Getting to 100

How Three Cities are Transitioning to 100% Renewable Energy

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Executive Summary

In 2018, the Intergovernmental Panel on Climate Change issued a report stating that in order to preserve a livable planet by the end of the 21st century, nations of the world must cut greenhouse gas emissions 45% by 2030 and to zero by 2050. Cities are where 70% of greenhouse gas emissions take place, so they will be a key player in meeting this goal. To date, 120 cities in the United States have passed legislation committing to 100% renewable energy by 2050 or before, and more than 200 mayors have pledged to pass this legislation.

Yet cities face a unique challenge when trying to lower greenhouse gas emissions: too much of the energy landscape is not under local control. More than two-thirds of city customers are served by private investor-owned utilities that generate energy in facilities far away and often out of state. State laws determine whether utilities are regulated, and whether cities can employ strategies such as aggregation, community solar, and stricter building codes. City residents put fuel put into their vehicles that comes from other states and often other countries. How can cities lower carbon emissions when they have so little local control over their own energy systems?

Previous research on this topic falls into two types: literature from peer-reviewed journals and literature from think tanks. The major topic of peer-reviewed literature is whether attaining 100% renewable energy is possible. Most of the literature shows that it is not only possible, but the most cost-effective option in the long run. However, most studies are of countries, not cities, and they do not discuss financing mechanisms for how to pay the up-front costs. The think-tank literature concentrates mainly on cities. These booklets break down city energy systems into sectors, then outline policies and implementation steps for transitioning from a fossil fuel-based system to clean energy. However, while these reports may reference single initiatives in specific cities, they do not examine how the transition works in practice for a city's entire energy system.

This report will begin to fill that gap by conducting case studies of three cities that have committed to 100% renewable energy: San Francisco, the first city to make this commitment in 2010; Atlanta, the only city whose plan includes a full consideration of policy alternatives; and Cincinnati, which has the most comprehensive plan of all large cities that have committed to this transition. The three case studies will draw from an analysis of each city's climate and energy plan, then use cross-case synthesis to identify common themes and explain differences how cities deal with the problem of having too little local control over their energy systems.

Specifically, this report will examine three possible explanations for why San Francisco, Atlanta, and Cincinnati chose the roadmap they did for how to get to 100% renewable electricity:

- Does the city plan to achieve its goal by taking action mainly at the local level, working within the rules and regulations set by the state?
- Does the city plan to achieve its goal mainly by pushing state governments to change the rules and regulations cities must work under?
- Does the city plan to achieve its goal mainly by continuing business as usual, allowing the energy systems it has in place to continue undisturbed?

The hypothesis for this study was the first alternative: that cities plan to work primarily on the local level to achieve 100% renewable electricity, and will seek to change state laws and regulations only if these rules prevent them from achieving their goals.

The case studies in this report find that all three cities are transitioning to 100% renewable energy primarily by taking action on the local level. For example:

- **San Francisco** is expanding its city utility, which supplies 100% energy from hydropower, and using a bulk purchase program to expand residential solar.
- **Atlanta** is making large investments in energy efficiency and renewable energy, while buying Renewable Energy Certificates to fill any gaps.
- **Cincinnati** is pursuing 80 recommendations in eight sectors, including an aggregation program to provide 100% renewable electricity and gas.

Only one of the three case study cities – San Francisco – has had a 100% renewable energy plan in place long enough to evaluate the results. Data there shows that carbon emissions fell 26% between 2010, when the city made its commitment, to 2017. Additional analysis of all three city energy plans provides a blueprint for transitioning to 100% renewable energy:

- Investing in energy efficiency, which reduces the amount of energy used and lowers the cost, especially for low-income residents.
- Promoting renewable energy by building solar generation on city facilities and providing incentives or assistance for residential solar.
- Transitioning city vehicle fleets to electric cars and buses, and encouraging citizens to consider electric vehicles.
- Greening the energy supply through aggregation or by working with local utilities.
- Using creative financing mechanisms such as municipal bonds, Property Assessed Clean Energy, right-of-way fees for utility lines, bulk purchasing of solar equipment, third-party ownership of leased equipment, or round-it-up repayments.

Cities still face several challenges in reaching 100% renewable energy. One major challenge is the split incentive issue. In many cities, a majority of residents rent their homes, and many businesses rent commercial space. Building owners must pay for clean energy upgrades, yet tenants receive the benefits of lower energy costs. Cities must find a way to deal with this challenge to a large portion of their population if they are to attain 100% clean energy.

Still, this report finds that investing in the local community is the most effective, equitable, and feasible way forward for cities that want to transition to 100% renewable energy. Whether or not these cities reach their goals, these actions will strengthen their infrastructure, create jobs, clean the air, and improve public health. Climate change may be the crisis that forces city leaders to confront longstanding issues of infrastructure and equity in their communities, but it is also an opportunity to build the world they want for future generations.

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Introduction

Climate change is the most challenging existential crisis in human history. Average global temperatures have increased about 1ºC (0.8ºC to 1.2ºC) since pre-industrial times due to human activities, chiefly the burning of fossil fuels (IPCC, 2018). Burning coal, oil and gas releases carbon, which acts as a greenhouse gas in the atmosphere, trapping the sun's heat on earth and warming the planet. Of the 10 hottest years on record, eight were in the last decade and the other two were in the decade before that (NOAA, 2018).

Global carbon emissions from fossil fuels have increased significantly since 1900, with 78% of the greenhouse gas increase occurring since 1970 (EPA). The year 2018 saw the highest carbon emissions on record: 37 billion tons of carbon were emitted globally (Dennis and Mooney, 2018), with 5.3 billion tons from the United States (Plumer, 2019). Currently the atmosphere has a carbon level of 410 parts per million – higher than at any point in the last 800,000 years when carbon levels never got above 300 ppm [Appendix IV]. The last time carbon levels were this high, humans had not evolved yet (Holthaus, 2018).

Raising global temperatures 1ºC requires a massive amount of energy. In fact, the heat created by current global carbon emissions is equivalent to detonating *four Hiroshima-class atom bombs per second* – with about 90% of the heat being absorbed by the oceans (Cook, 2013; Nuccitelli, 2012). This has led to a variety of deleterious effects, including a significant increase in the amount and intensity of extreme storms, heavy precipitation events, droughts, heat waves, wildfires, rising sea levels, ocean acidification, coral reef die-offs, extinction of species, jet stream and ocean current disturbances, shrinking ice caps, and diminishing sea ice.

To address climate change, nations of the world came together under the United Nations Framework Convention on Climate Change at the Earth Summit in Rio de Janeiro in 1992. Since then, nations have been meeting in an annual Conference of Parties to hammer out agreements on climate action. The history of these agreements has been rocky, but in 2015 all but two countries (Nicaragua and Syria) signed the historic Paris Climate Agreement committing to specific voluntary goals to lower carbon emissions (Taylor, 2017). The agreement also committed nations to increasing their goals every five years, and the world to holding temperature rise to no more than 2ºC and as close to 1.5ºC as possible (United Nations, 2015).

The Paris Agreement was the first to include an aspirational goal of limiting warming to 1.5ºC. The Copenhagen conference of 2009 had set a goal of limiting warming to no more than 2ºC. By 2015, however, island nations vulnerable to sea level rise, along with an increasing number of scientists, had begun arguing that the 2ºC limit was too high. To sort this question out, the United Nations asked the Intergovernmental Panel on Climate Change (IPCC), the body for assessing the science related to climate change, to examine the difference in climate impacts at global warming of 1.5ºC and 2ºC (Davenport, 2018; Nuccitelli, 2018).

The resulting "Special Report on Global Warming of 1.5ºC," written by 91 scientists from 40 countries who analyzed 6,000 studies, found major differences in the outcomes of climate change at 1.5ºC and 2ºC, in measures such as Arctic sea ice, severe heat waves, severe drought, species loss, coral reefs, sea level rise, and cumulative costs (Plumer and Popovich, 2018). Table 1 summarizes these findings:

Table 1. Effects of climate change at 1.5ºC and 2ºC (IPCC, 2018)

	Effects at 1.5ºC	**Effects at 2ºC**
Arctic summer sea ice	Sea ice stays intact most summers	Ice-free summers 10 times more likely
World population exposed to severe heat	14% of the population affected	37% of the population affected
Increase in population exposed to severe drought	350 million people	411 million people
Species losing more than half their range	6% of insects, 8% of plants, and 4% of vertebrates	18% of insects, 16% of plants, and 8% of vertebrates
Status of coral reefs	Frequent mass mortalities	Disappear almost entirely
Population exposed to flooding from sea level rise	31 to 69 million	32 to 80 million
Cumulative costs	$54 trillion	$69 trillion

To limit global warming to 1.5ºC, the report said, carbon emissions must be reduced by 45% from 2010 levels by 2030, and 100% by 2050. Playing a key role in this transition will be cities. Although cities cover only 2% of land on the Earth's surface, they are responsible for more than 70% of carbon emissions from energy use (Seto et al., 2014). Cities are where risks associated with climate change – such as heat stress, terrestrial and coastal flooding, new disease vectors, air pollution, and water scarcity – will coalesce. But cities are also uniquely positioned to "harness the mega-trends of urbanization, digitalization, financialization and growing sub-national commitment to smart cities, green cities, resilient cities, sustainable cities and adaptive cities, for the type of transformative change required" (IPCC, 2018). The next two decades present a window of opportunity for cities to leverage urban form and infrastructure, spatial planning and land use, policy instruments, and finance to address the climate crisis. Such sustainable development has co-benefits for air quality, energy security, public health, socioeconomic equality, and urban heat island effect (Seto et al., 2014).

Cities are stepping up to meet the challenge. At the Paris Climate Conference, nearly 1,000 mayors from around the world signed a declaration supporting a municipal transition to 100% renewable energy (Englart, 2015). After President Trump withdrew the United States from the Paris climate accord, mayors of 407 cities pledged to uphold the agreement (Climate Mayors, 2017), and the U.S. Conference of Mayors passed a resolution supporting 100% renewable energy at its annual meeting in Miami (Kusnetz, 2017). Conferences such as CitiesIPCC and the Global Climate Action Summit are providing platforms for cities to collaborate and exchange ideas for dealing with climate change, while organizations such as C40 Cities and the Bloomberg Philanthropies offer guidance and financial support.

In 2016, Sierra Club, the nation's oldest and largest environmental organization, launched its Ready for 100 campaign urging city leaders to adopt a goal of moving to 100% renewable energy (Travis, 2016). So far 120 cities in the United States have made this commitment through passing legislation and writing action steps into their climate plans. In addition, more than 200 mayors have pledged to pass this legislation in their cities. Six cities in the United States now generate 100% of the electricity used community-wide from clean and renewable sources (Ready for 100). City leaders across the country could learn a lot by examining why these cities made this commitment and how they plan to get there.

Yet city governments face a unique challenge when trying to lower carbon emissions in their municipalities: Too much of the energy landscape is not under their local control. More than two-thirds of city customers are served by private investor-owned utilities that get energy from generation facilities far away and often out of state (Laurent et al., 2017). State laws determine whether utilities are regulated or not, and whether cities can employ strategies such as aggregation, distributed solar, and stricter building codes (Laurent et al., 2017). City residents put fuel put into their vehicles that comes from other states (IEA, 2018a) and often other countries (IEA, 2018b). How can cities lower carbon emissions when they have so little local control over their own energy generation, regulations, and supply?

To answer this question, this report will conduct case studies of three cities that have committed to 100% renewable energy: San Francisco, the first city to make this commitment in 2010 with the most experience in implementing plans to get there; Atlanta, the only city to include a full consideration of policy alternatives in its climate plan; and Cincinnati, which has the most comprehensive plan of all large cities that have committed to this transition. The three case studies will draw from an analysis of each city's climate and energy plan as well as interviews with city leaders responsible for climate, energy, or sustainability. By using the methodology of multiple case studies, this report can engage in pattern matching, explanation building, and cross-case synthesis to identify common themes or explain differences how cities deal with the problem of having too little local control over their energy systems.

Behind the question of local control over energy use is the concept of home rule, or delegation of power from a state to sub-units of government such as cities, counties, townships, or villages (National League of Cities, 2016). While the U.S. Constitution does not mention local governments, the relationship between cities and states is analogous to federalism, which reserves certain powers such as collecting taxes, providing for common defense, and regulating interstate commerce to the federal government, with all other powers going to the states. While state constitutions vary in the powers they reserve for states and the powers they give to local jurisdictions, 44 states have some form of home rule (Russell and Bostrom, 2016). Typically the broadest discretionary authority is given to local government structure and the narrowest to finance. But even when local governments have broad authority, they often do not use it (National League of Cities, 2016). This means that city leaders have a great deal of latitude they do not usually think about to bring their energy systems under more local control.

In examining the climate, energy, and sustainability plans of San Francisco, Atlanta, and Cincinnati, this report will consider the following policy alternatives:

- **Local action**: Does the city plan to achieve its goal of 100% renewable energy mainly by taking action at the local level, working within the confines of rules and regulations set by the state?
- **State action**: Does the city plan to achieve its goal of 100% renewable energy mainly by pushing state governments to change the rules and regulations that cities must work under to achieve their goals?
- **Status quo**: Does the city plan to achieve its goal of 100% renewable energy mainly by continuing with business as usual, allowing the energy systems they had in place before making a commitment to continue undisturbed?

To reach the goal of 100% renewable energy, cities must address energy use across several sectors including residential, commercial, industrial, and transportation. Cities could use various types of renewable energy such as solar, wind, hydro, geothermal, or biogas. Cities can also enact different policies to reach their goals; for example, some use aggregation to leverage more renewable energy from utilities, while others have invested in community solar projects or enacted a carbon tax. Cities are also increasing the amount of renewable energy through finance mechanisms such as Property Assessed Clean Energy (PACE), public banks, or municipal bonds. While cities may pursue a mix of local, state, and status quo strategies across multiple energy sectors, the hypothesis of this study is that cities are moving toward the goal of 100% renewable energy *primarily* by taking actions that claim local control over their energy systems.

Accordingly, some of the questions this study will consider include:

- What policies are cities putting into place to reach a goal of 100% renewable energy? Is renewable energy to supplying power directly to the city, or are renewable energy certificates considered sufficient?
- Which sectors are cities placing the most emphasis on in moving to 100% renewable energy? What challenges have cities encountered?
- What is the role of energy efficiency? Are cities trying to use less energy, or are they simply trying to convert the energy they now use to renewables?
- How are cities paying for the transition to 100% renewable energy? Are they borrowing money, taxing citizens, or paying from reserves? What kind of returns do they expect to see on their investments?
- How are cities addressing equity in moving to 100% renewable energy? Are they taking steps to ensure low-income residents are not left behind?

By understanding how three major U.S. cities are moving toward a goal of 100% renewable energy, this study will identify what kinds of technical, financial and policy options are most effective, efficient, equitable, and feasible. This study is particularly relevant to Columbus, which is the 14^{th} largest city in the country and considering its own commitment to 100% renewable energy. Identifying how other large cities have charted a course to this goal will give Columbus city officials a variety of models for how they could do the same.

To that end, this study will begin by providing background on stakeholders, as well as a review of existing literature about research on achieving 100% renewable energy. Next, the report will outline the methodology it will use in case studies of San Francisco, Atlanta, and Cincinnati. Finally, results will be presented and conclusions discussed, along with recommendations for how Columbus could commit and achieve 100% renewable energy.

Background

Stakeholders

The primary stakeholders for this report are city officials responsible for climate, energy, or sustainability plans. When the city council signs a resolution or ordinance requiring the city transition to 100% renewable energy, or when the mayor signs a pledge that the city's energy supply will become 100% renewable, it is the city climate, energy, and sustainability officials who must figure out how to get this done. Often these officials provide advice to the mayor and city council. If they tell elected leaders that it is possible to get to 100% renewable energy, then the elected officials are more likely to pass legislation requiring it to happen. Therefore, this study is primarily designed for these city officials, so that they can learn how cities are implementing 100% renewable energy and see three real-world examples.

It is also important to understand that city energy managers, climate advisors, and sustainability directors have their own set of stakeholders. Energy powers everything being done in a city, whether by city government itself, major business and industry, or members of the community. Therefore, city energy plans must include a wide range of stakeholders, and cities cannot commit transitioning to 100% renewable energy without stakeholder engagement. All three cities in this study engaged in extensive stakeholder discussions.

- In San Francisco, Mayor Gavin Newsom committed to 100% renewable energy in 2010, and Mayor Edwin Lee formed a Renewable Energy Task Force comprised of local clean energy leaders, business and community members, and relevant city departments, to advise the city on how to make this transition (Murray, 2012).
- In Atlanta, the City Council passed a resolution directing the Mayor's Office of Resilience to develop a plan for 100% renewable energy in city operations by 2025 and community-wide by 2035. After extensive engagement with more than 3,500 community members, the Office of Resilience recommended adjusting the timeline to 2035 for city operations and 2050 community-wide (Clean Energy Atlanta, 2017).
- In Cincinnati, Mayor John Cranley convened a Steering Committee comprised of government, corporate, academic, nonprofit, faith, and community organizations to lead more than 30 public meetings and gather more than 1,400 recommendations. The 80 goals and recommendations included in the city's sustainability plan were those determined to be the highest impact and most feasible while making Cincinnati more equitable, sustainable, and resilient (City of Cincinnati, 2018).

Stakeholders are broadly defined as anyone who has an impact on the organization or project under consideration, and anyone who is impacted by the organization or project. In order to understand how a city can effectively work with such a wide range of stakeholders, it is helpful to sort them on Bryson's Power vs. Interest Grid [see Table 2]. In this grid, power on the X axis describes how much influence the stakeholder has over the organization, while interest on the Y axis describes how much influence the organization has over the stakeholder. The result is a graph with four quadrants representing four types of stakeholders:

- **Players**, with high power and high interest. These are the key stakeholders whose preferences must be taken into account in a transition to 100% renewable energy.
- **Context setters**, with high power and low interest. These are often the funders of a transition to 100% renewable energy who must kept informed about progress.
- **Subjects**, with low power and high interest. These are the people most affected by a transition to 100% renewable energy but with the least influence.
- **The crowd**, with low power and low interest. These are citizens who choose not to be involved with the process even though energy decisions affect them.

