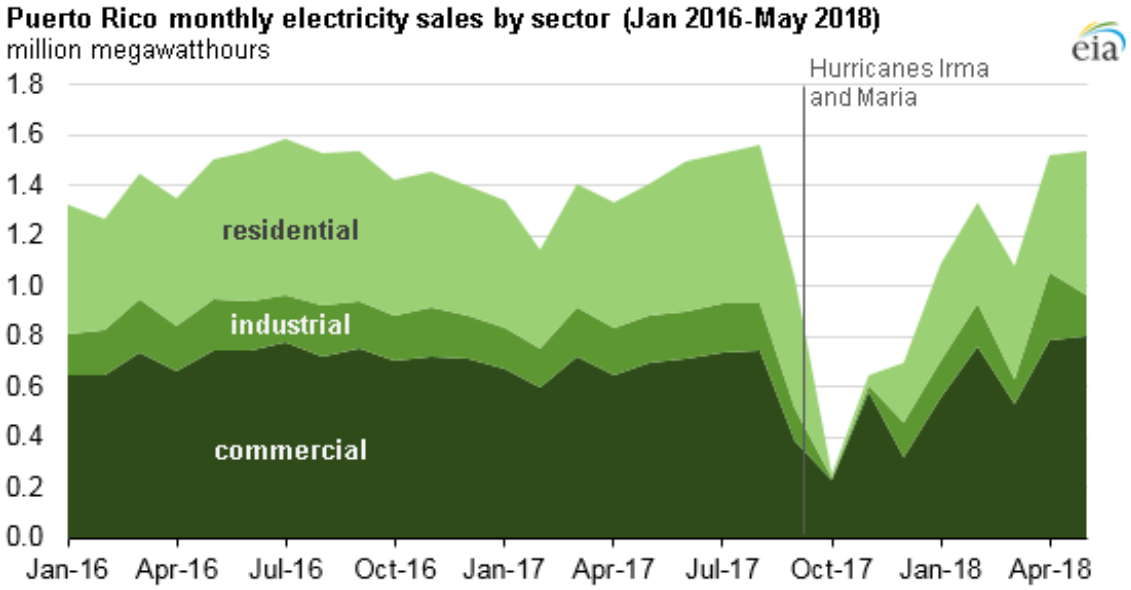

Figure 4.2.15. Puerto Rico monthly electricity sales by sector ("Puerto Rico", 2020) (Jan 2016 - May 2018).

4.2.8 The Circular Carbon Economy

Transitioning from a Linear Economy

Municipal solid waste (MSW) management is inextricably linked to increasing urbanization, development, and climate change. The U.S. is among the world's most urbanized nations, and cities play a pivotal role across the country.[87] Over 85 percent of the United States' population lives in urban areas and, by 2050, it is expected that metropolitan populations will grow to 360 million people. In 2015, 90.8 percent of U.S. GDP was generated in metropolitan areas. However, as Chapter 5.6 (Accelerating Sustainable Materials Management in the U.S.) explores in more detail, our current socioeconomic system is based on a linear economy that uses the "make it / use it / dispose it" (see Figure 4.2.16) pathway. The municipal authority's ability to improve solid waste management also provides large opportunities to mitigate climate change and generate co-benefits, such as improved public health and local environmental conservation.[88]

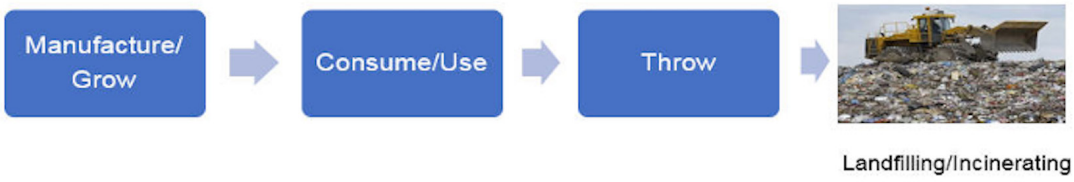

Figure 4.2.16. *Linear Economy* resource management (Guran, 2019).

The linear economy pathway of material movement is rooted in exponentially increasing resource consumption, excessive energy use, degradation of ecosystems and a massive amount of waste generation.[89] As urbanization increases, the global solid waste problem is also expected to expand if waste generation is not minimized and residents continue to use linear waste disposal practices. Literature suggests that a city resident generates twice as much waste as their rural counterparts of the same affluence. If we account for the fact that urban residents are generally more affluent, their waste generation rate is estimated to be almost four times higher than rural residents.[90] United Nations Environmental Programme (UNEP) and International Solid Waste Association (ISWA)'s Global Waste Management Outlook (GWMO) estimated that in 2015, 2 billion people around the world lacked access to regular waste collection and 3 billion people lacked access to controlled waste disposal services. Waste management remains a global challenge in the 21st century.[91]