Table 2: Stakeholders for city energy officials

Interest (Low ↔ High)	Power: Low		Power: High
High	**Subjects** • City residents • Low-income residents • Renewable energy industry • Fossil fuel industry	**Either/Both** • Landlords/property owners • Nonprofits • Unions and workers • Faith leaders	**Players** • Elected city officials • Utilities • Business and industry • Builders and developers
Low	**Crowd** • Uninvolved citizens		**Context Setters** • Financial institutions • Colleges and universities

Although the exact placement of these stakeholder groups may vary by city, stakeholders for city energy officials can be generally sorted as follows:

Players – High power and high interest

- **Elected city officials** are players because they decide whether to commit to 100% renewable energy. If they do, it is city energy officials who must make that happen.

- **Utilities** are players because they provide electricity to the city. If it is a city-owned utility, the city can tell them what to do within certain regulations. If it is an investor-owned utility, the city does not have a direct line of authority. As the location of a large customer base for the utility, the city does have leveraging power, but as the actual energy provider, the utility is the decision-maker. Some utilities are more willing to invest in renewable energy than others, which the city must take into account.
- **Business and industry** are players because they use a lot of energy, create jobs in the community, and often contribute to the campaigns of elected city officials. Again, some are more willing and able to invest in renewable energy than others, so city officials will need to dialogue with them to find out where they stand and plan accordingly.
- **Builders and developers** are players because buildings are responsible for the majority of carbon emissions in a city. New buildings can be ultra-efficient or even net zero emissions, and existing buildings can be retrofitted to make them much more efficient. Cities can make this happen through requirements and building codes, incentives such as tax breaks, or special financing options, but getting the buy-in of developers is critical.

Subjects – High interest but low power

- **City residents** are high interest because they are not only the users of energy in the city but also the taxpayers who will fund most energy projects. However, they are low power because they have little say over a city's energy plans except through public meetings or by voting elected city leaders in or out of office during elections.
- **Low-income residents** pay more than average for energy and are especially affected by problems of environment injustice such as air particulate matter from polluting industries. Clean energy could benefit them the most, but they are the least able to pay for it.
- The **renewable energy industry** has obvious interests in cities pursuing a transition to 100% renewable energy. Such a transition would create jobs in their companies, in both construction and maintenance of clean industry generation facilities.
- Likewise, the **fossil fuel industry** has an obvious interest in stopping cities from pursuing 100% renewable energy. Some ways in which the fossil fuel industry can intervene in these decisions include running campaigns aimed at convincing city voters not to approve initiatives for power purchases or public transportation; making campaign donations to candidates for mayor or city council who oppose a transition to renewable energy; or lobbying state government to pass measures that stop the city from enacting its plans.

Either/Both – subjects or players depending on the city, its culture, and personalities involved

- **Landlords and property owners** are stakeholders because they rent space to businesses and tenants. Because the property owners pay for maintaining the property but tenants pay for energy costs, there may be an incentive gap for them to make energy efficiency upgrades. Cities can close this gap through regulations that require efficiency, incentives such as tax breaks for investing in upgrades, or special financing options.
- **Nonprofits** such as environmental organizations and community groups can be key allies for cities committing to 100% renewable energy. They can help cities make the case for how such a transition will benefit residents, create jobs, and improve public health.
- **Unions and workers** are a key constituency for cities moving to 100% renewable energy. Although such a transition would create jobs, those jobs are not always unionized. Further, workers in fossil-fuel jobs may feel threatened. Cities will need to manage this stakeholder group carefully, both by highlighting how renewable energy jobs are the fastest growing in the country, but also by encouraging the renewables industry to unionize.
- **Faith leaders** are another possible ally in the transition to 100% renewable energy. All major religions have a core belief that humans should act as stewards of natural resources, and many denominations see creation care and sustainability as a top priority. Cities can enlist these faith leaders to help get broad support for a transition to renewable energy.

Context setters – low interest but high power

- **Financial institutions** such as private banks, public banks, credit unions, and grant making institutions that can finance a transition to 100% renewable energy. Such institutions are not interested in managing the day-to-day operations of this transition, but do need to believe that a transition is necessary, beneficial, and feasible.
- **Colleges and universities** that train students also are not interested in managing the day-to-day operations of a transition to 100% renewable energy, but they do want to place their students into good jobs and their want their students to have a sustainable future.

The crowd – low power and low interest

- When it comes to energy, everyone has a stake. However, not everyone feels personally invested or wants to get involved. Thus, the crowd is made up of uninvolved citizens who will be affected whether the city commits to 100% renewable energy or not, but they don't choose to educate themselves on the issue or exercise their interest in any way.

Literature Review

Peer-Reviewed: Subnational Level

Of the U.S. cities that have committed to 100% renewable energy, almost all made the commitment in the last five years, with three-quarters committing in the last two years. Thus, most 100% cities are only starting to enact their plans, and it is too soon to evaluate the results. That means there is little peer-reviewed literature examining 100% renewable energy on the city level. However, there is a large body of peer-reviewed work looking at whether it is possible to achieve 100% renewable energy on the national or international level, in some cases comparing the costs. The findings of these studies would likely apply to the city level as well.

A handful of peer-reviewed articles do examine city energy systems. For example, Grewal and Grewal (2013) examine four scenarios for renewable energy installation in Cleveland, Ohio, which currently imports almost all energy used for electricity and transportation. They find that Cleveland has the potential for 100% self-reliance through massively scaling up offshore wind development in Lake Erie, deploying solar panels on one-fourth of rooftops, and installing biodiesel on half of the city's vacant lots using high-production algae. Although the study did not examine the up-front costs of such a scenario, it did find that this scenario could prevent up to $1.76 billion from leaving Cleveland annually.

Another study by Foster and Kelly (2018) examined electricity options available to customers of the East Bay Community Energy Program (EBCE), a coalition of seven cities in the San Francisco Bay area that is using community choice aggregation to pool together their customer base and leverage it to bargain for lower-cost renewable energy. The study found that by choosing 100% greenhouse-gas-free energy over the default option of only 38% renewables, EBCE could massively reduce greenhouse gas emissions with no net impact to customer bills and no negative impact on the financial viability of the overall program. This made a very compelling case for cities in the coalition to choose the GHG-free option.

A third city-level study by Zhao et al (2017) examines three scenarios for Beijing leading up to 2030: a reference scenario in which Beijing continues to use mostly coal; a scenario based on the city's plans to replace coal with natural gas and increase the share of renewable energy; and a 100% renewable energy scenario based on solar, wind, and burning municipal solid waste to generate electricity. The study found that 100% renewable energy was feasible and would cut fuel consumption by 72%. However, the study did not consider the cost of this transition.

Peer-Reviewed: National/International Level

Most of the peer-reviewed literature about transitioning to 100% renewable energy examines the country or international level and uses modeling techniques to examine whether 100% renewable is feasible technologically and financially. Much of this research is inspired by the work of Mark Jacobson, professor of civil and environmental engineering at Stanford University and co-founder of The Solutions Project, which has created roadmaps for how 139 countries (Jacobson et al., 2017), all 50 states (Jacobson et al., 2015b), and 53 cities (Jacobson et al., 2018) can be powered with 100% renewable energy from wind, water, and sunlight by 2050. The fundamental idea in these roadmaps is that everything – heating, cooling, transportation, industry, and agriculture – must be electrified then converted to run on renewables. Electrifying everything uses 32% less energy than burning fossil fuels, Jacobson says, because most of the energy created by combustion escapes as waste heat. Additional energy efficiency can be introduced, lowering overall demand another 7% (Jacobson, 2015c).

Jacobson's research team also uses a grid integration model to deal with the variability of renewable energy. Wind and solar do not dispatch energy in an even, predictable manner. Sometimes they do not produce enough to meet demand (i.e., the sun doesn't always shine and the wind doesn't always blow), and sometimes they produce much more energy than can be consumed at that moment (i.e., during a heavy wind event or particularly sunny day). To solve this problem, Jacobson's team proposes three main strategies (2015a):

- Demand response, or shifting when energy is demanded to times when it is more available, for example by making deliveries in off-peak hours.
- Expanding connections across the grid and connecting renewable energy to the grid. It is usually sunny or windy somewhere, and it tends to be windier at night when the sun is not shining. If variability is spread out across a large area, it has less effect.
- Deploying various types of energy storage to hold excess energy for later use.

Most of the literature inspired by Jacobson's research finds that transitioning countries or even regions of the world to 100% renewable energy is not only technologically feasible, but would result in a lower energy costs. Examples of these studies include:

- For **Finland**, Child and Breyer (2016) modeled a 100% renewable energy system for 2050, finding that high shares of solar energy are feasible even at extreme northern latitudes in an integrated system that includes electricity, heating and cooling, and mobility. Such a system cost less than options that included nuclear and biomass.

- For **India**, Gulagi et al (2017a) simulated a 100% renewable energy scenario for 2030 with centralized grid integration to cover demand for electricity, synthetic gas production, and reverse osmosis water desalination. They found that the total system levelized cost of energy fell from 71.6 Euros per megawatt-hour (€/MWh) to 67.2 €/MWh, making 100% renewable energy more cost-competitive than nuclear energy.
- For **Iran**, Aghahosseini et al (2018) modeled 100% renewable energy by 2030 examining the optimal mix, least-cost supply, and role of storage. They found in an integrated system that included electricity generation, water desalination, and synthesis of industrial gas that levelized cost of energy fell from 45.3 €/MWh to 40.3 €/MWh, making it more cost-effective than alternatives such as nuclear energy and carbon capture and storage.
- For **Pakistan**, Sadiqa et al (2018) presented a roadmap to 100% renewable energy by 2050. They found that solar energy could contribute 92% to 96% of power with the levelized cost of energy falling from 106.6 €/MWh to 46.2 €/MWh.
- For **Central and South America**, Barbosa et al (2017) modeled four scenarios for 100% renewable energy in 2030: three that looked at electricity on the national, regional, and area-wide levels, and an integrated scenario that included water desalination and production of synthetic natural gas. They found that energy cost 62 €/MWh in a decentralized scenario but only 56 €/MWh in a centralized scenario, and that hydropower reduced the need for battery storage, making energy even cheaper.
- For **North America**, Aghahosseini et al (2017) modeled 100% renewable energy and storage by 2030 using four scenarios. They found energy cost 63 €/MWh in a decentralized scenario but only 42 €/MWh in a centralized scenario, with wind and solar energy as the least-cost options. 100% renewable energy is a real policy option, but enacting it will require political will, they concluded.
- For **Southeast Asia**, Gulagi et al (2017b) modeled three scenarios for a 100% renewable energy system in 2030. They found the cost of energy was 66.7 €/MWh in a decentralized grid but only 63.5 €/MWh in a centralized grid, and that integrating desalination plants and synthetic gas production brought energy costs down further.

While the number of these studies is impressive, few of them considered the steps in how the deployment of renewable energy would actually take place or be financed. It is on these grounds that another team of 21 academic and private energy researchers disputed Jacobson's roadmaps. Clack et al. (2017) attacked Jacobson's work on several points:

- Some of the technology Jacobson relies on is not proven at a mass scale.
- A nationally integrated grid model does not exist.
- Jacobson's estimations of energy from hydropower were off.

Importantly, Clack et al. did not say that achieving 100% renewable energy is impossible. Instead, they argue that in order to bring carbon emissions to zero, several technologies Jacobson excluded – chiefly nuclear energy and carbon capture and storage -- need to be part of the portfolio. Reducing emissions by 80% will be difficult, they argue, and without nuclear and carbon capture and storage, it will be impossible to decarbonize the last 20% (Clack et al., 2017).

Think Tank Literature

Although most of the peer-reviewed literature does not speak directly to how cities can transition to 100% renewable energy, think tanks such as C40 Cities, Bloomberg Philanthropies, ICLEI – Local Governments for Sustainability, Innovation Network for Communities, and Rocky Mountain Institute have published a wealth of information. The mission of these organizations is to drive a worldwide transition to 100% renewable energy by helping cities commit to what looks like an overwhelming task and map out a series of key milestones to get there. Their goal is to help cities understand the specific policies, implementation steps, and challenges in transforming their energy systems from fossil fuel-based to zero carbon emissions. These groups urge city officials to think big and put together a plan that leverages city government, private-sector business, and public opinion to support these lofty goals – and their publications provide real-world examples of how cities are enacting these programs.

This think tank literature falls into two rough categories: substance and process. The literature on substance generally divides a city's energy landscape into sectors, then discusses how emissions from each sector can be lowered and ultimately brought to zero. The literature on process discusses general strategies cities can use to inventory their energy landscape and prioritize actions in transforming it from fossil fuels to renewable energy.

One early sector-based paper was from the think tank Stockholm Environment Institute (Erickson and Tempest, 2014). This study identified four sectors for city action to reduce carbon emissions: buildings, urban form and transportation, freight, and waste management. It found that cities could decrease greenhouse gas emissions 24% or 3.7 gigatons CO_2e (carbon dioxide equivalent) by 2030, and 47% or 8 gigatons CO_2e by 2050 through these actions [see Figure 1]:

- **Urban building energy use**, including stringent codes for new buildings, and energy retrofits for existing buildings. Both new and existing buildings would receive low-energy appliances, LED lights, and solar water-heating systems and heat pumps.

- **Urban form and transport**, in which developing cities would plan compact, pedestrian- and public transit-oriented communities. Transport would center on rail, subways, buses, and bus rapid transit, along with cycling and walking. Developed cities would emphasize the city core over suburban sprawl, with investment in public transit.
- **Improving urban freight**, which would reduce "last leg" energy consumption through improving freight logistics, consolidating shipping centers, and shifting delivery times, as well as encourage use of hybrid engines with idle-off technology or electric vehicles.

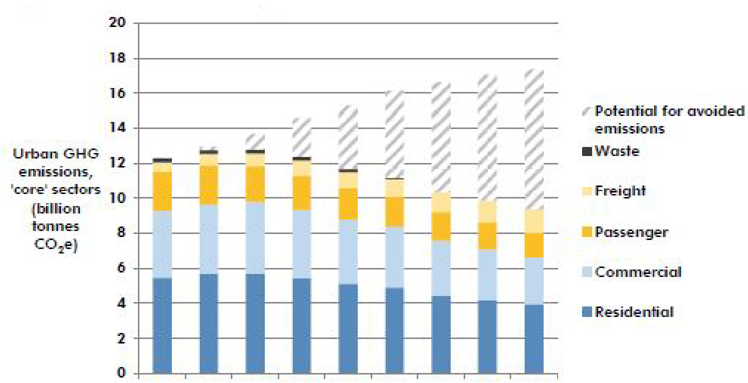


Figure 1: Emissions avoided (Erickson and Tempest, 2014)

- **Urban waste management**, which would reduce the amount of methane-producing organic content (wood, paper, and food) going into landfills and well as cap landfills to capture the biogas produced and use it for energy in place of fossil fuels. Recycling would also be encouraged to reduce the amount of energy used to make new products.

The authors also discussed, but did not quantify, other actions cities can take to lower carbon emissions, including encouraging electricity providers to expand renewables; encouraging programs to share cars and bicycles; and encouraging residents to eat less meat.

Subsequent publications on lowering city carbon emissions built on this model by adding an important sector: electricity supply. For example, a study by Innovation Network for Communities and Bloomberg Philanthropies (Cleveland and Plastrik, 2016) identified buildings, transportation, and waste as important sectors, but instead of discussing freight, it looked at how to decarbonize the electricity consumed by city residents. Cities could green the electricity supply, the study said, by asking utilities to generate more renewable energy, building substantial amounts of local renewable energy generation, eliminating the use of fossil fuels for heating such as by installing heat pumps, and modernizing the electricity grid.

The study also developed new recommendations for the other three sectors it identified. For example, in the buildings sector it suggested making energy management for buildings a highly trained and technically advanced operation, and creating a robust green buildings industry that generates good-paying jobs. In the transportation sector, the study recommended setting a goal of 60% or more transportation by walking, biking or taking public transport and fostering a market for cars and trucks dominated by clean-fuel vehicles. And in the waste management sector, it recommended shifting responsibility for the costs of resource recovery and disposal from consumers to producers to incentivize design and packaging for reuse and recycling.

By 2017, think tank publications moved the goal they were urging cities to adopt from 80% reduction in carbon emissions to 100% renewable energy. A prominent example is *The Carbon-Free City Handbook*, published by Rocky Mountain Institute (Calhoun et al., 2017). This booklet identified the same four sectors for city emissions reductions as previous studies – buildings, transportation, waste management, and electricity supply – and added a fifth sector: industry. Within industry, the handbook recommended converting to low-carbon fuels, repairing infrastructure, replacing motors with high-efficiency models, capturing and reusing waste heat, and developing programs to recognize commitments to continual emissions reductions.

The *Carbon-Free City Handbook* also fleshed out recommended actions in the other four sectors for city emissions reductions. For example, for buildings, the booklet recommended performing deep energy retrofits on existing city-owned buildings, using building codes to phase in requirements for new buildings to achieve net-zero energy, and requiring existing privately-owned buildings to meet specified energy efficiency metrics after a trigger event such as a sale, refinance, or major renovation. In the transportation sector, it recommended converting the city fleet to all electric vehicles, limiting gas cars in city centers, setting freight emissions standards, creating car-free pedestrian zones, and introducing bikeshare programs.