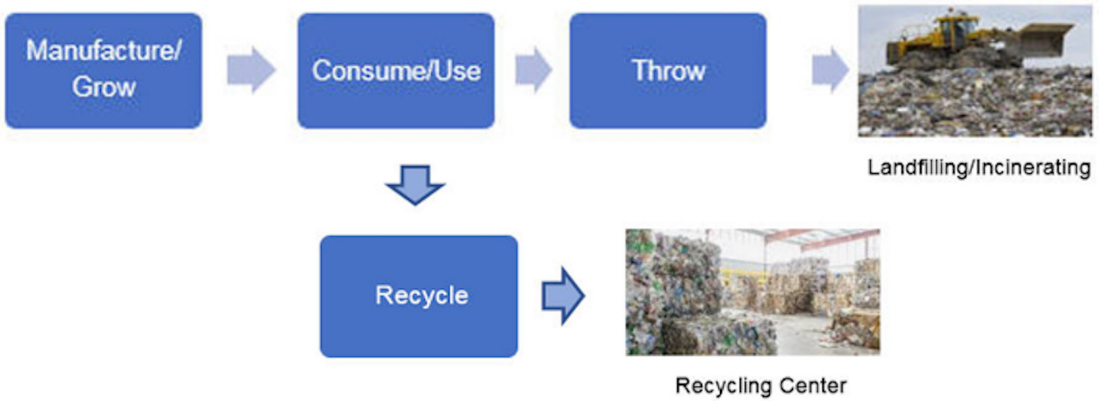

Figure 4.2.17. *Linear Economy* resource management with recycling (Guran, 2019).

Recycling

Globally, it is estimated that only one quarter to a third of the total 3.4-4 billion tons of municipal solid waste (MSW) and industrial waste produced annually is recycled.[92] While some cities and towns have reached 50 percent, 60 percent, and even 70 percent recycling rates, most major U.S. cities recycle at 20 percent or less.[93] The national recycling rate in 2000 was about 29 percent, and grew to 35 percent in 2017.[94] However, it is expected that 2019 data will likely show a drop below 35 percent, "and [recycling] shows no signs of picking up steam again."[95] Recycling is a process to separate valuable materials into new products; it can be further sub-classified as downcycling or upcycling, converting materials to lower value or higher value products respectively. Some communities practice single-stream recycling in which mixed recyclable materials are moved together to be sorted at a Materials Recovery Facility (MRF). Global recycling practices also vary from region to region and country to country. While some growing economies do not practice recycling at all, some low-income communities practice recycling (as well as reuse) to create economic benefits.

In the U.S., some communities require "source separated recycling" in which materials are separated and collected in separate containers at the point of discard. Source separated recycling requires more effort by the consumer; however, it reduces the cross contamination of the waste. Single-stream recycling undeniably increases the quantity of recycled materials collected, but reduces the quality, resulting in a contaminated supply and reduced economic viability of recycling operations.[96]

It is estimated that the residue amount at the MRFs is approximately 10-15 percent, higher if an MRF is receiving single-stream waste as compared to MRFs receiving source separated recycled waste. Cross contamination of waste streams, such as plastics contamination with paper waste or vice versa, and plastic waste contamination in food waste also negatively impact efficient reutilization practices, such as composting. The cross contamination of recycled materials affects their market penetration, which is highly dependent on the materials' physical and chemical characteristics.[97]

Circular Carbon Economy & Resource Management

The "circular economy" is an industrial system to restore and regenerate all systems by design in order to preserve and enhance natural capital, optimize resource yields, and foster effectiveness.[98] It has the potential to be an effective pathway towards less carbon-intensive systems. The transformation from a linear make-it/use-it/dispose-it pathway to circular resource recovery pathways can provide the foundation for a "circular carbon economy". The circularity approach also redefines waste as a "resource" and efficiently feeds waste back into the economy. Chapter 5.6 further discusses the benefits of a circular economy.

Figure 4.2.18. Closing the loop for resource recovery (Guran, 2019).

Case Study - The National Western Center in Denver, Colorado

The National Western Center in Denver, Colorado, a multi-use district that was approved by Denver voters, is being constructed on the site of Denver's annual National Western Stock Show, which is held for two weeks every January.[99] It incorporates many energy design features. One key feature is that it makes thermal use of a six-foot diameter pipe carrying the city of Denver's wastewater that runs through the property.[100] Because this water is at a temperature of between 61°F and 77°F throughout the year, it provides an excellent heat source and sink for heat pumps operating in heating and cooling mode. A heat exchanger exchanges heat between this pipe and a buried water loop circulating through the district. Heat recovery chillers (heat pumps that can simultaneously heat and cool) utilize this water to provide efficient heating and cooling to the various buildings.[101]

The electricity used to operate the heat pumps, provide lighting, and power other equipment will be supplied by solar photovoltaic arrays that are located on the district campus. This will be augmented by wind- and solar-powered electricity provided from off-site installations.[102]

Figure 4.2.19. Artist's rendering of the National Western Center (Alvarez, 202).