In the electricity supply sector, the handbook recommended converting all city streetlights and stoplights to LEDs, replacing natural gas for cooking, heating, and hot water with electric-only infrastructure, and leveraging mechanisms such as aggregation and power purchase agreements to secure more renewable energy. Finally the handbook reframed waste management to encompass all biological resources, with recommendations to divert organic waste from landfills, create urban forests, and incentivize a shift to a plant-based diet. See Table 3 for a summary of sector-based recommendations for city emissions reductions across these reports.

Table 3: Recommendations for sector-based emissions reductions in three think tank reports

Sector	Recommendation	Stockholm Environment Institute	Innovation Network for Communities	Rocky Mountain Institute
Buildings	City building retrofits	x		x
	Net zero building codes	x	x	x
	Progressive building codes	x	x	x
	Smart LED lighting	x		
	Installing heat pumps	x	x	
	Professional energy management		x	x
	Grow market for green buildings		x	
	Benchmarking and transparency			x
Transportation	Subways and/or light rail	x	x	x
	Bus and/or bus rapid transit	x	x	x
	Introduce bike share		x	x
	60% walking, biking, mass transit		x	
	Convert city fleets to electric			x
	Market for clean-fuel vehicles		x	
	Expand EV charging infrastructure			x
	Emphasize city core over sprawl	x	x	x
	Limit/prohibit cars in city center			x
	Reduce freight emissions	x		x
	Connect regional mobility systems		x	
Electricity supply	Decarbonize supply from utilities		x	x
	Build municipal solar generation			x
	Increase local solar generation		x	x
	Modernize the grid		x	
	LED street/traffic lights			x
	Create green electricity districts			x
Waste management and biological resources	Divert organics from landfill	x		x
	Cap landfills to capture biogas	x		
	Increase recycling	x		
	Adopt zero waste		x	
	Require products to be recyclable		x	
	Create culture to buy less, reuse		x	
	Create urban forests			x
	Shift menus to plant-based diets			x
Industry	Convert to low-carbon fuels			x
	Repair industrial infrastructure			x
	Capture and reuse waste heat			x
	Install high-efficiency motors			x
	Recognize energy commitments			x

The second type of think tank literature on how cities can transition to 100% renewable energy concerns process – that is, how can cities evaluate their overall energy systems to decide which actions to prioritize? A 2015 report by World Wildlife Fund and ICLEI-Local Governments for Sustainability (Steinhoff and Wei) exemplifies this approach. The authors used case studies of four cities with ambitious greenhouse gas reduction goals – Atlanta, Cincinnati, Minneapolis, and Portland – to identify three common themes:

- Strong government leadership to reduce emissions 80% by 2050, with strategies for city government operations including renewable energy and energy efficiency.
- Mutually reinforcing policies from states such as Minnesota's state emissions reduction targets of 80%, Oregon's urban growth boundaries, and Ohio's community choice aggregation rules that allow Cincinnati to provide 100% green electricity.
- Engaging with the private sector to support climate efforts, such as Atlanta's Better Buildings Challenge and Minneapolis's clean energy partnership with utilities.

The report also gathered information about greenhouse gas emissions inventories for 116 cities in the United States using data from ICLEI's ICLEI's ClearPath and carbon*n* Climate Registry (cCR) reporting platforms along with Carbon Disclosure Project,. The results [see Figure 2] show the importance of long-term planning for cities to make the largest reductions in carbon emissions. ICLEI found that communities with 2020 targets would reduce emissions by 38 million tons each year, while those with targets between 2020 and 2035 would reduce emissions by an additional 12 million tons each year. However, cities with long-range targets between 2035 and 2050 were expected to have the biggest, reducing emissions by more than 179 million tons per year starting in 2035. Together all cities studied were expected to reduce emissions by 328 million tons, or 54% from their baseline totals.

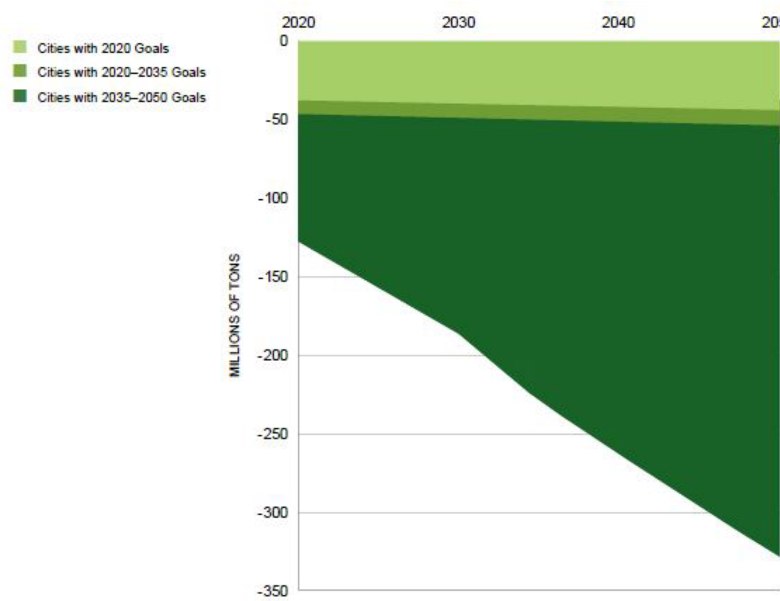


Figure 2: Projected greenhouse gas reductions (Steinhoff and Wei, 2015)

Perhaps the most comprehensive think tank publication about the process of creating a city commitment to 100% renewable energy is *Pathways to 100: An Energy Supply Transformation Primer for U.S. Cities* (Laurent et al., 2017). This booklet outlines a three-step process for city leaders to put together a plan to transform their energy systems: 1) mapping the city's energy landscape; 2) identifying available strategies; and 3) and organizing for transformation. Most important for this report are the first two steps. Step 1 helps city leaders determine the city's relationship with state government [for summary, see Table 4]. It includes:

- **What type of utility serves the city?** Cities are usually served by three utility types:
  - *Investor-owned utilities* are privately owned and serve 68% of U.S. customers. Cities do not have direct control over them, as state regulators determine the utility's rates and services. But cities can influence investor-owned utilities by intervening in state regulatory proceedings, leveraging buying power, or collaborating on programs. Cincinnati has leveraged buying power to obtain 100% renewable energy from Dynergy Energy Systems. Atlanta has worked with Georgia Power to help low-income residents make energy efficiency upgrades.
  - *Municipal utilities* are owned by cities and serve 15% of U.S. customers. Cities have direct influence over municipal utilities, often with full authority to appoint board members, approve a resource plan, and negotiate procurement contracts. San Francisco has used its municipal utility, the San Francisco Public Utilities Commission (SFPUC), to provide 100% renewable energy to city residents.
  - *Rural electric utility cooperatives* serve 14% of U.S. customers and are owned by the customers they serve. Cities do not have jurisdiction over a coop but can collaborate with or lobby the coop's board of directors.
- **What is the state regulatory policy landscape?** Six key energy policies determine which strategies a city can use to enable greater municipal control:
  - *Are utilities regulated or deregulated?* In regulated states, utilities own the power plants that generate energy. In deregulated states, utilities do not own the generation plants, and customers can buy energy from a supplier other than the utility. This makes it easier to seek more renewable energy. All three cities in this report – San Francisco, Atlanta, and Cincinnati – are in deregulated states.
  - *Does the state have tariffs for distributed renewable energy generation?* An example is net metering, which allows customers who own renewable energy such as solar panels to be charged only for energy they use that is supplied by the

utility. This provides an incentive for city residents to add renewables. California and Ohio allow net metering. Georgia does not but has other types of tariffs.

- *Does the state enable Community Choice Aggregation?* CCA allows cities select an electricity provider on behalf of their residents. By pooling their customer base, cities can obtain lower prices or more renewable energy. Eight states including California and Ohio allow CCA. Georgia does not.
- *Does the state enable Power Purchase Agreements?* A PPA enables a third party to build, own, and operate a renewable energy system on behalf of a host customer. The customer usually pays below market rates, and can rent or lease the system. California and Ohio enable PPAs. Georgia does not.
- *Does the state have a Renewable Portfolio Standard?* An RPS requires utilities to generate a certain amount of energy through renewables or buy a certain amount of renewable energy through Renewable Energy Certificates (RECs), a market-based instrument issued when one megawatt-hour of renewable energy is generated and delivered to the grid. California and Ohio both have an RPS, though California's is much stronger than Ohio's. Georgia does not.
- *Does the state require revenue decoupling for utilities?* A utility bill is divided into the cost of generating the energy and the cost of maintaining the transmission lines. Typically the utility's profit comes only from selling electricity to consumers. Decoupling allows the utility to tie profits to transmission, which keeps it from losing money when people generate their own energy from renewables. California and Ohio have electric decoupling. Georgia does not.

Table 4: Mapping the city's energy landscape (Laurent et al., 2017)

	Utility type / Policy	San Fran	Atlanta	Cincinnati
Utility type	Investor owned	Yes	Yes	Yes
	Municipal owned	Yes	No	No
	Rural cooperative	No	No	No
Policy and regulatory landscape	Regulated or deregulated	Dereg	Dereg	Dereg
	Renewable energy tariffs	Yes	No	Yes
	Community Choice Aggregation	Yes	No	Yes
	Power Purchase Agreements	Yes	No	Yes
	Renewable Portfolio Standard	Yes	No	Yes
	Revenue decoupling	Yes	No	Yes

Step 2 of *Pathways to 100* helps city energy officials identify regulatory and legislative strategies they can enact on the local level to encourage a transition to 100% renewable energy. These strategies can target consumers, city operations, or utilities:

- **Consumer oriented strategies** include:
    - Engage the community in setting energy goals.
    - Establish local incentives such as rebates for on-site renewable energy.
    - Establish mandates for on-site renewable energy.
    - Host a renewable energy bulk purchasing program to lower costs.
    - Reduce permitting, zoning, and inspection requirements for renewable energy.
    - Lease public land for renewable energy.
    - Establish tariffs to compensate consumers for energy generated on site.
    - Establish a community renewable energy program such as community solar.
    - Establish a Community Choice Aggregation program.
- **Strategies targeting municipal operations** include:
    - Establish renewable energy purchasing requirements for city buildings.
    - Buy renewable energy from retail electricity suppliers.
    - Partner with the utility or a third party to buy renewable energy.
    - Install renewable energy on site such as solar panels to supply city operations.
- **Utility-focused strategies** include:
    - Engage the utility in setting goals for more renewable energy.
    - Establish a local Renewable Portfolio Standard that requires renewable energy.
    - Approve or influence the utility's long-term energy generation plan.
    - Ask the utility to conduct a feasibility study for buying renewable energy.
    - Approve or negotiate contracts with utilities to procure renewable energy.
    - Pilot a program in which utilities lease rooftops for solar energy generation.
    - Tax utility property to raise money for clean energy programs.
    - Renegotiate agreements that allow utilities to use municipal right-of-way.
    - Establish a city-utility partnership to share decision making power.
    - Purchase the local electric grid to establish a municipal utility.
    - Appoint or approve decision makers for municipal utilities.
    - Intervene in proceedings of the state public utilities commission.

Please see the Results section for discussion of which strategies the case study cities use.

Methods

So far, 120 cities in the United States have committed to transitioning to 100% renewable energy by 2050 or before through passing legislation, and mayors of more than 200 additional cities have pledged to pass such legislation in their cities. Yet cities face a unique challenge when trying to lower carbon emissions: too much of the energy that is bought and consumed by their residents is not under local control. City residents fuel their cars with gasoline produced out of state or in another country. They buy electricity from utilities that generate the power from facilities in another city or state. State, not local, laws often determine the rules for how energy is supplied and used in municipalities. Therefore the major research question for this paper is: How can cities lower carbon emissions when they have so little local control over their own energy generation, regulation, and supply?

To answer that question, this report will examine three cities that have committed to 100% renewable energy and published climate, energy, and sustainability plans for how to achieve this commitment:

- San Francisco, the first city to commit to 100% renewable energy and has the most experience implementing policies to get there.
- Atlanta, the only city to include a full consideration of policy alternatives in its climate and energy plan.
- Cincinnati, which has the most comprehensive sustainability plan of all large cities that have committed to this transition.

The primary research methodology for this report will be a comparative case study approach examining the climate, energy, or sustainability plan for San Francisco, Atlanta, and Cincinnati. According to research methodologist Robert K. Yin, case studies are a good approach when the study is focused on contemporary events and its primary questions are How and Why (Yin, 2018). This project seeks to find out how these cities plan to achieve 100% renewable energy, and why they chose the plans they did.

Case studies are also a useful way to investigate a contemporary phenomenon within its real-world context, especially when the boundaries between the case and its context may not be completely clear, Yin says. Each of these city plans was created within the context of state policy. Just as federalism generally defines when federal policy supercedes state policy and when states can set policy, so states and cities have an analogous relationship often delineated by home rule. State policy generally supercedes city policy, but cities can set their own agenda in many areas. Like state powers under federalism, home rule allows cities to act as laboratories of innovation and adapt to the needs of their residents. Many of the rules and regulations about energy production and consumption are set by states, but cities can also claim a great deal of latitude to set or influence energy policy on a local level.

McNabb (2002) also discusses case studies as a form of qualitative analysis. Qualitative research is useful when there are diverse theories underlying the approach, diverse perspectives of the participants, or construction of cases as a starting point, all of which are features of this project. Qualitative research can be explanatory, or designed to build theories and predict events; interpretive, or designed to build an understanding between researcher and participants; and critical, or designed to question the social structures that society rests on. Of those approaches, this project is explanatory, seeking to identify which of a series of policy alternatives best explains why cities have chosen their plans for achieving 100% renewable electricity.

Bardach and Patashnik (2016) advise modeling the policy alternatives on the system in which the problem is located. In this research project, the problem is that cities do not have enough local control over how the energy their residents use is generated, regulated, and supplied. Thus, the problem rests within the system of extended federalism, in which federal policy supercedes state policy in many areas, while state policy supercedes city policy in many areas. Yet states and cities both have the authority to set policies in areas not regulated by state and federal governments, even if they do not always choose to do so.

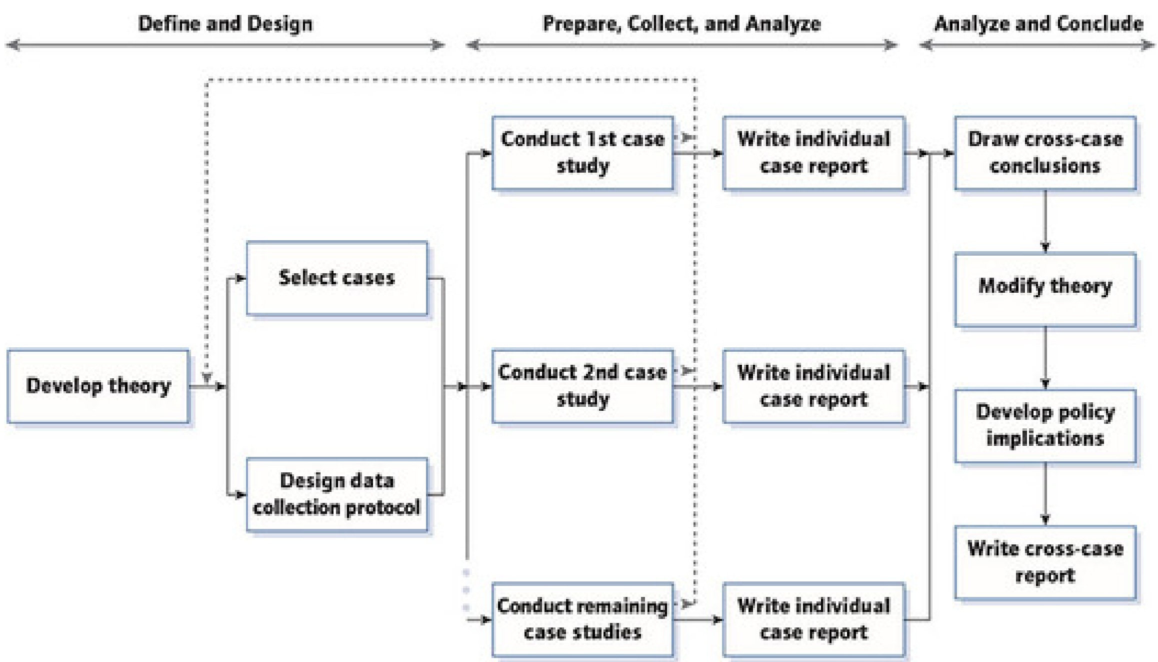
Specifically, this project will examine three possible alternatives for how Atlanta, Cincinnati, and San Francisco chose the particular roadmap they did for how to get to 100% renewable electricity:

- Do these cities plan to achieve their goal of 100% renewable electricity mainly by taking action at the local level, working within the confines of the energy rules and regulations set by the state?
- Do these cities plan to achieve their goal of 100% renewable electricity mainly by pushing state governments to change the rules and regulations that cities must work under to achieve their goals?
- Do these cities plan to achieve their goal of 100% renewable electricity mainly by continuing with business as usual, allowing the energy systems they had in place before making a commitment to continue undisturbed?

The hypothesis for this study is the first proposition: that cities plan to work primarily on the local level to achieve 100% renewable electricity, and will seek to change state rules only if they cannot achieve their goal in another way. Note that these alternatives are not mutually exclusive. A city might take local action in one area, pressure the state in another area, and go with the status quo in a third area. But the key question is which approach dominates their plans to achieve their goal of 100% renewable electricity.

Multiple case studies are preferable to a single case study for this project for several reasons. First, while a single case study works well when the case in question is unusual or extreme, such as in the case of a rare medical disorder, multiple case studies are considered more robust because the investigation can be replicated (Yin, 2018). Each city will be the subject of its own case study, but the same evidence will be sought from each investigation. That will allow for a comparison of cases on the basis of the same research questions and analysis of data through pattern matching, explanation building, and cross-case synthesis. Theories can then be modified depending on findings. For example, in this project if it turns out that one city primarily plans to work at a local level to achieve 100% renewable energy, while the other two cities primarily plan to work with their states, then further research would be needed to determine why these cities took different approaches [see Figure 3].

Figure 3: Multiple Case Study design



Yin, Robert K. (2018) Case Study Research and Applications: Design and Methods, Chapter 2.

The comparative case study approach is also considered a high-quality research design if it passes the four major tests of social science research: construct validity, internal validity, external validity, and reliability. Construct validity, or identifying the correct operational measures for the concepts being studied, will be bolstered in this study by collecting multiple lines of evidence. Internal validity, or seeking to establish a relationship between context and outcome, will be achieved through analysis that includes pattern matching, explanation building, and addressing alternative explanations. External validity, or showing whether a case study's findings can be generalized, will be served by having multiple case studies. And reliability, or demonstrating that the operations of a study can be repeated, will be achieved through a strong case study protocol (Yin, 2018).

One crucial piece of a comparative case study research project is a protocol for ensuring that data is collected consistently across all cases. The case studies in this research project will draw from Yin's methodology to cover the following [see Table 5]:

A. **Overview** – background information about the city, its environmental profile, and substantive issues the city's energy plan had to address.
B. **Source of data** – the city's energy plan for transitioning to 100% renewable energy.
C. **Questions** – the heart of the case study examining the city's recommended actions and goals, as well as the process for decisions about what to include in the plan.
D. **Evaluation** of the city's energy plans along four criteria (Nagel, 1986):
    - *Effectiveness* – the extent to which the policies put the city on the path to achieving 100% renewable electricity.
    - *Efficiency* – the extent to which the policies provide benefits to the city while keeping costs down.
    - *Equity* – the extent to which benefits and costs are spread among those affected so no group receives less than a minimum benefit or pays more than a maximum cost
    - *Feasibility* – how technically and politically likely the policies are to be enacted
E. Which **policy alternative** is dominant?
    - The city is acting mostly on the local level to transition to 100% renewable energy.
    - The city is mostly working with the state to transition to 100% renewable energy.
    - The city is making no changes to its previous energy policies to transition to 100% renewable energy.

Table 5: Protocol for multiple case study of city plans for achieving 100% renewable electricity

A. Overview	City background
	Environmental profile
	Major issues addressed in the city climate plan
B. Source of data	City's climate and energy plan
C. Sectors in which cities can take action to achieve 100% renewable energy	Electricity supply
	Buildings
	Transportation
	Industry
	Waste management
	Regulatory
D. Evaluation of the city's energy plan	*Effectiveness*. How well will the city energy plan achieve a goal of 100% renewable electricity? Which actions have the most impact?
	*Efficiency***.** How much will the city energy plan cost, and how much will it benefit the city? What is the general cost-benefit ratio?
	*Equity***.** How well does the city energy plan take the interests of low income neighborhoods and communities of color into account?
	Feasibility. Are the actions described in the city energy plan feasible both technologically and politically?
E. Which policy alternative is the city primarily using?	The city is acting mostly on the local level to transition to 100% renewable energy.
	The city is mostly working with the state to transition to 100% renewable energy.
	The city is making no changes to its previous energy policies to transition to 100% renewable energy.

This comparative case study will draw the climate and energy plans each city has published outlining how the city intends to achieve 100% renewable electricity. Documents are an important source of data for case studies (Yin, 2018). They are stable and can be reviewed repeatedly and unobtrusively. They are specific, containing details, numbers, rationales, and steps for achieving 100% renewable electricity. The main weakness of relying on documents is that they can reflect the agenda of the author. However, that is not as much of a concern for this research project. The city climate and energy plans are designed to state publicly the steps a city intends to take to achieve 100% renewable energy, so that the city can be held accountable.

As the heart of the case study protocol, Section C deserves special consideration. In examining the climate plans for each city, it is useful to know what substantive actions cities can choose from in putting together a plan for how to reach 100% renewable energy, as well as what process a city might go through in choosing some actions over others.

Two important sources speak to these questions. First, on the question of **how** cities can achieve 100% renewable energy, is *The Carbon-Free City Handbook*, a manual by the Rocky Mountain Institute, an independent nonprofit that works to transform global energy use to create a clean, prosperous, and low-carbon future (Calhoun et al., 2017). This handbook lists 22 recommendations for actions that cities can take in five sectors to transition to 100% renewable energy. Second, on the question of **why** cities might choose some actions but not others, is *Pathways to 100: An Energy Supply Transformation Primer for U.S. Cities*, a strategic and technical consultancy compelled to help solve the world's most challenging problems (Laurent et al., 2017). This booklet lays out 25 strategies grouped by stakeholders and designed to help cities plan for and enable the transformation of their energy systems. Drawing from these two guides, this report will inventory each city's climate and energy plans by examining which of the options listed in Table 8 that it includes and, if included, whether that option works on the local level, the state level, or continues the city's status quo in transitioning to 100% renewable energy.

While Table 6 outlines is a comprehensive list of possible options for city energy leaders to choose from in both the substance and the process of moving to 100% renewable energy, it is important to keep a few things in mind. First, most cities are not going to implement all of these options but choose the most important ones depending on their energy and environmental profile and state regulatory context. More importantly, the reason for examining the city's goals in all six sectors rather than choosing one sector is to see how all the pieces fit together. Because energy systems are rapidly evolving, what happens in one sector will affect how the other sectors operate, and ultimately affect whether cities act locally or work with their states.

For example, as cities increase the number of electric vehicles, electricity supply becomes more important as increasingly cars will be running on electricity rather than gasoline. This in turn makes state regulation of the electricity supply more important. Meanwhile, as cities make buildings and industrial processes more efficient, that reduces the amount of electricity being used but also may run up against state regulations. In a third example, some cities may choose to divert organic waste from landfills to lower the amount of methane produced, while others may choose to cap landfills and use the methane to run city operations. Thus, each energy sector is related to the others, and how the city acts in one sector will affect its actions in other sectors, ultimately influencing whether the city plans to achieve 100% renewable electricity primarily by working locally or with the state.

Table 6: City energy plan options in six areas

Sector	General category	Specific actions
Buildings	Retrofits	City buildings
		All buildings
		LED building lights
		Heat pumps
	Net-zero	City buildings
		New buildings
		Progressive codes
	Benchmarking and transparency	City buildings
		Commercial and large residential
Transportation	Increase EVs, reduce gas cars	Electrify city fleets
		Penalize gas cars
		Reduce freight
		Expand EV charging stations
		Car-free downtown
	Mobility options	Bike, scooter, car share program
		Complete streets
		Public transit – Bus rapid transit
		Public transit – Light rail
Electricity supply	On-site renewable energy	Municipal solar
		Community solar
		Bulk-purchase program
		Lease program
	Off-site renewable energy	Community Choice Aggregation
		Power Purchase Agreements
		Renewable Energy Certificates
	City structure	LED street lights
		Green districts
Industry	Industrial processes	Clean industrial heat
		Efficient motors
		Operator training
Biological resources	Organic waste	Compost organic waste
		Capture and use methane
	Green infrastructure	Urban forestry
	Food	Encourage plant-based diets
Regulatory	Promote renewable energy	Incentives / rebates
		Net metering
		Streamline permitting
	Set standards	Renewable Portfolio Standard
		Carbon budget
	Engage with utility	Partner with
		Exert power over
	Engage with state	Public Utilities Commission
		State legislature, agencies

Data: Case Studies

San Francisco

San Francisco was the first major city to commit to 100% renewable energy through passing Ordinance 81-08 in 2008, which instructed the San Francisco Public Utilities Commission (SFPUC) to develop a plan to achieve the goal of becoming fossil fuel free by 2030. The ordinance was built on a solid foundation of previous climate action by both the city and state. On the city level, the Electricity Resource Plan of 2002 had already successfully reduced greenhouse gas emissions from 1.7 million metric tons of CO_2 ($mtCO_2$) in 2004 to 1.3 million $mtCO_2$ in 2011 through closing two fossil fuels plants, conducting extensive energy efficiency improvements, installing 15 megawatts (MW) of solar generation facilities, and meeting all electricity needs for city government through energy generated by the Hetch Hetchy hydropower plant near Yosemite. Meanwhile, on the state level, California's Renewable Portfolio Standard of 2002 required utilities such as PG&E to generate 33% of their energy from renewable sources by 2020, and the California Global Warming Solutions Act of 2006 required the state to reduce greenhouse gas emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050.

In 2011 the SFPUC issued an Updated Electricity Resource Plan laying out how the city could meet its goal of generating, deploying, and procuring all its electricity needs from renewable and zero-emission energy sources by 2030. The plan projected that business as usual city and state programs to encourage energy efficiency and renewable energy could lower emissions from 1.3 million $mtCO_2$ in 2011 to 1 million $mtCO_2$ in 2020, but that getting to zero emissions by 2030 would require significantly expanded efforts.

However, the plan also found three major challenges to implementation:

- **Control of decisions over energy procurement**. PG&E and other direct service providers supplied 83% of electricity to San Francisco residents and businesses, with 48% generated from fossil fuels. Significantly increasing the share of renewable energy in this supply would require San Francisco to either directly participate in the wholesale energy market or influence the procurement choices of PG&E.
- **Control of transmission and distribution serving the city**. With the exception of public power services at Hunters Point and Treasure Island, PG&E owned the electric distribution and infrastructure system in San Francisco, as well as most transmission lines entering the city. As a result, in order to ensure the transmission and distribution

infrastructure was sufficient to support renewable energy, the city would need to either influence the choices of PG&E or increase city control of infrastructure.

- **State and federal regulations**. PG&E and providers are extensively regulated by the California Public Utilities Commission (CPUC) regarding distribution and sale of electricity, and by the Federal Energy Regulatory Commission (FERC) regarding wholesale transactions and transmission. These regulations prevent San Francisco from regulating most conditions for electric service from PG&E and other providers.

To deal with these challenges. The 2011 Updated Electricity Resource Plan identified three new strategies: empowering San Francisco residents and businesses to reduce emissions from their own energy use; increasing the amount of zero-emission electricity supplied to city customers from the wholesale energy market; and expanding greenhouse gas-free electricity offered by SFPUC. Each of these strategies included a series of recommendations, with a total of 14 recommendations across all three strategies. Together, these strategies and recommendations sought to increase local control over San Francisco's energy generation and supply, and where the city could not control its energy directly, it sought to influence the decisions made by others. See Appendix I for a list of the 2011 San Francisco plan's strategies and goals.

The first strategy, empowering San Francisco residents and businesses to reduce emissions, was centered on increasing local control over energy. The plan recommended numerous ways to do that. First, the city recommended significantly increasing energy efficiency investments. This could be funded through $2 million collected annually in right-of-way fees for the TransBay Cable, and through GreenFinanceSF, the city's Property Assessed Clean Energy program that created $150 million in loans to cover installation of energy efficiency and renewable energy in commercial buildings. The city also sought to gain control over funds for energy efficiency generated through the state's Public Goods Charge and collected by PG&E. Of special concern was the "split incentive" problem: 60% of residential properties in the city were rental units where tenants paid electric bills, giving landlords little incentive to upgrade. The 2011 plan did not have any concrete proposals for how to deal with that.

Another recommendation was to promote "behind the meter" activities, meaning activities on the customer rather than the utility side of the electricity meter. This could include feed-in tariffs allowing people who generate excess power from solar panels to sell it back to PG&E at retail prices, and GoSolarSF, which lowered the price for solar installations by allowing people to buy them in bulk. Since starting in 2008, GoSolarSF had already created 71 jobs and increased solar generation capacity by 5 MW. A related recommendation was to develop community scale energy systems, for example by requiring developments of a certain size to become energy self-sufficient through energy efficiency and renewable energy. The plan also recommended strengthening the city building codes to be more stringent than state requirements for energy efficiency, and to require public disclosure of energy use. Building owners would also be required to replace diesel generators with backup battery storage.

The SFPUC's second strategy for significantly lowering emissions was to increase the amount of renewable and carbon-free energy in the city's electricity supply. The principal way the city did this was by implementing Community Choice Aggregation (CCA), a program in which the city could pool its electricity customers to negotiate more renewable energy from electricity suppliers. To carry out this recommendation SFPUC created CleanPowerSF, which offers options of 48% and 100% renewable energy to San Francisco residents. The city noted two concerns with creating a CCA. First CleanPowerSF would be directly competing with PG&E, meaning it would need to keep prices low enough to attract their customers. Second, customers who left PG&E would have to pay exit fees, meaning CleanPowerSF's prices would need to be even lower to absorb those costs. CleanPowerSF has successfully navigated these concerns: Its current 48% renewable option is cheaper than PG&E's 39% renewable option, and its current 100% renewable energy option is much cheaper than PG&E's [CleanPowerSF, 2019].

The electricity plan also recommended that San Francisco look into developing its own transmission lines from the Hetch Hetchy hydropower plant; develop a green pricing option allowing customers to pay a premium above normal electricity rates, with proceeds used to buy renewable energy; and participate in regulatory proceedings on the state and federal levels. Notably, tihs latter recommendation was the only one that entailed working with the state.

The city's third strategy for gaining local control over its energy system was to continue and expand municipal electricity service from SFPUC. To do this, the 2011 electricity plan outlined four recommendations. First, it urged the city to revamp electricity rates charged by SFPUC, which was providing electricity to many customers at greatly reduced or even no cost. City residents had passed measures allowing SFPUC to issue $100 million in bonds to fund renewable energy investments, but the city could not get the credit rating it needed to issue those bonds because the rates it was charging electricity customers were too low. Second, the plan urged the city to find new uses for energy generated by the Hetch Hetchy hydropower system, such as by installing more EV charging stations. Third, the city could renegotiate its interconnection agreement allowing PG&E to transmit and distribute energy in San Francisco.

Finally, the electricity plan recommended the city implement environmental justice through stakeholder involvement, workforce development, and collaborative partnerships.

At the same time as the SFPUC was working on the Updated Electricity Resource Plan, Mayor Edwin Lee established a Renewable Energy Task Force with the directive of developing recommendations for the city to achieve a 100% renewable electricity supply. The task force, made up of clean energy leaders, business and community stakeholders, and relevant city departments, met monthly for over a year to discuss opportunities for and barriers to renewable energy, including technical, financial, regulatory, policy, and public awareness. The result was 39 recommendations in three areas: energy efficiency, distributed renewable energy, and utility scale renewable generation. Just as SFPUC did in its updated electricity plan, the Renewable Energy Task Force emphasized actions the city could do to gain local control of its electricity generation and supply. Only three of the 39 recommendations discussed trying to influence state regulations or policy; the rest were actions the city could take directly.

Table 7 uses the rubric developed in the Methods section to characterize the policy recommendations from both San Francisco energy plan documents. Almost all recommendations from both plans fell into three categories: buildings, electricity supply, and legislative/regulatory. Entire sectors of energy use such as transportation, industry, and food were ignored. Another theme almost absent was equity. Although prominent in other city energy plans, equity is an afterthought in the San Francisco plan, tacked on last to the third set of recommendations.

An overall evaluation of San Francisco's energy plans along four criteria is as follows:

- **Effectiveness: 5**. The plans put San Francisco on a solid course to achieving 100% renewable electricity, based on energy efficiency, renewable energy, and aggregation.
- **Efficiency: 4**. The plans were cognizant of up-front costs and specified funding mechanisms such as TransBay Cable fees, PACE financing, or municipal bonds.
- **Equity: 2.** The plans implied equity has been achieved by closing power plants in low-income neighborhoods. They did not discuss the impact of raising SFPUC's rates.
- **Feasibility: 4.** Most recommendations are very doable. One exception was extending PACE financing to residential buildings, which federal regulators had not approved.

Table 7. San Francisco recommendations at a glance (SFPUC, 2011) (RE Task Force, 2012) (Both)

Sector	**General category**	**Specific actions**
Buildings	Retrofits	City buildings
		All buildings
		LED building lights
		Heat pumps
	Net-zero	City buildings
		New buildings
		Progressive codes
	Benchmarking and transparency	City buildings
		Commercial and large residential
Transportation	Increase EVs, reduce gas cars	Electrify city fleets
		Penalize gas cars
		Reduce freight
		Expand EV charging stations
		Car-free downtown
	Mobility options	Bike, scooter, car share program
		Complete streets
		Public transit – Bus rapid transit
		Public transit – Light rail
Electricity supply	On-site renewable energy	Municipal solar
		Community solar
		Bulk-purchase program
		Lease program
	Off-site renewable energy	Community Choice Aggregation
		Power Purchase Agreements
		Renewable Energy Certificates
	City structure	LED street lights
		Green districts
Industry	Industrial processes	Clean industrial heat
		Efficient motors
		Operator training
Biological resources	Organic waste	Compost organic waste
		Capture and use methane
	Green infrastructure	Urban forestry
	Food	Encourage plant-based diets
Legislative/Regulatory	Promote renewable energy	Incentives / rebates
		Net metering
		Streamline permitting
	Set standards	Renewable Portfolio Standard
		Carbon budget
	Engage with utility	Partner with
		Exert power over
	Engage with state	Public Utilities Commission
		State legislature, agencies

Atlanta

San Francisco has several natural advantages in setting a goal of 100% renewable energy, including the large Hetch Hetchy hydropower plant that powers all city operations, a sympathetic state government setting ambitious goals for utilities, and the ability to leverage its customer base through aggregation. Atlanta does not have any of these advantages. The state of Georgia has no Renewable Portfolio Standard, provides few incentives for renewable energy and energy efficiency, and does not allow cities to aggregate customers when seeking energy contracts from utilities. Yet in 2017, the city council passed a resolution pledging to transition Atlanta to 100% renewable energy for city operations by 2025 and community wide by 2035, and directed the Mayor's Office of Sustainability to develop a plan for how to get there. What drove city council to make this 100% commitment? In a word, equity, which is at the heart of the Clean Energy Atlanta plan's structure and recommendations. "100% of Atlantans have a right to 100% clean energy," the plan states, proposing three major priorities in achieving this goal: energy equity, investments in energy efficiency, and local investments in renewable energy.