4.2.9 Conclusions and Policy Recommendations

The U.S. federal system allows state and city governments to set policy and targets, design laws and standards, implement financial mechanisms to develop and support markets (e.g., green bonds), and enforce regulatory compliance. These are key levers through which decarbonization actions can be – and are already being – delivered, and through which a thriving low-carbon goods and services sector is being developed. However, the Federal Government oversees interstate electricity transmission, aviation, shipping, interstate pipelines, and coal and gas leasing on public lands. Key regulatory requirements, such as those for the power sector and for energy intensive industries like cement and steel, may be difficult to implement at the state level because of interstate competitiveness and leakage concerns.

Climate-related policies at the federal level should provide cities and states with economic development benefits as states and cities shift to infrastructure systems associated with low-carbon development. Cities and states cannot fund climate change responses on their own. Multiple funding sources are needed to deliver the financing that is essential to low-carbon development and climate risk management.

As states and cities plan and implement bold strategies for reducing GHG emissions, an opportunity exists to address existing disparities and to create stronger, more equitable communities for everyone. Making climate action plans more responsive to equity concerns will also help to galvanize broader constituencies of support for bold climate solutions.

Transportation Strategies

- State-level vehicle standards and ZEV policies should be encouraged by the Federal Government as some states may be able to go further faster.
- Link federal and state transportation funding to metropolitan planning organizations (MPOs) to per capita vehicle miles traveled (VMT) reductions.
    - › Example: California has a goal of 19 percent per capita VMT reduction by 2035 for major metro areas (SB375).
    - › Create a similar national target to be used in all states.
- Create state and city pricing systems that encourage more intensive use of vehicles.
    - › Example: Incentives for multiple occupants in Transport Network Companies (TNCs), personally owned vehicles, and transit.
    - › Discourage single occupant vehicles and single passenger services.
    - › Include VMT pricing, congestion pricing, and parking policies.

Aligning Policies Across Scales

- States and cities should implement land use policies that promote densification, transit-oriented development, and complete streets[vii]

  › Urban populations are encouraged to walk, bike, or use public transit, as opposed to single-occupant vehicles, for commuting and other trips.

- Cities should align incentives and programs for building retrofits with state climate goals and begin efficient retrofit of existing buildings.
- Provide jurisdiction to cities/municipalities that enables them to create hauler contracts that sorting and separation quality of materials.

  › Municipalities need different state level goals that broaden their jurisdiction; keeping the system localized for product sorting, recycling, refurbishment (and sale) needs to be incentivized.

- Reduce post-harvest losses by 50 percent compared to 2010 levels. Reduce household-level food waste from 30 percent to 15 percent by 2050.

  › San Francisco passed an ordinance in 2009 requiring all businesses and households to sort organics for collection and composting. The city now collects more than 220,000 tons of organic waste each year, and is considered the country's most successful composting program. It provides a model for Congress, states, and localities to follow when designing legislation banning food waste in landfills.

- The 2018 Farm Bill would benefit from federal-state coordination to disseminate information to potential applicants, and it should be linked to other long-term policy initiatives to promote its use and longevity.

  › This program appears to be underutilized, based on an announcement from USDA in July 2019, which solicited applications and noted $400 million still remaining of its $565 million FY2019 budget.[103]

Public/Private Funding Partnerships

- Allocate RDD&D investments toward industrial process and product redesign, electric and low-carbon manufacturing process development, and enhanced material efficiency.
- The Federal Government should invest directly in key parts of the national energy system, including inter-state power transmission, public land use for power generation, and supporting infrastructure.

  › The Federal Government should engage in innovative green financing, such as government guarantees for green bonds, tax incentives on utility bonds for renewable energy, direct equity, funding of state-level green banks, and others, and in the needed regulation of the financial sector for the disclosure of climate risks.

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vii Complete Streets are streets designed and operated to enable safe use and support mobility for all users. Those include people of all ages and abilities, regardless of whether they are travelling as drivers, pedestrians, bicyclists, or public transportation riders.

- Establish state-level programs to promote forest conservation and restoration, agroforestry, and urban forestry.
  - › Example: Create trusts or funds to help landowners enhance climate-friendly management capabilities, require evaluations of carbon impacts in land use decision-making, and integrate forest-level carbon sequestration into carbon pricing schemes as avoided emissions credits.

No-Regret Policies

- Promote interstate and interagency coordination, including electricity demand modeling as well as land use change and land-based activities.
  - › Regional planning (at level of Western Interconnection or REGGI, for example) improves planning outcomes.
  - › More robust policies with explicit requirements for assessing the impacts on host communities and engaging impacted communities in the siting process (as well as decisions on compensation) are needed.
- Local governments and states should engage in regional planning efforts that bring multiple states and municipalities together.
- Direct resources toward a just transition through a variety of approaches including workforce programs and hiring preferences.
  - › In states and localities with fossil fuel-dependent communities, establish hiring preferences that help people transition from work in the fossil fuel industry.
  - › Ensure equity is a key consideration in building retrofit efforts.
  - › Example: New York's goal of net-zero carbon emissions by 2050 is now law (with New York State sources required to reduce their direct emissions by at least 85 percent by 2050 and 40 percent by 2030). It specifies that a third of the benefits of the investments go to disadvantaged communities.[104]
- 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.

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