Although the city could not look to state government for help, it did have a strong foundation for action on the local level. A sustainable building ordinance required all construction or renovations of buildings over 5,000 square feet and all existing buildings over 2,500 square feet to be certified by Leadership in Energy and Environmental Design (LEED), one of the most important green building certification programs used worldwide. Through the Atlanta Better Buildings Challenge, the city was on track to improve water and energy efficiency in 114 million square feet of commercial building space by 20%, much of which was financed through $500 million in Property Assessed Clean Energy (PACE) funding. The Solarize Atlanta program was helping private and nonprofit owners afford the cost of installing solar energy through buying in bulk, while the city had installed 1.5 MW of solar capacity on 24 city properties through a Power Purchase Agreement. Finally, the city was on track to transition almost one-third of its vehicle fleet to electric and other alternative fuels by 2020.

Because the city saw equity as the guiding principle of its energy plan, it conducted an extensive stakeholder engagement process. More than 1,700 city residents responded to surveys, 1,000 attended neighborhood planning meetings, 500 participated in community conversations, 100 experts met in stakeholder groups, and 100 leaders took part in focus groups. Through this effort, the city found broad support for the goal of 100% renewable energy but a concern for how it would be financed. Over 80% of participants wanted more solar purchasing options, and 78% wanted more programs for energy efficiency. The top priority for stakeholders was energy efficiency to bring down the cost of energy. Least important was Renewable Energy Certificates, or purchases of renewable energy elsewhere to offset carbon emitted at home. Stakeholders stressed that clean energy should not result in higher electricity bills, and pointed to the split incentive between landlords and tenants as an obstacle for investing in rental units.

To process all the community feedback, the city developed three possible scenarios for how to get to 100% renewable energy. The city then input these models into a computerized tool called Atlanta Clean Energy Scenario, or ACES, to determine how each scenario would affect the cost of energy, job creation, public health, and emissions reduction [see Figure 4].

Scenario 1, Business as Usual, assumed no action to reduce energy consumption or increase renewable energy generation. Instead, the city would offset all of its greenhouse gas emissions through spending $1 million to purchase Renewable Energy Certificates (RECs) generated by wind farms out of state. While this was the least expensive option, it was also the least benefit. It would provide no additional clean energy, result in no economic development, create no local jobs, make no difference on electricity bills, and not improve public health.

Scenario 2, Achieving 50% of Atlanta's Local Clean Energy Potential, assumed the city would achieve half the maximum amount of local clean energy available through energy efficiency and rooftop solar given state regulations in 2018. This was the most cost-effective scenario, resulting in $11 in local benefits for every $1 spent. The vast majority of these benefits would be achieved through energy efficiency, especially for the residential sector. The ACES analysis found that this scenario would create 4,250 local jobs, increase local incomes by almost $1 billion, and grow the local economy by $838 billion, while saving $231 million in public health costs and reducing carbon emissions by 5.3 million metric tons. Atlanta households would save $1.3 billion in electricity costs, or an average of $141 per household each month.

Scenario 3, Maximizing Atlanta's Local Clean Energy Potential, assumed the city would achieve all possible clean energy available through energy efficiency and rooftop solar given current regulations in 2018. This scenario provided the greatest benefit to Atlantans, creating almost 8,000 jobs, increasing local incomes by $1.8 billion, and growing the local economy by $1.5 billion, while saving almost $600 million in health care costs and reducing carbon emissions by 13.5 million metric tons. Atlanta households would save $2.3 billion in electricity costs, or an average of $234 per household each month. Commercial energy efficiency and rooftop solar would be the most important parts of this scenario.

Figure 4: Scenarios for 100% renewable energy (Clean Energy Atlanta, 2018)

	Scenario No.1 *Business as Usual - 0%*	**Scenario No.2** *50% Clean Energy*	**Scenario No.3** *100% Clean Energy*
The following three scenarios outline estimated impacts from clean energy investment with no change (0%), a 50% investment in clean energy, and a 100% investment.	18% of Atlanta's electricity is directly provided by clean energy sources. No homes and commercial buildings undergo energy renovations. No homes and commercial buildings install solar panels. No homes powered by community solar. Out-of-state wind farms financed by Atlanta.	38% of Atlanta's electricity is directly provided by clean energy. 45K homes undergo energy renovations. 6.75K commercial buildings undergo energy renovations. 24.2K home solar installs. 715 commercial solar installs. 6.2K homes powered by community solar. 15 out-of-state wind farms financed by Atlanta.	66% of Atlanta's electricity is directly provided by clean energy. 90K homes undergo energy renovations. 13.5K commercial buildings undergo energy renovations. 48.3K home solar installs. 1,430 commercial solar installs. 12.5K homes powered by community solar. 30 out-of-state wind farms financed by Atlanta.

Renewable Energy Source Key

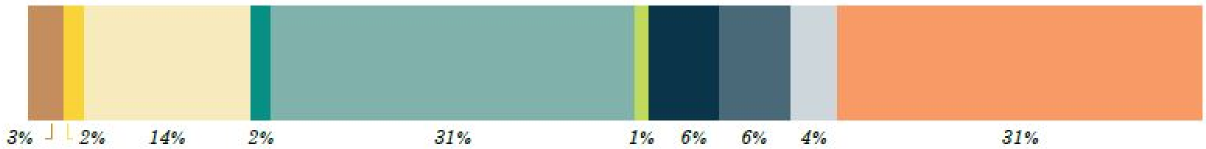
- Residential Solar
- Commercial Solar
- Utility Solar
- Hydro Con
- Imported REC Purchase
- Imported Wind
- Single Family Efficiency
- Multifamily Efficiency
- Commercial Efficiency
- GA SREC

Scenario No.1: Business As Usual, Renewable Energy Credits Only

Cumulative Benefits
$0
Cumulative Costs
$1,000,000
Net Benefits
-$1,000,000
Benefit to Cost Ratio
0

Through 2035	**Full Impact**	**Equal To**	
Local Jobs Created	0	0	Coca Cola HQ
Local Incomes Increased By	$0	$0	Per Atl. Citizen per Year
Local GDP Growth	$0	0%	Delta Global Revenue
Public Health Savings	$0	$0	Months Health Ins. Savings
Metric Tons CO_2 Reduced	0	0	Months without Cars
In 2035			
Household Bill Savings	$0		
Monthly Bill Savings: Participants	$0	0%	Home Electricity Savings
Monthly Bill Savings: Non Participants	$0	0%	
Commercial Total Bill Savings	$0		
Monthly Bill Savings: Participants	$0	0%	Commercial Electricity Savings
Monthly Bill Savings: Non Participants	$0	0%	

Scenario No. 2: Achieving 50% of Atlanta's Local Clean Energy Potential

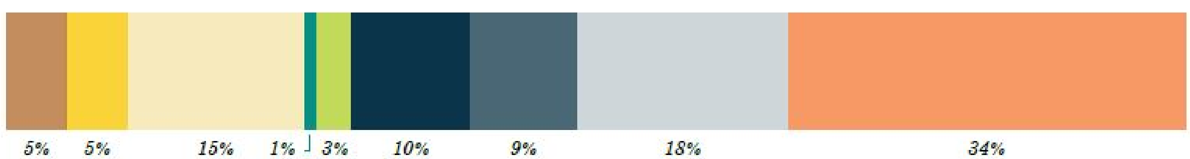


Cumulative Benefits
$15.435 Billion
Cumulative Costs
$373 Million
Net Benefits
$15.062 Billion
Benefit to Cost Ratio
41.4

Through 2035	Full Impact	Equal To	
Local Jobs Created	4,250	1.9	Coca Cola HQ
Local Incomes Increased By	$991 Million	$117	Per Atl. Citizen per Year
Local GDP Growth	$838 Million	13.7%	Delta Global Revenue
Public Health Savings	$231 Million	$2.26	Months Health Ins. Savings
Metric Tons CO_2 Reduced	5.3 million	7	Months without Cars

In 2035			
Household Bill Savings	$1.3 Billion		
Monthly Bill Savings: Participants	$141	57%	Home Electricity Savings
Monthly Bill Savings: Non Participants	$35	14%	
Commercial Total Bill Savings	$2.4 Billion		
Monthly Bill Savings: Participants	$770	28%	Commercial Electricity Savings
Monthly Bill Savings: Non Participants	$513	19%	

Scenario No.3:
100% Renewable Energy



Cumulative Benefits
$28.783 Billion
Cumulative Costs
$1.379 Billion
Net Benefits
$27.404 Billion
Benefit to Cost Ratio
20.9

Through 2035	Full Impact	Equal To	
Local Jobs Created	7,775	3.5	Coca Cola HQ
Local Incomes Increased By	$1.8 Billion	$213	Per Atl. Citizen per Year
Local GDP Growth	$1.5 Billion	25.2%	Delta Global Revenue
Public Health Savings	$594 Million	$5.82	Months Health Ins. Savings
Metric Tons CO_2 Reduced	13.5 Million	17	Months without Cars

In 2035			
Household Bill Savings	$2.3 Billion		
Monthly Bill Savings: Participants	$234	95%	Home Electricity Savings
Monthly Bill Savings: Non Participants	$63	26%	
Commercial Total Bill Savings	$4.4 Billion		
Monthly Bill Savings: Participants	$2,040	74%	Commercial Electricity Savings
Monthly Bill Savings: Non Participants	$929	34%	

While the Clean Energy Atlanta plan did not choose one of these scenarios for achieving 100% renewable energy, it did note the vast majority of stakeholders preferred Scenario 2 or 3. The plan ruled out Scenario 1, spending $1 million on Renewable Energy Certificates, even though that was the cheapest option, because it would not result in local investments and did not address equity. Instead of relying solely on RECs to offset carbon emissions, the city thought the better option was to invest in the local community. First, the plan recommended investing in energy efficiency to reduce the amount of energy needed, lower carbon emissions, and save residents money. Next the plan recommended investing in increasing renewable energy, especially through incentives and financing of rooftop solar. Only after these steps were taken would the city buy RECs to make up the difference and get to 100% renewable energy.

To achieve this goal, the Clean Energy Atlanta plan recommended a list of actions in the immediate, short, and long term in the areas of energy efficiency, renewable energy, electric vehicles, energy storage, and cross-cutting categories.[See Table 8 for a summary of these recommendations, and see Appendix II for a full listing.] Clean Energy Atlanta's recommendations to reach 100% renewable energy center on the same three sectors as San Francisco's plan: buildings, electricity supply, and engagement on regulations, with a few additional actions in transportation. Notably, while a number of the recommendations in the Atlanta plan entail working in collaboration with their local utility Georgia Power, not a single recommendation involves trying to partner with or exert influence over the state legislature or regulatory agencies. The plan also pushed back on city council's directive to reach 100% renewable energy community wide by 2035, seeking instead to get city operations to 100% renewable energy by 2035 and community wide by 2050.

An overall evaluation of Atlanta's energy plan along four criteria is as follows:

- **Effectiveness: 3**. While the plan leverages all the partnerships it can, it is unclear whether that will be enough to get to 100% renewable energy by 2035 or even 2050.
- **Efficiency: 4**. While Scenarios 2 and 3 are the more expensive options, they provide a huge return on investment that will strengthen the city whether or not it gets to 100%.
- **Equity: 5.** Atlanta makes equity a central concern through engaging stakeholders and examining how each action affects the least advantaged city residents.
- **Feasibility: 4.** Most recommendations are very doable. However, many are centered on public education and exploring options, and may not actually reduce emissions.

Table 8. Atlanta recommendations at a glance (Clean Energy Atlanta, 2018)

Sector	General category	Specific actions
Buildings	Retrofits	City buildings
		All buildings
		LED building lights
		Heat pumps
	Net-zero	City buildings
		New buildings
		Progressive codes
	Benchmarking and transparency	City buildings
		Commercial and large residential
Transportation	Increase EVs, reduce gas cars	Electrify city fleets
		Penalize gas cars
		Reduce freight
		Expand EV charging stations
		Car-free downtown
	Mobility options	Bike, scooter, car share program
		Complete streets
		Public transit – Bus rapid transit
		Public transit – Light rail
Electricity supply	On-site renewable energy	Municipal solar
		Community solar
		Bulk-purchase program
		Lease program
	Off-site renewable energy	Community Choice Aggregation
		Power Purchase Agreements
		Renewable Energy Certificates
	City structure	LED street lights
		Green districts
Industry	Industrial processes	Clean industrial heat
		Efficient motors
		Operator training
Biological resources	Organic waste	Compost organic waste
		Capture and use methane
	Green infrastructure	Urban forestry
	Food	Encourage plant-based diets
Legislative/Regulatory	Promote renewable energy	Incentives / rebates
		Net metering
		Streamline permitting
	Set standards	Renewable Portfolio Standard
		Carbon budget
	Engage with utility	Partner with
		Exert power over
	Engage with state	Public Utilities Commission
		State legislature, agencies

Cincinnati

While San Francisco's plan to reach 100% renewable energy was the first by a major city, and Atlanta's plan was distinguished by its comparison of scenarios with a commitment to equity, Cincinnati's plan to reach 100% renewable energy is marked by its comprehensiveness. The breadth of the 2018 Green Cincinnati Plan is a result of how it was developed. Cincinnati's inspiration was *Drawdown*, a project led by Paul Hawken that pulled together a broad coalition of researchers, scientists, policy makers, business leaders, and activists to map, measure, and model the 100 most substantive solutions to climate change. Every solution in Drawdown is ranked by greenhouse gas impact, cost effectiveness, feasibility, and benefit to society, and Cincinnati set out to do the same. In 2017 Mayor John Cranley appointed 30 local leaders to a steering committee that then put together task teams that generated solutions to climate change in eight sectors. These solutions were analyzed by university researchers for costs, benefits, and carbon reduction potential before being circulated at community meetings for public comment. The resulting 2018 Green Cincinnati Plan includes 80 recommendations in eight areas, each listing examples in peer cities, local champions, feasibility, obstacles, costs and benefits, keys to equity, and impact on greenhouse gas emissions.

As in both San Francisco and Atlanta, Cincinnati's plan builds on a solid foundation of previous city action. From 2006 through 2015, greenhouse gas emissions in Cincinnati had dropped 36% for city operations and 18% community wide. The chief contributing factor for this reduction was the 2012 electricity aggregation process in which the city pooled all residential electricity customers to leverage an option of 100% renewable energy from Dynegy Energy Services at better pricing than the Duke Energy standard rate. The program achieves renewable energy through purchasing Renewable Energy Certificates to offset consumption of electricity by participants. In 2017, Cincinnati expanded aggregation to include natural gas through a contract with Constellation to supply biogas from landfills and farms. Besides aggregation, the city also made significant investments in energy efficiency for city buildings, facilitated energy efficiency upgrades for commercial buildings, installed solar panels several city facilities, and instituted programs to increase recycling and divert waste from its landfill.

To implement the Green Cincinnati Plan, the city identified three strategies:

- Lead by example to green city operations and implement efficiency gains.
- Partner with businesses, nonprofits, and others to identify a champion.
- Set quantitative goals and measure progress in each of the eight focus areas.

The eight focus areas in the Green Cincinnati Plan included two that both San Francisco and Atlanta focused on – buildings and electricity supply – but Cincinnati also put much more emphasis on transportation and biological resources.

In the building sector, Cincinnati made some of the same recommendations as other cities for significantly increasing energy efficiency and incentivizing or requiring buildings to meet sustainability standards such as LEED certification. Cincinnati also singled out the split incentive in encouraging landlords to make energy efficiency upgrades on their property even though energy bills are paid by tenants. Whereas San Francisco and Atlanta proposed no solutions for the problem, Cincinnati recommended requiring landlords to publish utility costs for their properties to incentivize energy efficiency investments. Cincinnati also went beyond other city plans in recommending creation of a Sustainability District committed to reducing building energy use, water consumption, and transportation emissions 50% by 2030.

Likewise, in the transportation sector, Cincinnati joined Atlanta in recommendations to electrify the city fleet, implement a car sharing program, and expand the number of charging stations. But Cincinnati went beyond other energy plans in several recommendations such as starting a pilot project for autonomous vehicles, improving walkability by installing more sidewalks, and increasing public transit funding.

The Green Cincinnati Plan also included entire sectors of action completely absent from other city plans. For example, an education and outreach group recommended installing solar panels on all city schools and expanding sustainability workforce training through a city-university-corporate partnership. A working group on food made recommendations to reduce food waste, expand urban agriculture, and set up hubs to distribute local food. A task team on natural systems recommended creating a carbon offset program to fund tree planting, expanding wetlands, developing an air quality plan, and conducting a biodiversity assessment. A resilience working group recommended conducting a neighborhood vulnerability assessment, developing a multilingual communication network, conducting an urban heat island assessment, and developing an environmental justice program to reduce burdens on polluted communities. Finally, a working group on waste made numerous recommendations to increase recycling rates and reduce waste through, for example, implementing a fee or ban on single-use bags.

Capping all 80 recommendations in eight areas were specific quantitative goals that can be measured and tracked. For example, in the building sector, Cincinnati plans to make all city facilities and operations net carbon neutral by 2035; in outreach, the city will establish a $1 million Green Cincinnati Fund to finance sustainability projects through donations; in energy, Cincinnati plans to triple renewable generation for residents and businesses; for food, the city plans to double the number of people eating plant-based diets; in natural systems, the city wants every resident to be within a 10-minute walk of a park; under resilience, Cincinnati hopes to decrease hospital admissions for childhood asthma by 50%; in transportation, the city plans to increase passenger miles traveled via public transit by 25%; and under waste, Cincinnati plans to be net zero waste by 2035. See Table 9 for the complete list of quantitative goals.

Table 9: Quantitative goals from the 2018 Green Cincinnati Plan

Built environment	• Make all city facilities, fleets, and operations carbon neutral by 2035 • Decrease household energy burden by 10% • Increase the percentage of city streets meeting complete streets requirement by 1% per year (center-lane miles)
Education / Outreach	• Register 100 businesses in a green business certification program • Establish a $1 million Green Cincinnati Fund to support sustainability • Increase by 10% the number of city residents that can name at least 3 actions they are doing to be green/promote sustainability
Energy	• 100% renewable energy for city government by 2035 • Triple renewable energy generation for residents and businesses • Reduce energy consumption 2% annually
Food	• 100% of residents have convenient access to healthy, affordable foods • Reduce food waste by 20% by 2025 • Triple acreage of urban food production • Double the number of residents consuming local foods • Double the number of people eating plant based diets
Natural systems	• Attain 100% of EPA National Ambient Air Quality Standards • Increase city-wide tree canopy coverage to at least 40%, ensure all residential neighborhoods to 30% tree canopy coverage • Meet EPA Recreational Water Quality Criteria in 90% of Cincinnati waterways, 90% of the time • Have a park within a 10-minute walk of every city resident
Resilience	• 50% decrease in childhood asthma-related hospital admissions in target neighborhoods. Reduce disparities between neighborhoods • No increase in storm or heat related fatalities • No increase in storm damage remediation costs
Transportation	• Decrease the consumption of fossil fuels by 20% • Increase the passenger miles travelled via public transit by 25% by 2035 • Double lane miles of bike trail
Waste	• Zero Waste by 2035 • Decrease residential tonnage to landfill by 20% • Increase participation in curbside recycling programs by 5% in residential and 20% in commercial

Of the 80 recommendations in the Green Cincinnati plan, only two involve approaching legislators and regulators. Cincinnati plans to partner with local and state organizations to apply for state funding to create regional programs to make the city more sustainable. The city also plans to partner with other cities to lobby for additional renewable energy and energy efficiency programs through such issues as reducing the setback requirement for wind turbines, strengthening the state's Renewable Portfolio Standard, legalizing virtual net metering which would allow for community solar installations, and opposing subsidies for inefficient coal plants. See a summary of Cincinnati's energy plan recommendations in Table 10 and a full list in Appendix III.

An overall evaluation of Cincinnati's energy plan along four criteria is as follows:

- **Effectiveness: 5**. The quantitative goals across a wide range of sectors is impressive, with expected greenhouse gas reductions defined for each recommendation.
- **Efficiency: 3**. Some recommendations are quite expensive, with costs to be determined for others. Priority should go to those with the most return on investment.
- **Equity: 4.** The Resilience section is all about equity, and this plan proposes a solution for the split incentive problem that derails efficiency in so much low-income housing.
- **Feasibility: 4.** Most recommendations are very doable. However, it is unclear whether the champions identified for each recommendation will actually push it through.

Table 10. Cincinnati at a Glance (Green Cincinnati, 2018) (unable to do due to state law)

Sector	General category	Specific actions
Buildings	Retrofits	City buildings
		All buildings
		LED building lights
		Heat pumps
	Net-zero	City buildings
		New buildings
		Progressive codes
	Benchmarking and transparency	City buildings
		Commercial and large residential
Transportation	Increase EVs, reduce gas cars	Electrify city fleets
		Penalize gas cars
		Reduce freight
		Expand EV charging stations
		Car-free downtown
	Mobility options	Bike, scooter, car share program
		Complete streets
		Public transit – Bus rapid transit
		Public transit – Light rail
Electricity supply	On-site renewable energy	Municipal solar
		Community solar
		Bulk-purchase program
		Lease program
	Off-site renewable energy	Community Choice Aggregation
		Power Purchase Agreements
		Renewable Energy Certificates
	City structure	LED street lights
		Green districts
Industry	Industrial processes	Clean industrial heat
		Efficient motors
		Operator training
Biological resources	Organic waste	Compost organic waste
		Capture and use methane
	Green infrastructure	Urban forestry
	Food	Encourage plant-based diets
Legislative/Regulatory	Promote renewable energy	Incentives / rebates
		Net metering
		Streamline permitting
	Set standards	Renewable Portfolio Standard
		Carbon budget
	Engage with utility	Partner with
		Exert power over
	Engage with state	Public Utilities Commission
		State legislature, agencies

Results

Since 2010, 120 cities across the United States have committed to transitioning to 100% renewable energy. This report conducted case studies of three of these cities – San Francisco, Atlanta, and Cincinnati – in an effort to answer a central research question: How can cities lower carbon emissions when they have so little local control over their own energy generation, regulations, and supply? This study considered three possible alternatives for how cities could achieve 100% renewable energy:

- **Local action**: Getting to 100% renewable energy mainly by taking action at the local level, working within the confines of rules and regulations set by the state.
- **State action**: Getting to 100% renewable energy mainly by pushing state governments to change the rules and regulations that cities must work under.
- **Status quo**: Achieving 100% renewable energy mainly by continuing with business as usual, allowing the energy systems they had in place to continue undisturbed.

Of these alternatives, the hypothesis for this project was that cities would plan to achieve 100% renewable energy mainly by taking action on the local level. The case studies of San Francisco, Atlanta, and Cincinnati have provided evidence to support that hypothesis. Each city's energy plan set strategies and goals, then made recommendations for how to achieve these goals. Although the number of recommendations varied from 14 to 80, the vast majority of energy plan recommendations were for things cities can do directly without having to rely on the state. San Francisco's 2011 energy plan had 14 recommendations of which only one – participating in regulatory proceedings with the California Public Utilities Commission – involved working with the state. Atlanta's energy plan had 35 short- and long-term recommendations, of which zero were to work with the state. Cincinnati's energy plan had 80 recommendations, of which only two – partnering with other cities to lobby state elected officials on sustainability issues and working with the Public Utilities Commission of Ohio to encourage energy efficiency and renewable energy – involved working with the state. Table 11 summarizes these results.

Table 11: Local and state-based recommendations in city energy plans

City	# Recommends	# Local-Based	# State-Based	% Local-Based
San Francisco	14	13	1	93%
Atlanta	35	35	0	100%
Cincinnati	80	78	2	97%

Of particular note in examining the energy plans of San Francisco, Atlanta, and Cincinnati are the relationships between the city and one of its key stakeholders, the major utility that serves its residents. This relationship in turn is shaped by state rules and regulations about energy generation and use. For example, a running theme throughout San Francisco's energy plan was efforts to take over control of the energy system from investor-owned utility PG&E, which supplied most of the electricity to city residents. The plan discussed numerous ways to declare independence from PG&E, compete against PG&E, make PG&E pay for city services, or wrest control of funding from PG&E. This pushback against a powerful local utility was possible because of the state setting in which San Francisco is placed. California has ambitious renewable energy and energy efficiency standards that have helped to build a strong foundation for city action, and California is one of only eight states where aggregation is legal, giving city leaders an important tool for increasing the amount of renewable energy. In addition, San Francisco owned its own municipal utility, already supplied with 100% hydropower. These advantages gave city leaders secure footing to compete directly with PG&E for customers through an aggregation program, and to claim ownership of funds from PG&E through mechanisms such as cable fees and right of way charges. San Francisco city leaders were also not shy about lobbying state regulators to do even more to increase clean energy, such as through transferring management of the public goods charge on utility customer bills of city residents to the city instead of PG&E.

By contrast, Atlanta had no such footing to compete against Georgia Power or demand that the utility pay for city services. Not only does Atlanta have no municipal utility to use as leverage, but it also is located in a state where the legislature is not sympathetic to renewable energy and energy efficiency, and where regulatory tools such as aggregation to help cities increase renewable energy are not available. Therefore, Atlanta has to rely on building a collaborative partnership with Georgia Power to carry out many of its recommendations, such as educating city residents about incentives for renewable energy and energy efficiency; starting a Round-It-Up program in which residents could pay for energy efficiency by rounding electricity bills to the nearest dollar; identifying potential sites for utility-scale solar development; establishing a special rate for renewable energy; adding electric vehicle charging stations; and facilitating bulk purchase of Renewable Energy Certificates. Atlanta does have some leverage to ask for this cooperation as the city is Georgia Power's largest customer, representing 10% of the utility's electricity demand. But if the city is to achieve 100% renewable energy, it will be through seeking a partnership, not confrontation. Nor are Atlanta city leaders engaging at all with the state on energy goals; instead, the city is making its own local clean energy investments.

If San Francisco's relationship with PG&E could be characterized as competitive and Atlanta's relationship with Georgia Power could be characterized as collaborative, Cincinnati's relationship with Duke Energy could be seen as indifferent. Only two of the 80 recommendations in the Green Cincinnati Plan involved working with Duke Energy – a plan to install 100% LED streetlights and a program to increase battery storage. This relationship again can be traced back to the state regulatory setting in which Cincinnati is placed. Ohio is a state with good laws for renewable energy and energy efficiency such as a Renewable Portfolio Standard and Community Choice Aggregation; however, an unsympathetic legislature is seeking to roll those laws back. Although Cincinnati does not have a municipal utility, it does have the ability to aggregate its customers to provide 100% renewable electricity. Cincinnati currently runs the largest city aggregation program in the Midwest. That means the city is not dependent on Duke Power to enact renewable energy or energy efficiency programs, though it can work with the utility where that makes sense. While the city does not prioritize lobbying the state legislature and regulatory agencies, it does plan to stay engaged to improve state energy policies or at least keep them from getting worse.

One challenge identified by all three city energy plans is the split incentive for rental properties both commercial and residential. In many cities, half or more of residents rent their homes, many of which are low-income households. This presents a challenge to city officials trying to increase energy efficiency and renewable energy. Landlords are generally responsible for maintenance and repairs on residential and commercial properties, but tenants generally pay the utility bills, thus giving landlords little incentive to spend money on energy efficiency and renewable energy upgrades. Although all three city energy plans identified the split incentive as a problem, only Cincinnati discussed how to address it, outlining tactics such as:

- Targeting apartment complexes for energy efficiency upgrades.
- Encouraging commercial building owners to use PACE financing that leverages property values to get loans for energy upgrades.
- Giving away LED light bulbs.
- Offering green leasing programs in which both landlords and tenants pay for energy upgrades.
- Requiring landlords to list energy costs along with rent for their properties so that prospective tenants can be informed.

Another theme across these three case study city energy plans is the wide variety of regulatory and financial mechanisms available for city leaders seeking to transition cities to 100% renewable energy. Step 2 of the *Pathways to 100* manual provides a range of regulatory strategies discussed on page 24 of this report, and all three of this report's case study cities took advantage of many of these options. For example, all three cities had programs to engage with the community on plans to transition to 100% renewable energy. This kind of engagement is crucial, as city residents, particularly low-income residents, are key stakeholders. All three cities plan to provide incentives for renewable energy and energy efficiency such as bulk purchasing of solar energy and reducing permitting requirements. All three cities also plan major investments in on-site renewable energy to power municipal buildings and operations. Where programs such as Community Choice Aggregation and community solar are legal, cities are pursuing them. Table 12 summarizes the regulatory programs in each case study city.

Table 12: Regulatory strategies used by three case study cities (Pathways to 100, 2017)

Focus	Strategy	San Fran	Atlanta	Cincinnati
Consumer	Engage the community	x	x	x
	Incentives for renewable energy	x	x	x
	Mandates for renewable energy			
	Bulk purchasing program for solar	x	x	x
	Reduce permitting requirements	x	x	x
	Lease public land for renewables		x	
	Tariffs to compensate consumers	x		
	Community solar	x	x	
	Community Choice Aggregation	x		x
City operations	Renewable mandates for buildings	x	x	
	Buy renewable energy retail			
	Partner with utility		x	x
	Install renewable energy on site	x	x	x
Utility	Get utility to set renewable goals		x	
	City Renewable Portfolio Standard			
	Long-term energy generation plan	x	x	x
	Study buying renewable energy		x	x
	Contracts to procure renewables			x
	Lease rooftops for solar generation			
	Tax utility to pay for renewables	x		
	Renegotiate right-of-way contracts	x		
	City-utility partnership		x	
	Purchase local electric grid	x		
	Approve utility decision makers			
	Intervene in state PUC	x		x

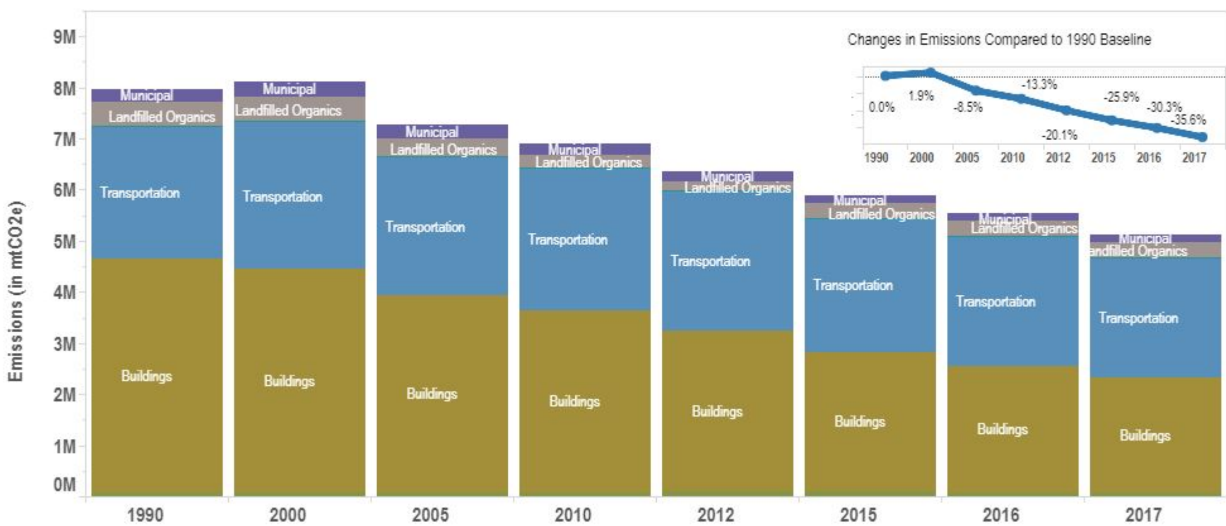
Just as cities have a wide array of regulatory strategies to choose from in transitioning to 100% renewable energy, they also have a wide array of funding mechanisms. Cities that have made this commitment see it not as a burden but as an investment in their local communities. For example, Atlanta chose not to follow the cheapest option for 100% renewable energy – spending $1 million on Renewable Energy Certificates – because that money would have gone out of state and would not have been invested in the local community. Instead, city leaders chose the more expensive option of investing in local energy efficiency and renewable energy, as a way to increase equity among Atlanta residents while cleaning the air and improving public health.

However, every investment has up-front costs, so these cities have identified a range of funding mechanisms to pay for the programs they are undertaking. Funding mechanisms explored by San Francisco, Atlanta, and Cincinnati include:

- **Traditional financing**. City issues municipal bonds for public-sector projects and commercial bank loans for private-sector projects.
- **City-funded**. City uses revenue from a targeted program such as a sustainability fund.
- **Green pricing**: City works with utility to establish a special renewable energy rate.
- **Net metering / feed-in tariffs**. Utilities pay customers that have solar generation equipment a fee for any excess energy the customer puts back onto the grid.
- **Bulk purchasing**. City gets discounts on solar energy systems by buying in bulk.
- **Round it up**. Utility customers pay a premium above the normal electric bill to finance renewable energy and energy efficiency.
- **Pay as You Save / On Bill.** Utilities issue loans to customers for energy efficiency projects, which customers repay through monthly payments on their electric bills.
- **Third-party ownership**. A third party owns the product or service and receives payments to cover the full cost. Includes equipment leases and service agreements.
- **Public-private partnership.** City grants responsibility to a private entity for infrastructure assets, project implementation, or ongoing services.
- **Utility fees.** City charges fees for right of ways for transmission and distribution lines or for interconnection with city facilities, and uses proceeds to fund clean energy projects.
- **Aggregation.** Pooling electricity customers in a jurisdiction to negotiate lower prices and more renewable energy from utilities and other electricity suppliers.
- **Property Assessed Clean Energy (PACE).** Financing for clean energy upgrades on commercial buildings is tied to property values and paid back on property tax bill.

Finally, no study of city transitions to 100% renewable energy would be complete without asking the ultimate question: Is what these cities are doing working? Of the three case study cities in this report, only one – San Francisco – has had a 100% renewable energy plan in place long enough to answer this question. Atlanta and Cincinnati both published their plans in 2018, but San Francisco made its commitment in 2010 and published a plan in 2011. To determine whether this plan is working, one can examine San Francisco's Climate Dashboard, published online by the Department of the Environment. This dashboard [see Figure 5] shows that while greenhouse gas emissions in San Francisco were already falling before 2010, emissions began to fall faster after the 2011 plan was put into place. Specifically, from 2010 through 2017, emissions from buildings, transportation, landfilled organics, and municipal operations fell 26% from 6.8 million mtCO_2e to 5 million mtCO_2e. During the previous 10 years from 2000 to 2010, emissions had fallen by only 15%.

Figure 5. San Francisco's GHG Emissions (Climate Dashboard, Department of Environment)



Of course, results for each city energy plan will need to be evaluated separately, and city leaders will need to use these results to determine what is working and where improvements are needed. In the case of San Francisco, emissions from buildings are clearly the driving force behind the city's overall success at reducing carbon emissions. If the city wants to get emissions to zero, it will need to do more to address the transportation sector. Thus, continual inventorying and measuring of carbon emissions from several sectors is critical for cities committed to 100% renewable energy. Other cities have much to learn from the experience of the city that went first.

Conclusions

This study of plans for 100% renewable energy plans in three major cities is a deep dive into what these plans consist of and why these cities shaped their plans in the way they did. The study provides evidence that cities are choosing to invest in energy efficiency and renewable energy in their local communities as a way of taking local control of their energy supplies. The study necessarily had to be a deep dive to cover all the areas in which cities are working on energy policy and investments. However, a deep dive on city energy plans has one key limitation in that it is not broad. This is a sample size of three cities, and it is possible that other cities with a commitment to 100% renewable energy are achieving their goal by working mainly with their states. More research is needed to evaluate the sustainability plans of other cities committed to 100% renewable energy to see how they are making it happen. In addition, as cities that have made this commitment move forward, it will be important to examine whether they are able to carry out the strategies and recommendations in their energy plans to achieve their goals, particularly for cities in states like Georgia that provide little support. Finally, it is critical for cities to continually measure their greenhouse gas emissions to see whether their transition to 100% renewable energy is having the desired effect of getting emissions to zero.

Although this report is based on a small sample size, the results are consistent enough across all three case study cities to identify a preliminary blueprint for how cities such as Columbus that might be considering a commitment to 100% renewable energy could move forward. Such a transition blueprint could consist of five steps:

1. **Invest in energy efficiency**, which reduces the amount of energy used and lowers the cost. Energy efficiency is especially important for low-income city residents, who are paying too high of a percentage of household income on electricity and gas.
2. **Promote renewable energy,** whether by building solar generation arrays on city buildings and land or providing incentives and assistance for residential solar.
3. **Transition to electric vehicles,** both by converting the city fleet of cars and buses and by encouraging private ownership of EVs by installing a robust EV charging infrastructure.
4. **Green the energy supply,** whether by encouraging investor-owned utilities to build utility-scale wind and solar generation, using the municipal utility to generate or procure renewable energy, or using aggregation to increase the supply of renewable energy.
5. **Buy Renewable Energy Certificates** only after the previous steps have been maximized, and ensure the certificates purchase energy from as close to home as possible.

Cities that commit to 100% renewable energy will face three main challenges. First is solving the split incentive challenge in which landlords are usually responsible for paying the cost of upgrades in energy efficiency and renewable energy, but tenants responsible for paying energy bills will receive all the benefit. Cincinnati's energy plan provides a range of possible solutions to address this issue, including providing energy efficiency upgrades for apartments, providing incentives for commercial building owners to make upgrades, supplying high efficiency items such as LED light bulbs, offering green leasing programs to split costs between landlords and tenants, and requiring landlords to list energy costs for their rental properties.

A second challenge is ensuring the city has the proper regulatory structure in place to support a transition to renewable energy. For example, aggregation is an incredible tool for cities in states where it is legal, but it does require passing a ballot initiative. If the city wants to negotiate with utilities to get a supply of 100% renewable energy, then residents need to vote to allow the city to represent them, and residents who do not want to participate in the aggregation agreement need a way to opt out. Likewise, many cities have a mix of permitting, zoning, and inspection requirements for businesses and residents that want to put solar panels on their roofs. Cities could assist these energy consumers by streamlining their requirements.

Finally, city leaders will need to find creative ways to pay the up-front costs. Investments in energy efficiency and renewable energy greatly benefit city residents and businesses by lowering energy bills, cleaning the air, and improving public health. But they do have up-front costs. Fortunately, cities committed to 100% renewable energy have a plethora of financing mechanisms to choose from. Among the most popular are bulk purchasing programs such as Solarize that help residents buy solar panels at discount prices; power purchase agreements that lease solar panels to homes and businesses; and Property Assessed Clean Energy (PACE) that allows commercial building owners to obtain loans for energy efficiency and renewable energy upgrades based on the property values and repay the loans through property taxes.

Regardless of whether and how these cities achieve 100% renewable energy, local investments in energy efficiency and renewable energy will strengthen the city's infrastructure, create jobs, clean the air, and improve public health. Provided these programs can be paid for, they are extremely popular among city residents, and will set cities up for a brighter, more prosperous future. In the end, that is the job of city leaders. Climate change may be the crisis that forces city leaders to confront longstanding problems of infrastructure and equity in their communities, but it is also an opportunity to build the world they want for future generations.

Appendices

I. San Francisco Recommendations

From the Updated Electricity Resource Plan, San Francisco Public Utilities Commission (2011)

Strategy 1: Empower San Francisco citizens and businesses to reduce carbon emissions.

Recommendations

1. Increase energy efficiency programs

- New sources of funding
  - TransBay Cable Funds. This is the large cable that runs from the mainland under the bay and brings electricity to San Francisco. The city receives $2 million per year for the cable owners to lease port property and gain right of way.
  - GreenFinanceSF. This is the city's Property Assessed Clean Energy (PACE) program to create $150 million in loans to cover installation of energy efficiency and renewable energy. However, program was suspended because Fannie Mae and Freddie Mac refused to guarantee mortgages on homes that use this financing.
- Need resolution of "split incentives" problem for owners and tenants.
  - In San Francisco, 60% of all residential properties are rental units
- Administration and collection of public goods charge
  - PG&E collects from consumers to pay for energy efficiency programs
  - Program must be reauthorized in 2012
  - San Francisco should advocate that funds collected from city residents should be allocated, controlled, and administered by the city, not by PG&E

2. Promote behind-the-meter activities

- Behind-the-meter activity is activity on the customer side of the meter.
  - Includes rooftop solar, small-scale wind, cogeneration (CHP), and battery storage.
  - Reduces energy needed from PG&E, creates jobs. But high up-front costs
- Funding mechanisms need to be identified
  - Programs such as feed-in tariffs allow people to sell power generated to PG&E.
  - City can provide additional assistance for residents and businesses.
  - GoSolarSF program – bulk purchasing – increased solar installations 450% in first year, cost $6.3 million. Funds from TransBay cable can help pay for this.

3. San Francisco test bed

- Achieving zero-carbon electricity by 2030 will require development of new technologies
    - SF home to over 250 clean technology companies
    - 2008 city passed Clean Technology Payroll Tax Exclusion. Clean tech companies with less than 100 employees exempt from business taxes for 10 years.
  - Could designate areas served by SFPUC such as Treasure Island, SF Zoo, or HopeSF housing project as green test beds

4. Community scale energy systems

- These systems extend "behind the meter" activities from a single building to a larger area
    - Identify large parcels not served by PG&E – ex. Hunter's Point, Treasure Island
    - Identify large private developments – ex. UCSF, California Medical Center
- Require all new developments of a certain size to determine if it is possible to become energy self-sufficient, operate largely off-grid
- Pass a city ordinance setting overall goal, then allow developers flexibility to optimize a mix of technology to meet the goal.

5. Improve building standards

- State must update building standards every three years. Cities codes can be more stringent
- SF should adopt energy efficiency for existing commercial buildings and require disclosure
- SF should accommodate clean technologies into building codes, such as requiring installation of charging stations for EVs, streamlining permitting for renewables

6. Back-up storage

- Significant number of buildings have backup electricity generation – hospitals, fire departments, data centers – several hundred MW, equal to medium-sized power plant
- City should examine whether diesel and gas generators could be replaced with storage

7. Implement Community Choice Aggregation (CCA)

- Goal is to offer electricity supply portfolio that is 51% renewable by 2021, 100% by 2030
- Program will need to balance trade-offs in cost, renewable content, and price stability
- CCA customers leaving PG&E will be subject to departing load charges / exit fees

Strategy 2: Increase renewable and carbon-free content of the city's electricity supply

7. Implement Community Choice Aggregation (recommended twice)

- CleanPowerSF will need to procure energy from both within SF and from broader energy market

8. Develop city owned transmission projects

- Evaluate feasibility of an underwater transmission line from Newark substation into SF.
- Evaluate upgrading existing transmission system from Hetch Hetchy to Newark.
- Would allow renewable energy to be delivered directly into SF, and would allow new renewable energy projects to be developed along the power line.
- Construction of new transmission lines would require significant capital investment. City is exploring funding opportunities with CAISO, WAPA and other utilities.

9. Green pricing

- Green pricing allows a customer to voluntarily pay a premium above the normal electric rate with the proceeds used to buy renewable energy
- SFPUC should develop green pricing option as part of CleanPowerSF
    - Could be more than California RPS of 33% but less than 100%
- Pricing and length of commitment needs to be sufficient to recover the higher cost of acquiring renewable energy

10. Regulatory participation

- SFPUC participates in state and regulatory proceedings to represent SF interests
    - CPUC regulates 83% of city's energy supply through PG&E and direct access
    - FERC regulates national energy transmission across state lines
- CPUC developing rules to govern CCAs. Major issues include
    - Exit fees PG&E customers will have to pay to join CCA
    - Limits on PG&E marketing efforts to prevent customers from choosing CCA
    - Ability of CCA to control energy efficiency funds collected from PGC by PG&E
- Intervention in legislative and regulatory process is time consuming and resource intensive with no certainty of results, but SFPUC and city attorney are already doing it.

Strategy 3: Continue and expand municipal electric service to guarantee reliable, affordable, and environmentally responsible service.

11. Develop a rate structure for the SFPUC power enterprise

- SFPUC provides electric power to all municipal facilities in SF
  - General Fund customers don't pay full cost to generate electricity.
  - Lack of defined rate structure makes it impossible for SFPUC to satisfy credit rating agencies, so not able to issue bonds to finance renewable energy projects
- SFPUC should establish a rate reform plan to propose new rates that satisfy credit rating requirements and support energy efficiency and renewable energy goals.

12. Increase the use of municipal load to displace fossil fuel use

- Identify new uses for power from Hetch Hetchy hydropower plant
  - Ex: power for cruise ships docking at piers, use of EVs, charging stations

13. Renegotiate the interconnection agreement

- SF does not own transmission lines from PG&E Newark substation to city. Has interconnection agreement with PG&E to transmit and distribute the electricity.
- The IA expires in 2015. City could renegotiate with PG&E or find alternative

14. Implement environmental justice and community benefit programs

- 2002 plan identified support for environmental justice as a major goal
  - Closed plants at Hunters Point and Potrero
  - Targeting low income housing for energy efficiency
  - Offering enhanced incentives under GoSolarSF for disadvantaged areas
- SFPUC now has formal environmental policy that includes
  - Stakeholder and community involvement
  - Workforce development – training, placement, succession planning
  - Clean renewable water and energy resources, decrease pollution
  - Collaborative partnerships that promote contracting with local companies
  - Use of land in a way that maximizes health, environment, innovation
  - Diversity and inclusion programs
  - Improvement of community health

II. Atlanta Recommendations

From the Clean Energy Atlanta plan, Mayor's Office of Resilience (2018)

Immediate Term

- **Advisory Board**: Form an Advisory Board to act as a sounding board for strategies being considered, contribute analytical and research support, and help the city select initiatives
    - People with background in environmental justice, green buildings, environmental policy, real estate, business, labor, energy, and urban planning, along with local elected officials, and neighborhood leaders.
    - Not consensus-based. City has ultimate authority to make decisions.
    - Third-party facilitator will help develop presentations, run initial board meetings, build consensus on issues, set stage for working relationship.

Energy Efficiency

- Short Term
    - Establish a **Renters Energy Task Force** to explore high performance leasing and other ways to overcome the split incentive barriers in rental housing
    - **Incentives education programming**: Partner with Georgia Power and community stakeholders to provide education on existing energy efficiency and renewable energy incentives and programming
    - **Building energy stretch code**: Engage with stakeholders to adjust the city's building codes to be 20% more efficient than state code.
    - **Building retuning policy**: Explore policy supporting building energy retrofits.
    - **Small and medium building retrofit policy**: Explore options to save energy in existing small and medium buildings.
    - **Efficient equipment policy**: Determine whether it is feasible to require procurement of high-efficiency new and replacement equipment in city buildings.
    - **Property Assessed Clean Energy (PACE) financing**: City will partner with Invest Atlanta to support a PACE financing program to provide businesses and residents with a mechanism finance clean energy on their properties.
- Long Term
    - Continue and expand **deep energy retrofits** for city buildings
    - **Round-It-Up**: Work with Georgia Power on a program to round up customer electricity bills to the nearest dollar to fund energy efficiency initiatives

- **Net-zero energy code**: Explore feasibility of phasing in an energy code that will require buildings to produce as much energy as they consume.
- **Pay As You Save**: Work with Georgia Power on a program to allow homeowners to finance energy efficiency projects through monthly payments on electric bills.

Renewable Energy

- Short Term
  - **Large scale and community scale solar**: Collaborate with Georgia Power to identify high-potential sites for additional solar development.
  - **On-site generation at Water Reclamation Center**: Department of Watershed Management's RM Clayton Digester is expected to contribute 10,000 MWh of clean energy annually through captured methane gas from anaerobic digestion.
  - **Low-income renewable energy pilot project**: City will partner with neighborhood development organizations on a program to help owners and tenants of residential properties bring clean energy to low-income communities.
  - **Solar-ready building code**: City will work with stakeholders to identify opportunities to adjust building codes to promote solar adoption.
  - **Assess zoning codes** to identify opportunities to ease on-site solar development
  - **Streamline solar permitting:** City will work with solar industry to address concerns related to building and electrical permits.
  - **Solar bulk purchasing:** City will support community bulk purchasing programs for on-site solar installations such as Solarize Atlanta
  - **Solar storage:** City will work with contractors to ensure use of diesel generators is replaced by solar + storage for city projects.
- Long Term
  - **Equitable community solar program**: City will develop a program through which payments for solar provided to the grid are credited to low-income bills.
  - **Retail net metering**: Building owners can sell excess electricity produced by solar panels on their property back to utility at retail cost.
  - **Combined Heat and Power at wastewater treatment plant**: City's Department of Watershed Management will expand CHP at water treatment facilities.
  - **Green Tariff**: City will work with Georgia Power to establish a special renewable energy rate.

- **Renewable Energy Certificates**: City will assess options with Georgia Power and local partners for bulk purchasing of RECs from locally generated energy.

Electric Vehicles

- **Expand EV charging infrastructure**: Partner with Georgia Power and the private sector to add EV charging stations.
- **Develop EV car-share program for low-income residents**: Work with partners to develop a car-share program to increase access EVs for low-income residents to overcome the first-mile/last-mile problem for public transit.
- **Vehicle grid interconnectivity**: Explore pilot with EV manufacturers and Georgia Power for electric vehicle grid integration, so EV can act as power storage, both taking power from and giving power back to the grid.

Energy Storage

- **EV battery reuse**: Used EV batteries can provide grid services and storage.
- **Education**: Establish partnerships to conduct education on value of energy storage.

Cross-Cutting Initiatives

- **Rate improvements**: Work with Georgia Power to develop rates that provide real-time price signals and fair payments for real-time grid services.
- **Workforce training**: Collaborate with technical colleges and trades to develop a clean energy workforce.
- **Communication and engagement**: Conduct ongoing outreach to keep the public aware of progress towards the goal of 100% renewable energy and receive stakeholder input.
- **Education on clean energy programs**: Provide regular information sessions on opportunities and incentives for clean energy.
- **Large buyers group**: Work with major users of energy to produce economies of scale and reduce overall purchase prices for clean energy equipment and technology.

III. Cincinnati Recommendations

From the Green Cincinnati Plan, City of Cincinnati (2018)

Buildings

Goals

- Make all city facilities, fleets, and operations net carbon neutral by 2035.
- Decrease household energy burden by 10%.
- Increase the percentage of city streets meeting complete streets requirements by 1% each year.

Recommendations

2. Create a Sustainability District (such as 2030 District).
3. Encourage population density and transit-oriented development in appropriate locations through zoning and incentives.
4. Improve city facilities by investing in energy efficiency - specifically HVAC and lighting.
5. Encourage development of high-performance buildings.
6. Incorporate complete street principles in all new roadway and rehabilitation projects.
7. Target multi-family properties for energy efficiency improvements.
8. Require all new city facilities to be LEED Silver certified or better.
9. Develop a plan to return vacant buildings to productive use.
10. Require or incentivize Low Impact Development for new developments and infrastructure.
11. Implement a coordinated site plan review process.
12. Plan to phase out HVAC systems using R-22, a potent greenhouse gas.

Education and outreach

Goals

- Register 100 organizations in a green business/neighborhood certification program.
- Establish $1 million in a Green Cincinnati Fund to advance sustainability initiatives.
- Increase by 10% the number of city residents who can name at least 3 actions they are doing to be green/promote sustainability.

Recommendations

13. Install solar panels on Cincinnati Public Schools facilities.
14. Outreach to multi-family buildings to educate residents about sustainability programs.
15. Create a Green Cincinnati Fund to finance sustainability initiatives.
16. Develop a Green Business/Neighborhood Certification program.

17. Expand workforce development, with an emphasis on students and low-income residents, through a city-university-corporate partnership for education and training.
18. Create branding and communication strategy for Cincinnati sustainability efforts.
19. Identify partners to lobby state government on sustainability issues.
20. Build partnerships with existing business incubators to include sustainability training.
21. Expand environmental education and experiences for CPS students and others.

Energy

Goals

- 100% renewable energy for city government by 2035.
- Triple renewable energy generation for residents and businesses.
- Reduce energy consumption 2% annually.

Recommendations

22. Increase outreach to and participation of industrial customers in renewable energy and energy efficiency projects.
23. Expand programs to increase energy efficiency and solar energy generation for the private market (e.g. Solarize, PACE financing).
24. Increase renewable energy generation for use by city government.
25. Improve access to financing for energy efficiency and renewable energy.
26. Implement mandatory energy benchmarking ordinance.
27. Purchase renewable energy credits (RECs) for city operations.
28. 100% LED streetlights.
29. Increase battery storage capacity.
30. Promote state policies that encourage energy efficiency and renewable energy.

Food

Goals

- 100% of residents have convenient access to healthy, affordable foods.
- Reduce food waste by 20% by 2025.
- Triple acreage of urban food production.
- Double the number of residents consuming local foods.
- Double the number of people eating plant based diets.

Recommendations

31. Encourage individuals and companies to prevent, recover, and recycle wasted food.
32. Promote understanding of the impact of dietary choices and benefits of a plant-based diet.
33. Create policies and support programs that encourage urban agriculture.
34. Increase the public and private land used for local food production.
35. Encourage the development and utilization of food hubs, and increase the distribution and processing of locally, sustainably produced foods.
36. Support and expand programs that make healthful foods more affordable for vulnerable populations.
37. Encourage and support development of local food system entrepreneurs to increase production and distribution of locally produced foods.
38. Support strategies for ensuring food security in all communities throughout Cincinnati.
39. Encourage purchasing of healthy, sustainable foods by major institutions.

Natural systems

Goals

- Attain 100% of U.S. EPA National Ambient Air Quality Standards.
- Increase city-wide tree canopy coverage to at least 40%, ensure all residential neighborhoods to 30% tree canopy coverage.
- Meet EPA recreational water quality criteria in 90% of Cincinnati waterways, 90% of the time.
- Have a park or outdoor recreation site within a 10-minute walk of every city resident.

Recommendations

40. Implement water loss control program to reduce water loss due to leakage.
41. Increase tree canopy and access to greenspace.
42. Create and expand wetlands.
43. Develop a carbon offset program to fund tree planting efforts.
44. Decrease the acreage of mowed grass and replace with bushes and trees.
45. Increase the amount of storm water holding capacity using green infrastructure and natural systems.
46. Develop an Air Quality Action Plan.
47. Conduct biodiversity assessment for Cincinnati.

Resilience

Goals

- 50% decrease in childhood asthma-related hospital admissions in target neighborhoods. Reduce disparities between neighborhoods.
- No increase in storm or heat-related fatalities.
- No increase in storm damage remediation costs.

Recommendations

48. Launch campaign to reduce childhood asthma rates in Cincinnati.
49. Develop multilingual communication network for disseminating risks and recommendations in the event of emergency (e.g. Rave Alert).
50. Conduct a neighborhood vulnerability assessment.
51. Climate Haven – Leverage climate resilience to attract new business and residents.
52. Encourage onsite stormwater retention and infiltration and discourage runoff by restructuring sewer and/or stormwater fee.
53. Conduct an Urban Heat Island assessment.
54. Implement renewable backup power systems for areas of refuge and emergency facilities.
55. Educate the public to reduce harms from intense storms and heat waves.
56. Require occupied residential rental units to have one air-conditioned room.
57. Develop and expand Metropolitan Sewer District's smart sewer SCADA system.
58. Develop an environmental justice program that identifies communities disproportionately burdened by pollution and hazardous waste, and acts to reduce or eliminate those burdens.

Transportation

Goals

- Decrease the consumption of fossil fuels, including gas, diesel, and natural gas by 20%.
- Increase the passenger miles travelled via public transit by 25% by 2035.
- Double lane miles of bike infrastructure.

Recommendations

59. Prepare for the adoption of autonomous vehicles, starting with a pilot project.
60. Encourage the use of electric vehicles through city programs that incentivize EV ownership and infrastructure.
61. Pursue car sharing service in Cincinnati as an equitable mobility solution.
62. Green the Fleet: Improve the fuel efficiency of the city’s fleet.

63. Encourage corporate sponsorship of transit passes and infrastructure to encourage employee bus and bikeshare ridership.
64. Improve neighborhood walkability by improving sidewalk connectivity and pedestrian safety, especially in low-income neighborhoods.
65. Police enforcement and legislative support for bike and pedestrian safety
66. Enhance public transit and increase transit funding.
67. Increase connectivity and cohesion within multimodal transportation options
68. Create a transit link between Downtown and Uptown.
69. Implement and update 2010 Cincinnati Bike Plan and Cincinnati Riding or Walking Network (CROWN) Plan.
70. Continue to support Red Bike (bike share) as an equitable mobility solution.

Waste

Goals

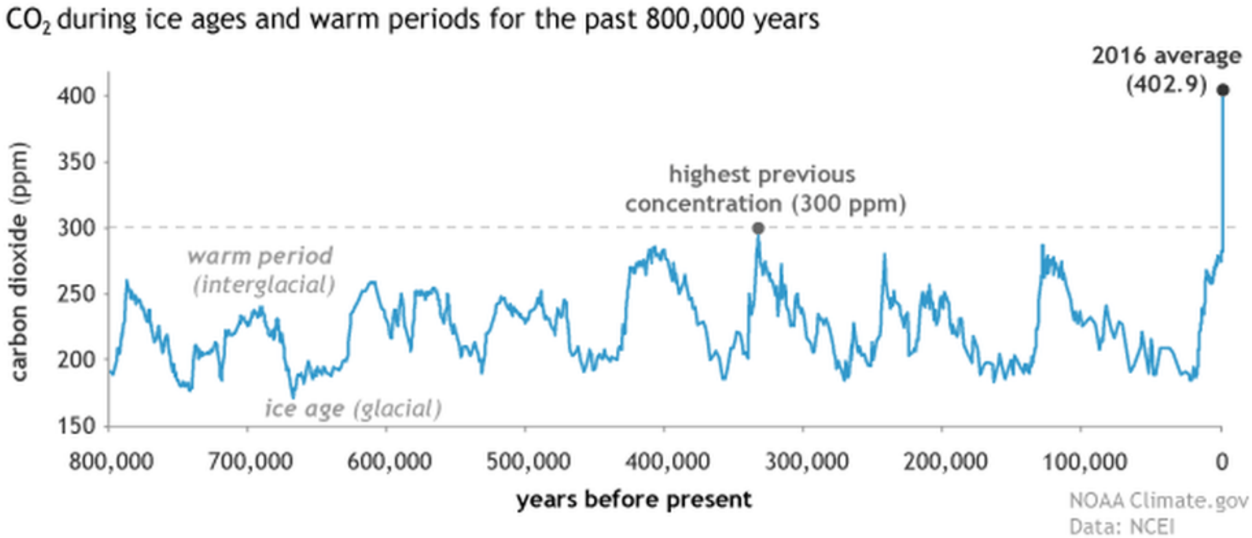
- Zero waste by 2035.
- Decrease (residential) tonnage to landfill by 20%.
- Increase participation in city curbside recycling programs by 5% for residential and 20% for commercial.

Recommendations

71. Incentivize recycling and increase cost of trash disposal to encourage diversion from landfill.
72. Divert organics from the landfill.
73. Attract credible manufacturers that make products from recycled materials to increase the types of materials that can be accepted in curbside recycling program.
74. Advertising and outreach to improve recycling rates, spending $1/household/month. Focus efforts on currently lower-performing communities.
75. Create outlets to recycle items that cannot be accepted by the curbside program.
76. Require recycling at any special events that require a city permit.
77. Install public recycling receptacles in neighborhood business districts.
78. Implement a fee or ban to discourage use of single-use bags.
79. Improve recycling and waste reduction in city facilities.
80. Conduct waste audit to understand the changing composition of our waste stream.

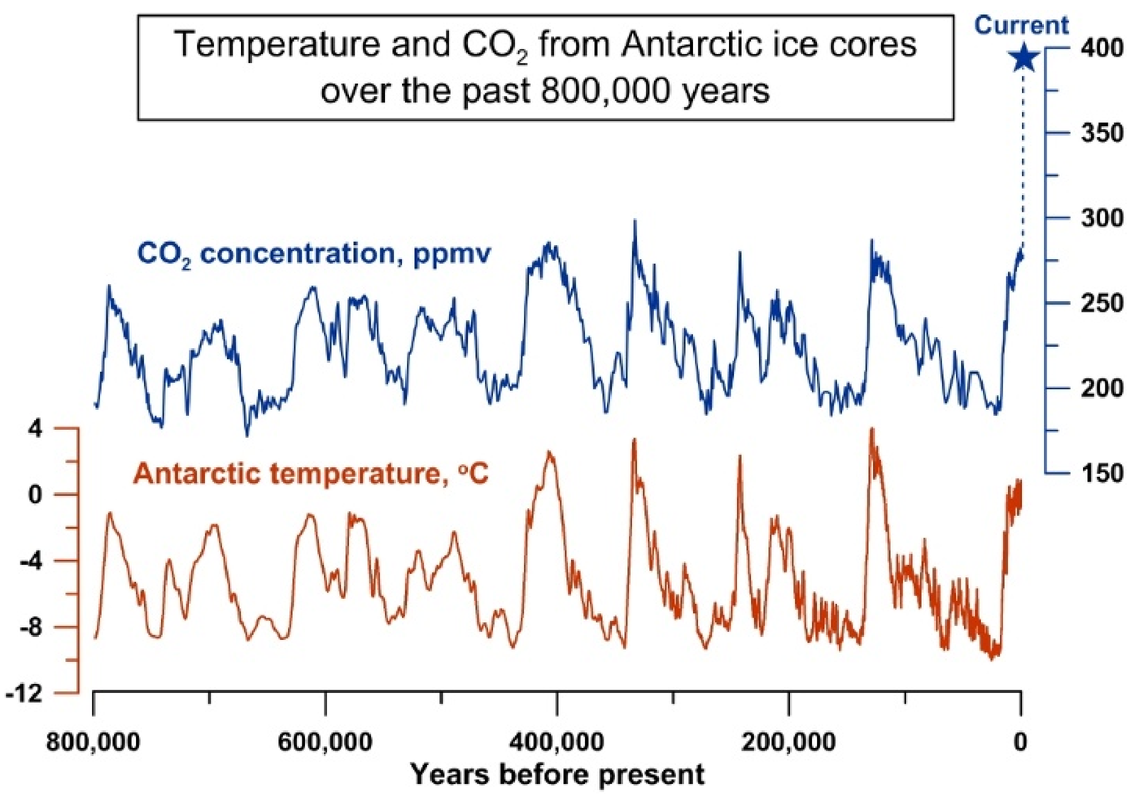
IV: Carbon dioxide levels and temperatures for the past 800,000 years

Figure A: Carbon dioxide levels



Credit: National Oceanic and Atmospheric Administration

Figure B: Temperature and carbon dioxide levels



Credit: Fanney,2014

V: Representative Concentration Pathways

How much worse will climate disasters get? That depends on whether and how quickly humans stop burning fossil fuels and transition to clean renewable energy. Scientists cannot predict which policies humans will choose to regulate (or not regulate) carbon emissions, but they can tell us what the results of various policies will be. The Intergovernmental Panel on Climate Change, the United Nations body for assessing the science related to climate change, does this through a series of scenarios called Representative Concentration Pathways, or RCPs. The IPCC's Fifth Assessment Report (2014a) has four RCPs [see Figure C and Figure D]:

- **RCP 8.5**: A business as usual scenario with very high uncontrolled emissions
- **RCP 6.0**: An intermediate high scenario with some controls over carbon emissions
- **RCP 4.5**: An intermediate low scenario with more controls over carbon emissions
- **RCP 2.6**: A stringent mitigation scenario with emissions kept very low

Of these scenarios, three are likely to result in more than 1.5ºC of warming by the end of the century, with two likely to result in more than 2ºC of warming. Only RCP 2.6, the most stringent mitigation scenario, is likely to hold global warming to 1.5ºC (IPCC, 2013). In 2009, the Copenhagen climate conference established a threshold of 2ºC warming above pre-industrial temperatures as the limit the Earth cannot go above and still have a planet hospitable to human life. In 2015, after a sit-in by vulnerable island nations that were already losing their homes along with others experiencing the effects of catastrophic climate change, the Paris climate conference established a goal of keeping warming as close to 1.5ºC as possible.

At this time the planet has warmed about 1ºC above pre-industrial temperatures, with another half degree locked in due to the long half-life of the carbon already emitted, which will stay in the atmosphere acting as a greenhouse gas for about 100 years. Thus, while it is not possible to avoid reaching 1.5ºC of warming, with strong climate action, it may be possible to avoid 2ºC of warming. The difference between 1.5ºC and 2ºC of global warming is significant. Half a degree more of warming could result in a complete loss of Arctic sea ice, 37 percent of the world population exposed to severe heat waves, tens of millions more people exposed to severe drought, twice to three times the number species losing more than half their range, disappearance of coral reefs, tens of millions more people exposed to flooding from sea level rise, and lower crop yields, especially in sub-Saharan Africa, Southeast Asia, and South America (IPCC, 2018).

Figure C. RCPs in IPCC Assessment Report 5

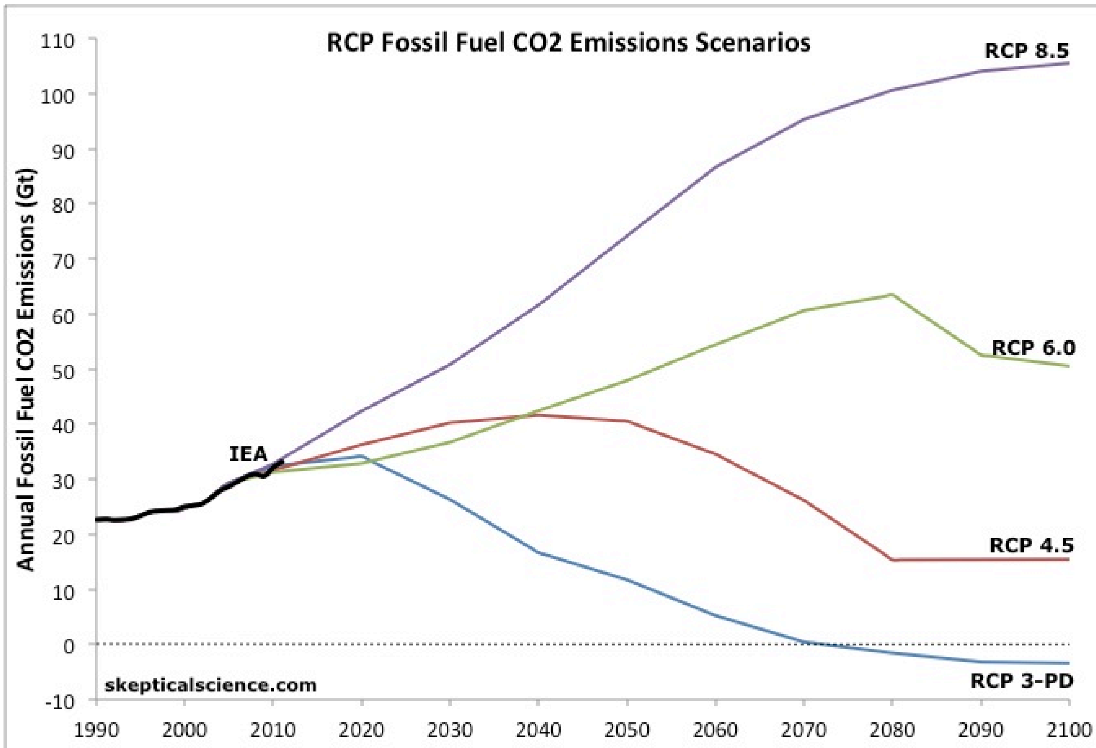
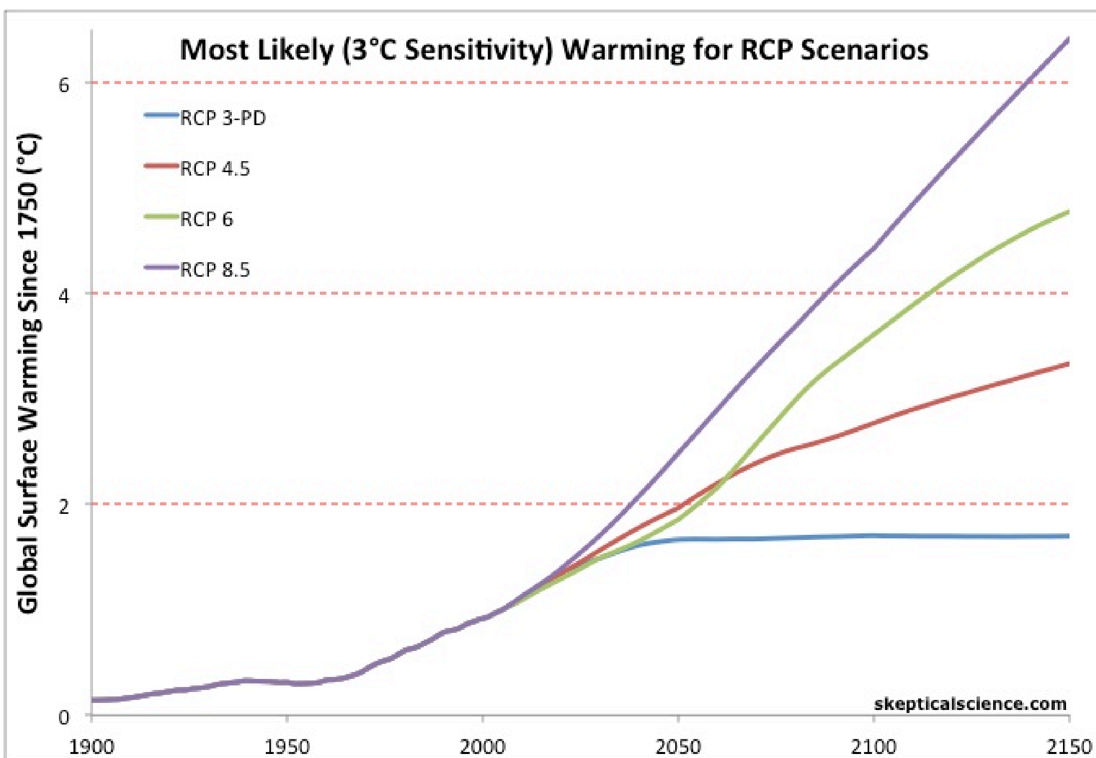


Figure D: Most likely climate scenario for each RCP



Credit: Nuccitelli, 2013

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